# RUBBER SEED AND ITS COMMERCIAL APPLICATIONS: A BIBLIOGRAPHY

The Rubber Research Institute of India, Kottayam, Kerala, India

# Rubber Seed and its Commercial Applications : A Bibliography

*Compiled by*
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## ABOUT THE COMPILATION

This bibliography, **Rubber Seed and its Commercial Applications: A Bibliography**, is a compilation of literature covering various aspects of rubber seed right from its collection to application. It also covers rubber seed oil, rubber seed cake, etc. and their commercial as well as industrial applications. These materials were collected from sources like journal articles, monographs, books, conference proceedings, seminar papers, reports, workshops, CDROMs, etc. available in the RRII library.

The compilation consists of two sections, the Bibliography Section and the Key Word Index Section. The bibliography section is arranged alphabetically by the title followed by author(s), citation, abstract (in major cases) and key words. In certain cases, abstracts were not included. The key word index section comprises all the key words from the respective article.

The immense help and active co-operation rendered by the scientific staff of Rubber Chemistry, Physics and Technology Division, Economic Research Division, Botany Division and staff of Library at various stages in this compilation are gratefully acknowledged.

March, 2003

V. R. SUJATHA
ACCAMMA C. KORAH
MERCY JOSE

# BIBLIOGRAPHY

1 **Activated carbon from rubber seed and palm seed coats: Preparation and characterization**

Rengaraj, S; Arabindoo, Banumathi and Murugesan, V

*Journal of Scientific and Industrial Research*, 57 (March) : 1998.129-132.

Activated carbons have been prepared from rubber seed coat and palm seed coat by various carbonization techniques such as acid, sulphate, carbonate, chloride, dolomite, and pyrolysis processes. Their characteristics such as bulk density, moisture content, ash content, matter soluble in water and in acid, pH, decolourising power, phenol number, ion exchange capacity, iron content and surface area have been carried out in order to determine the suitability of these carbons for water and wastewater treatment. The results are compared with commercially available activated carbon. Surface area, decolourising power and phenol number of the activated carbons derived from palm seed coat are found to be higher than the carbon obtained from rubber seed coat and the commercially available activated carbon.

Key words : Rubber seed; Palm seed; Rubber seed coat; Activated carbon; India

2 **Agro-industrial by-products as livestock feeds: Rubber seed cake**

Ananthasubramaniam, C R

Technical Bulletin No.5, Kerala Agricultural University, Vellanikkara, Trichur, 1980, 23 p.

Though rubber seed cake has been identified as having immense scope as an ingredient in livestock feeds, there have not been many studies in this area prior to 1980. However, an exception to this may be the study by Ananthasubramaniam who examined the feasibility of incorporating rubber seed cake into livestock feed. The results of a 12 year study utilising rubber seed cake (*Hevea brasiliensis*) in the rations of cattle, pigs and poultry carried out at the Kerala Agricultural University indicate that the material can be incorporated profitably in livestock feeds. The results may be summarised as follows: (1) The material possesses a crude protein content of 25 percent with a DCP of 15 and a TDN of 66 for cattle (2) The DCP and TDN of the material in respect of pigs are 16 and 78 respectively. (3) The material contains nearly 9 mg/100g of hydrocyanic acid which has no deleterious effect on feeding at the recommended levels. The HCN content, however, can be reduced by drying. (4) Rubber seed cake can be fed up to 30 percent of the concentrate mixture for cattle and at 10 percent level in the ration for pigs and chicken with monetary benefits.

Key words : Rubber seed cake; Livestock; HCN content; India

3 **Alkyd resin from rubber seed oil**

Njoku, Obioma U and Ononogbu, Ikpendu C

*Indian Journal of Natural Rubber Research*, 8(1): 1995. 63-65.

Rubber seed is reported to contain about 42% oil, which is semi-drying type oil. Rubber seed oil used in the present study was prepared by extracting the seed with petroleum ether. Two types of modified alkyds were prepared from the refined rubber seed oil and

these were used for the production of white gloss paint. The viscosity values of the paints were comparable but the drying characteristics were different. The level of unsaturated fatty acids such as linolenic and linoleic acids is found to be the deciding factor, which helps drying.

Key words : Rubber seed; Rubber seed oil; Alkyd resin; Paint; Nigeria

## Alkyd resins from polymerised rubber seed oil

Patel, R P; Patel, Pulin N and Raval, D A

*International Journal of Polymeric Materials*, 46: 2000. 243-253.

Rubber seed oil (RSO) was thermally polymerised at different temperatures. It was also polymerised at the same temperature using various percentage of benzoyl peroxide (BPO) and azobisisobutyronitrile (AIBN) as free radical catalysts. During polymerisation, the free fatty acid content increased as revealed by increased acid value and unsaturation decreased as indicated by decreased iodine value. The FFA, unsaturation, viscosity and refractive index of the polymerised oil samples were determined. Alkyd resins were prepared from as it is and polymerised rubber seed oil samples. The physical properties and air dried and baked film properties of these alkyd resins were studied and compared.

Key words : Rubber seed oil; Alkyd resin; Polymerization; Film properties; India

## Alkyd resins from acrylated prepolymerised rubber seed oil

Patel, R P; Patel, Pulin and Raval, D A

*International Journal of Polymeric Materials*, 48(1): 2000. 49-61.

Rubber seed oil (RSO) was polymerised at different temperatures, *viz.* 60, 90 and 230°C using various percentages of benzoyl peroxide (BPO) and azobisisobutyronitrile (AIBN) as free radical catalysts. This polymerised RSO was then subjected to acrylation by using MMA as an acrylic monomer and BPO as free radial initiator. The viscosities of the acrylated oil samples were examined. Alkyd resins were prepared from as is and acrylated RSO samples. The physical properties and air dried and baked film properties of these alkyd resins were studied and compared.

Key words: Rubber seed oil; Alkyd resin; Acrylates; Polymerization; Film properties; India

## Analysis of some factors affecting seed production and availability in rubber (*Hevea brasiliensis*)

Odetola, J A; Sagay, G A; Igeleke, C L and Duze, F O

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986. pp. 88-95.

Some physiological, phytopathological and biotic factors affecting development, production

and survival of rubber seed under field conditions were studied. Incidence of parthenocarpy, per se, was very low in all clones examined and could not account for the common absence of endosperm in seeds collected from the forest floor. Four genera of fungi associated with the flowering stage were implicated in subsequent floral abortion. Two of them, *Phytophthora* and *Helminthosporium* also interfered with postanthesis stages of development, causing rotting of seed parts and pericarp tissues. Seed survival on the forest floor was affected seriously by various agents including insects, arachnids, nematodes, molluscs and mammals. The effect of these factors on large-scale commercial seed production is discussed.

Key words: *Hevea brasiliensis*; Rubber seed; Seed production; Seed collection; Parthenocarpy; Microflora; Nigeria

7 **The animal feed industry for developing countries**

Koenig, Horst R

Conference: Regional Preparatory Meeting on Animal feed and Related Industries in Africa, 1992, Bamako, Mali,UNIDO-ID/ WG.529/3, pp.26.

Animal feed production for developing countries-covers (1) animal feed industry as a development factor: the utilization of agro-industrial by-products, use of agricultural residues (2) large-scale production of compound animal feed, market-orientation, feed raw materials, storage, automation, computerization (3) rural industrial production of animal feed (4) special feedstuffs and feed ingredients: oil cakes, oils and fats, rubber seed press cakes, cassava, molasses (5) economic feasibility, storage, quality control.

Key words : Rubber seed; Animal feed industry; Feed production; Developing countries

8 **The antioxidant effect of some amino acids in rubber (*Hevea brasiliensis*) seed oil**

Njoku, Obioma U

*Nigerian Journal of Biochemistry and Molecular Biology*, 11: 1996. 35-37.

All the 9 amino acids had some antioxidant activity when added in virgin rubber seed oil. The amino acids added as solids namely, arginine, phenylalanine, glycine, methionine, serine, aspartic acid and cysteine had lower antioxidant activity, and their protection factor (AOM) being 2.5. Those added as aqueous solution had higher antioxidant activity than those added as solids. Chelation of metals by amino acids was presumably responsible for the antioxidant activity. Increase in concentration of some amino acids trippled the protection factor (AOM) in the rubber seed oil.

Key words: *Hevea brasiliensis*; Rubber seed oil; Antioxidants; Amino acid; Nigeria

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Key words: *Hevea brasiliensis*; Rubber seed oil; Antioxidants; Amino acid; Nigeria

9 **Applicability of the Freundlich and Langmuir adsorption isotherms in the bleaching of rubber and melon seed oils**

Achife, E C and Ibemesi, J A

*Journal of the American Oil Chemists' Society*, 66(2): 1989. 247-252.

The applicability of Freundlich and Langmuir adsorption isotherms to guide bleaching of vegetable oils was examined using rubber [*Hevea brasiliensis* (Willd. ex Adr. Juss) muell. Arg.] and melon [*Colocynthis vulgaris* (Schrad)] seed oil at temperatures of 30, 55 and 80 C. Fuller's earth, activated charcoal and a mixture thereof (1:1 ratio) were used as the decolorizing agents (adsorbents). The degree of bleaching was monitored spectrophotometrically. Plots of log (x/m) versus log $X_e$ (for Freundlich) and ($X_e$/x/m) versus $X_e$ (For Langmuir) were made; where x is the amount of coloring matter removed per unit mass of the adsorbent, m, and $X_e$ is the equilibrium concentration of the coloring matter. The results obtained show good agreement with Freundlich and Langmuir isotherms, indicating that the adsorption of the coloring matter from the oils proceeds by monolayer formation on the surface of the adsorbent. The specific adsorption (x/m) and the Freundlich and Langmuir constants were found to increase with temperature for a given oil/bleaching agent ratio, showing the formation of more active sites on the adsorbent with a rise in temperature.

Key words : Rubber seed oil; Melon seed oil; Bleaching; Adsorption; Physico-chemical properties

10 **The application of thin-layer chromatography for the analysis of fatty acids in *Hevea* seed oil**

Hoesnan, Aman and Hardjosuwito, Baryono

*Menara Perkebunan*, 44(5): 1976. 261-267.

Key words : *Hevea*; Rubber seed oil; Fatty acid; Thin-layer chromatography; Indonesia

11 **An assay of growth inhibitors in seed oil and normal and diseased (brown bast) bark of *Hevea***

Ratnayake, C M B

*Rubber Research Institute of Sri Lanka. Quarterly Journal*, 50(1-2) : 1973. 19-27.

*Mikania* stem apices and *coreopsis* flower stalks were shown to be acceptable substitutes for oats in the coleoptile test; both these materials were used to test the growth substances present in rubber seed oil, normal bark and brown bast diseased bark. The concentrations of growth-promoting substances in normal and diseased bark were similar, but those of inhibitors were greater in diseased bark. The concentrations of inhibitors in the seed oil were higher than those in bark. Content of growth inhibitors was significantly higher in diseased than in healthy rubber bark but it is not yet established that the increase causes

the disease. High yielding clones are generally more susceptible to brown bast and may have susceptibility bred into them.

Key words : *Hevea*; Rubber seed oil; Growth substances; Brown bast; Sri Lanka

## 12 An assessment of some methods of storage of rubber seeds and undefatted seed cake

Otoide, V O and Begho, E R

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed .Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp.130-134.

Rubber seeds (fresh and predried whole seeds and kernels) were stored by four methods, viz: in polythene bags, plastic jerry cans, nylon-matted bags and on the floor. After a period of two months of storage, the fresh seeds recorded significantly higher levels of mouldiness compared to the pre-dried seeds. While 10-100% of the fresh whole seeds and kernels were mouldy, depending on the storage method, 6.7-30% of the pre-dried whole seeds and kernels were mouldy. The moisture contents of the fresh seeds dropped significantly from 29.7% to less than 10 % except for those stored in plastic jerry cans and fresh whole seeds in polythene bags. A trace of mouldiness was observed on the surface of the undefatted seed cake stored in nylon-matted bags. In all cases, mouldiness was caused by *Aspergillus sp.* A few insects (*Tribolium sp.*) were observed in the fresh kernels stored on the floor and in nylon-matted bags. From the preliminary results obtained it is concluded that drying rubber seeds before storage is desirable to minimise mouldiness.

Key words : Rubber seed; Seed storage; Mouldiness; Moisture content; Nigeria

## 13 Bibliography on rubber seed oil (with abstracts). No 10

Rubber Research Institute of Malaya, Kuala Lumpur, 1970, 22 p.

Key words : Rubber seed; Rubber seed oil; Bibliography; Malaysia

## 14 Biochemical and nutritional qualities of rubber-seed meal

Nwokolo, Emmanuel

*Tropical Agriculture*, 64(3):1987.170-171.

In Nigeria ether extract fractions of rubber-seed meal were analysed for saponification, iodine and peroxide values and free fatty acid content. The saponification value was 183.37, iodine value was 15-26, peroxide value was 0.90 and free fatty acid (oleic acid) content 19.71%. An analysis of the fatty acid composition of rubber-seed oil indicated a high content of linoleic acid (37.18%) and linolenic acid (29.95%). The defatted meal was analysed for its amino acid content. It was high in arginine, valine and leucine, moderate in lysine and low in methionine.

Key words : Rubber seed meal; Nutrition; Biochemistry; Nigeria

## 15 Biochemical viability test of *Hevea* rubber seeds

Toruan-Mathius

*Menara Perkebunan*, 59(2): 1991. 38-42.

*Hevea brasiliensis* seeds are classified as recalcitrant. They have no dormancy period and tend to lose their viability rapidly during storage. The conventional methods for viability test have several weaknesses, either time consuming (21 days) or the results are less accurate. This experiment was aimed at finding a rapid method to determine the viability of *Hevea* seeds by investigating the correlation between the parameters of seed viability (germination percentage, germination value, rate of spread of germination) and electrical conductivity or free fatty acids (FFA) content in two clones, i.e. GT1 and LCB 1320. It was found that there was a strong linear correlation ($r>-0.80^{**}$) between seed viability and electrical conductivity in both clones. Between seed viability and FFA content, however, the correlation was found to be exponential ($r>-0.90^{**}$). It was concluded that electrical conductivity and FFA tests can be applied as rapid methods for determining seed viability of the two clones. The methods are simple, accurate and require only 8 hours instead of 21 days in the conventional method.

Key words : *Hevea brasiliensis*; Rubber seed; Seed viability; Indonesia

## 16 Biological evaluation of para-rubber seeds (*Hevea brasiliensis*)

Fetuga, B L; Aveni, T O; Olaniyan, A; Balogun, M A; Babatunde, G M and Oyenuga, V A

*Nutrition Reports International*, 15(5): 1977. 497-510.

Proximate nutrient composition and mineral constituents were determined in full-fat and defatted rubber seeds. Total amino acid composition of full-fat rubber seeds, peanut and soybean meals was also determined by column chromatography for amino acids. Four experiments were conducted using 28-day old albino rats (initial weights, 50-55g) with the following objectives: (i) to compare the protein quality of full-fat and defatted rubber seed meals; (ii), to test the effect of autoclaving on the protein quality of full-fat and defatted rubber seed meals; (iii) to assess the effects of hot water, dilute acid and dilute alkali extraction on the nutritive value of rubber seed and (iv) to measure responses to amino acid supplementation of both full-fat and defatted rubber seed meals. The full-fat and defatted rubber seeds had protein contents of 22.54 ± 0.52% and 36.48 ± 0.84% respectively and fat contents of 49.49 ± 1.54% and 8.54 ± 0.38%. Both the full-fat and defatted samples contain fairly high levels of calcium (0.48 ± 0.02 and 0.88 ± 0.05%); phosphorous(0.64 ± 0.06 and 0.94 ± 0.09%); potassium (0.96 ± 0.42 and 1.54 ± 0.63); iron (92.72 ± 11.54 and 147.45 ± 8.32 mg/kg) and zinc (78.46 ± 2.11 and 112.29 ± 4.86 mg/kg). Amino acid analysis indicated lower levels of lysine, iso-leucine, leucine phenylalanine, tyrosine, proline and glycine compared to peanut and soybean and lower methionine and cystine content compared to soybean. Poorer protein quality indices were obtained for both types of rubber seed compared to peanut and soybean, while the full-fat seed meal was nutritionally superior to the defatted sample. Autoclaving did not improve the nutritive indices of the rubber seed meals. Dilute acid or alkali treatment worsened rat

responses, while hot water extraction resulted in nonsignificant improvements in the nutritive value. Responses to amino acid supplementation suggest that lysine and methionine are most limiting in rubber seed protein. The overall results also suggest an impairment of the nutritive value of rubber seeds by extraction with petroleum spirit.

Key words : *Hevea brasiliensis*; Rubber seed; Rubber seed meal; Biological evaluation; Nutritive value; Defatted rubber seeds; Full-fat rubber seed; Protein quality, Nigeria

## 17 By-products and ancillary activities in rubber plantations

Pushpadas, M V; Haridasan, V and Jayarathnam, K

*In: Handbook of Natural Rubber Production in India.* (Ed. P N Radhakrishna Pillai). Rubber Research Institute of India, Kottayam, 1980, pp. 505-514.

Rubber seed is a source of non-edible oil. The collection of rubber seeds was not widely practised in India until the last decade. However, the increase in the price of non-edible oil in recent years generated interest in the collection and processing of rubber seeds. The seed fall season in India is between July and September. Apart from powdery mildew disease and abnormal leaf fall disease caused by *Phytophthora spp.*, rainfall also reduces the yield of seed from the rubber trees. The non-availability of adequate workers for collection at a reasonable wage, difficulty in storing the seed, presence of luxuriant cover crops and steep and hilly terrain are other adverse factors affecting collection of rubber seeds. Various estimates are available regarding the seedling potential of rubber trees. According to a study conducted by the Rubber Board, on an average, a healthy tree can yield about 500 g. of useful seeds during a normal year and this works out to an estimated availability of 150 kg. of seeds per ha. The price of rubber seeds range between 30-60 paise per kg. Very young and old trees do not produce sufficient seeds to make collection economical. Although the total area under rubber in India was 2.36 lakh ha at the end of 1978-79, after excluding areas planted before 1948-49 and after 1972-73, only two lakh ha may be considered as potential plantation capable of yielding seeds. It has been estimated that the above area could produce about 30000 tonnes of seeds during a normal year. About 10 per cent of it would be used for raising planting materials in the estates and smallholdings. Rubber seed oil can be used for making soap. As semi-drying oil, it can be used as a substitute for linseed oil in the manufacture of paints. Rubber seed oil, in suitable treatment with sulphur, produces a material known as factice, which could be used in rubber compounds.

Key words : Rubber seed; Rubber seed oil; Seed utilization; By-products; India

## 18 By-products and ancillary sources of income

George, K Tharian; Reghu, C P and Nehru, C R

*In: Natural Rubber: Agromanagement and Crop Processing.* (Eds. P J George and C Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, 2000, pp. 507-520.

The growing commercial exploitation of inter-crops, by-products and process wastes in rubber plantations since 1980s brings out the attempts to maximise net income from NR

cultivation. Theses attempts assume importance in the backdrop of the emerging trends in the NR sector characterised by an escalation in the prices of material inputs, instability in prices and erosion of relative profit margins. Apart from the economic benefits of establishment of cover crops and inter-crops during the immature phase, the three by-products, viz., rubber seed, rubber honey and rubber wood form the major sources of ancillary income in the mature phase of rubber plantations. In India, a preliminary attempt at the commercial exploitation of rubber seed was initiated by the Khadi and Village Industries Commission (KVIC) as early as late 1960's. The two major products processed from rubber seed are rubber seed oil and rubber seed cakes. The weight of rubber seed varies from 3 to 5 g., of which about 40 per cent is kernel, 35 per cent shell, 25 per cent moisture. The oil content in dried kernel ranges from 35 to 38 per cent and the recovery rate of seed cake is in the range of 57-62 per cent. In India, rubber seed collection remains as an unorganised activity and the commercial exploitation by the planters is not up to the desired extent. The major contributing factors are low prices of seed in the market and difficulties in storage. The three major factors adversely affecting seed production are powdery mildew disease, abnormal leaf fall disease and severe rainfall. Seed production season in India falls between July and September and the estimated seed production potential is about 150 kg per ha. The production of rubber seed oil and cake for 1997-98 was 2890 and 4710 tonnes respectively. Although 85 per cent of the area under rubber cultivation in India is in Kerala, the rubber seed processing industry is concentrated in the Virudhunagar district of Tamil Nadu. Mainly due to the favourable weather condition and availability of unutilised capacity in the groundnut oil processing industry. The current industrial use of the seed oil is confined to soap manufacturing industry. Rubber seed cake is rich in protein and has been evaluated as a source for cattle and poultry feeds. In India, 50% of the seed cake is reported to be used by the cattle and poultry feed manufacturing industries while the remaining is directly used without blending or mixing.

Key words: Rubber seed; Rubber seed oil; By-products; Commercial use; India

## 9 By-products of estate crops- processing and utilization: A review

Prasad, N B L and Azeemoddin, G

The existing scientific literature on collection, storage behaviour, processing techniques and effective utilisation of three by-products of plantations in India, viz., rubber seeds, tea seeds and coffee grounds is reviewed. These are not only good sources of vegetable oil/fat but the extracted meal can be used as manures, animal feeds and soil conditioners. The review concluded that the commercial exploitation of rubber seeds and tea seeds available in plantations and coffee grounds available in the soluble/instant coffee processing industry in India insignificant against the potential. The study highlighted the dire need to conduct systematic surveys on the availability and utilisation of these by-products.

Key words: Rubber seed; Tea seed; Coffee grounds; Seed utilization; India

20 **Carbohydrates of the seeds of the rubber tree, *Hevea brasiliensis***
Anderson, D M W; Greenwood, C T and Robertson, J S M

*Journal of the Chemical Society*, 1957. 401-405.

The carbohydrate materials present in the endosperm, cotyledons, and shell of the seeds of the rubber tree, *Hevea brasiliensis*, have been examined by means of a graded extraction procedure, and the results of chromatographic and other analyses of the fractions so obtained are reported. The endosperm, cotyledons, and shells all contain a mixture of polysaccharides which gave on hydrolysis galactose, glucose, arabinose, xylose, rhamnose, and uronic acid units. (The percentages of these residues were 4, 60, 20, 8, 2, and 6, respectively for the endosperm; 5, 56, 22, 7, 3 and 7, respectively for the cotyledons; and 4, 11, 1, 80, trace, and 4, respectively for the shells). The cold-water extract of the endosperm has been studied in detail and an araban-rich fraction isolated.

Key words: *Hevea brasiliensis*; Seed shells; Carbohydrates; Extraction

21 **The cell wall structure and the industrial utilization of the oil of the rubber seed for paint manufacture**
Njoku, O U

Ph.D. Thesis, Dept. of Biochemistry, University of Nigeria, Nsukka, 1994, 195 p.
(Cited by Njoku, Obioma U and Ononogbu, Ikpendu C., 1995)

Key words: Rubber seed oil; Cell wall structure; Industrial use; Paint; Nigeria

22 **Changes in cyanogenic glucoside content in seeds and seedlings of *Hevea* species**
Selmar, D; Lieberei, R; Junqueira, N and Biehl, B

*Phytochemistry*, 30(7): 1991. 2135-2140.

The content of cyanogenic glucosides was determined in seeds of *Hevea brasiliensis* (cultivars FX 25 and IAN 873), *H. pauciflora*, *H. benthamiana* and *H. camargoana* collected in Brazil. Large amounts of the monoglucoside linamarin were detected in all seeds tested but lotaustralin, which occurred in much lower concentrations, did not occur in every individual seed. After storage (at 27°C and 50% RH) the diglucosides linustatin and neolinustatin were also detectable, implying that the 2 monoglycosides were glucosylated during aging. During germination and seedling development, the patterns of developmental changes in HCN-potential differed between the species and within the *H. brasiliensis* cultivars. In the "wild type" IAN 873 seedlings the HCN-potential fell to less than 15% of the initial content whereas it remained nearly constant in FX 25 seedlings. In the other *Hevea* species the potential first increased and then decreased. These changes depended on the conversion of cyanogenic glucosides to non-cyanogenic compounds and on *de novo* synthesis of cyanogens.

Key words: *Hevea*; Rubber seed; Seedlings; Cyanogens; Glycosides; Metabolism; Biochemistry

23 **Changes in germination, respiration rate and leachate conductivity during storage of *Hevea* seeds**
Normah, M N and Chin, H F

*Pertanika*, 14(1):1991. 1-6.

*Hevea* seeds were stored at the temperatures of 10, 22 and 27°C. After each month of storage, changes in percentage germination, respiration rate and leachate conductivity were observed. There was a decrease in percentage germination, seedling height, seedling dry weight, respiration rate and an increase in leachate conductivity as duration of storage increased. Loss of membrane integrity was suggested as one of the causes of deterioration of seeds during storage

Key words: Rubber seed; Seed storage; Moisture content; Germination; Respiration rate; Leachate conductivity; Malaysia

24 **Characteristics and some fatty acids of para rubber seed oil in Malaysia**
Suzuki, Y; Tatsu, L B; Saito H and Ohara, T

*Japanese Journal of Tropical Agriculture*, 21 (3-4): 1978. 201-205.

Key words: Rubber seed oil; Fatty acid; Malaysia

25 **Chemical analysis for possible sources of oils of forty-five species of oil-bearing seeds**
Padilla, S P and Soliven, F A

*Philippine Agriculturist*, 22: 1933. 408-415.
(RRIM Bibliography. No.10 Bibliography on Rubber seed oil)

Key words: Oil bearing seed; Rubber seed oil; Chemical composition

26 **Chemical and biological evaluation of rubber (*Hevea brasiliensis*) seed meal**
Nwokolo, E and Akpakunam, M

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 54-61.

Fresh, shelled rubber seed meal was solvent extracted for chemical characterisation of the ether extract. Routine tests included saponification number, iodine value, peroxide value and free fatty acid contents. For detection and quantification of component fatty acids, the ether extract fraction was acid hydrolysed (4 hours), extracted with chloroform and analysed in a Varian model 3700 Gas Chromatograph using a stationary phase of 20% Carbowax deactivated with 1% $H_3PO_4$. Proximate analysis of defatted rubber seed meal was followed by atomic absorption spectrophotometry to quantify component minerals.

From a short duration experiment involving feeding mineral-free reference diets as well as the test ingredients, availability of minerals in rubber seed meal was determined. Finally, defatted rubber seed meal was incorporated at levels of 10%, 15% and 20% into diets of three-week old broiler chicks for a 14 day feeding trial. A summary of the results of chemical and biological evaluation of rubber seed meal with reference to its suitability as a major protein source in poultry nutrition is provided.

Key words : Rubber seed meal; Chemical evaluation; Biological evaluation; Poultry diet; Amino acid; Fatty acid; Nutrition; Nigeria

27 **Chemical composition and nutritional value of para-rubber seed and its products for chickens**

Narahari, D and Kothandaraman, P

*Animal Feed Science and Technology*, 10: 1983/84. 257-267.

Para-rubber (*Hevea brasiliensis*) seed and its products were subjected to different methods of processing such as decortication, oil extraction, autoclaving and fermentation and assayed for their chemical composition and nutritional value. Pea nut oil meal and yellow maize were also assayed similarly for comparison. Decortication reduced the crude fibre content, with proportionate increases in other nutrients and energy value. Autoclaving and fermentation failed to improve the nutritional value of undecorticated rubber seed oil meal. Crude protein content of rubber seed and its products ranged from 11.5% in rubber seeds to 27.4% in commercial decorticated rubber seed oil meal. The oil content of the rubber seeds and kernels was 24.0 and 40.1% respectively. The available carbohydrate content of rubber seed and its products ranged from 6.3% in rubber seeds to 15.9% in commercial decorticated rubber seed oil meal; these values may be compared with the value of 59.0% for yellow maize. Both undecorticated and decorticated rubber seed oil meals appeared to be deficient in sulphur-containing amino acids and lysine. The gross protein value of undecorticated and decorticated rubber seed oil meals and peanut oil meal was estimated to be 43.6, 47.0 and 49.7, respectively. Both undecorticated and decorticated rubber seed oils were rich in oleic and stearic acids, but relatively poor in poly-unsaturated fatty acids, compared with peanut oil. Determined apparent ME (AME) values were (kcal/g dry matter): rubber seeds, 2.91; kernels,4.70; undecorticated rubber seed oil meal, 2.00; and decorticated rubber seed oil meal, 2.80. The true ME (TME) values were 3.24, 5.16, 2.22 and 3.00 kcal/g dry matter, respectively. In general, TME values were about 10% higher than the AME values.

Key words: Para rubber seed; Rubber seed meal; Rubber seed oil; Chemical composition; Nutrition; Broiler chicken; India

28 **Chemical composition and nutritive value of rubber seed cake**

Amrithkumar, M N and Sampath, S R

*Indian Journal of Dairy Science*, 32(1): 1979. 58-61.

A study was carried out to determine the chemical composition of rubber seed cake and to

evaluate its nutritional value. Five adult bullocks were selected and each of them was fed 3 Kg of rubber seed cake to meet their protein requirement and ragi straw, fed *ad lib*. The study was carried out for a period of 28 days and during the last seven days a metabolism trial was carried out. From the chemical composition, it is clear that there is scope for using rubber seed cake as a protein component of the diet. Effective processing can reduce the level of HCN concentration in the cake, thereby rendering it safe for feeding animals. The animals did not record any loss in weight. They ingested about 3 Kg of rubber seed cake/day/animal and the dry matter intake was 1.56 Kg/100 Kg body weight. The average digestibility coefficients of the nutrients and the nutritive value of rubber seed cake are also presented. The study indicated that rubber seed cake can replace coconut cake, linseed cake or cotton seed cake in the ration of dairy animals.

Key words: Rubber seed cake; Nutritive value; Chemical composition; Cattle feed; India

## 29 Clonal seed collection areas in Malaya and their improvement

*Planters' Bulletin*, No.32: 1957. 91-96.

Key words: Rubber seed; Seed collection; Malaya

## 30 The collection and utilisation of rubber seed in Ceylon

Nadarajah, M

*RRIC Bulletin*, 4(3&4): 1970. 23-32.

The status of the collection and utilisation of rubber seeds in Ceylon is accounted in detail. The methods of collection and processing of rubber seeds practised in Ceylon are accounted along with estimates of cost of collection and processing. The technical and practical problems connected to the using of rubber seed oil for soap, paint and alkyd resin manufacturing are highlighted. The use of rubber seed cake as an easily digestible cattle meal is explained and its properties as an organic manure are also brought to light. The major results of research projects conducted in Ceylon on rubber seed processing and enduses are reported.

Key words: Seed collection; Seed utilization; Nutrition; Decortication; Oil extraction; Poultry diet; Ceylon

## 31 Commercial evaluation of rubber wood and seed in India

Haridasan, V and Krishnankutty, P N

Kottayam, Rubber Board (Mimeographed), 1974, 3 p.

In this study the authors have attempted to estimate the potential and commercial uses of the by-products of natural rubber such as rubber wood and seed. At the felling stage of rubber tree the average girth varies between 100 and 110 centimetres at a height of 125 cm

from ground level and the stand per hectare is estimated as 184. Accordingly, the actual potential of rubber wood from one hectare of rubber plantation is 0.39 cubic metre of stump wood and 0.62 cubic metre of branch wood. The identified commercial uses of rubber wood are the manufacturing of furniture after treatment, making fibre boards and hard boards and paper ryon. Normally, mature rubber trees between 7-22 years of age produce seed. In the case of seed the actual potential is estimated as one Kg of rubber seed consists of 205 seed at an average weight of 4.87 gms. Assuming 350 trees per ha. after giving allowance for tree losses due to natural factors 150 Kg of seed can be procured. Rubber seed is mainly used for agricultural as well as industrial purposes. In the agricultural, it is used for nursery purpose while for industrial purpose it is processed as oil after crushing the decorticated and dried kernel. The oil so crushed is used for manufacturing of soap, alkyd resin, paint etc. The cake is used as manure and cattle/poultry feed.

Key words: Rubber seed; Rubber wood; Commercial evaluation; India

32 **Commercial exploitation of ancillary rubber products**
Joseph, Toms and George, K Tharian
*Economic and Political Weekly*, 29(8): 1994. 413-415.

With the International Rubber Agreement, the only existing commodity pact on the verge of collapse, the commercial exploitation of ancillary rubber products such as rubber wood, rubber seed and honey has assumed importance. This paper describes the case of natural rubber as a classic example of the vulnerability of the developing countries to price fluctuations in the world market. The response of the natural rubber production sector is examined from a policy angle. Although the response varies across countries, it is unique in capitalizing available opportunities for squeezing the unit cost of production and exploring potential outlets for increasing the net income per unit of area. Using examples from India and Malaysia, the commercialization of all three ancillary products of rubber, are described; greatest attention is paid to rubber wood since this occupies an important position in terms of its growing market potential and the basic characteristics as a renewable by-product of rubber plantations. The main uses of the by-products are detailed, ranging from safety matches and packing case manufacture to rubber seed oil and cake.

Key words: Rubber products; Rubber seed oil; Rubber industry; India

33 **Commercial possibilities of para rubber seed oil**
Eaton, B J
*Agricultural Bulletin of the Federated Malay States*, 7(2): 1919.73-78.

Key words: Rubber seed; Rubber seed oil; Rubber seed cake;Commercial application

34 **The commercial utilization of the seeds of para rubber tree (*Hevea brasiliensis*)**
*Bulletin of the Imperial Institute*, 1: 1903. 156-159.
(RRIM Bibliography No.10 Bibliography on Rubber seed oil)

Key words: *Hevea brasiliensis*; Rubber seed; Commercial application

35 **The commercial utilization of the seeds of the para rubber tree (*Hevea brasiliensis*)**
*Bulletin of the Imperial Institute*, 2 (March): 1904. 22-23.

Key words: *Hevea brasiliensis*; Rubber seed; Commercial application

36 **Comparative utilization of rubber seed oil and palm oil by broilers in a humid tropical environment**
Fajimi, A O; Babatunde, G M; Ogunlana, F F and Oyejide, A
*Animal Feed Science and Technology*, 43(3-4): 1993. 177-188.
(AGRIS. 1993-1994)

Key words: Rubber seed oil; Palm oil; Feed intake; Broiler chicken; Weight gain; Humid tropics

37 **A comparison of the stability of oils from Brazil nut, para rubber and passion fruit seeds**
Assuncao, F P; Bentes, M H S and Serruya, H
*Journal of the American Oil Chemists' Society*, 61(6): 1984. 1031-1036.

The oxidation at 46°C of oils from Brazil nut, *Bertholletia excelsa* H.B.K-Lecythidaceae (BNO), and from seeds of para rubber, *Hevea brasiliensis*-Euphorbiaceae (PRO), and passion fruit, *Passiflora edulis- f. flavicarpa*-Passifloraceae (PFO), was followed over 115 days through the measurement of peroxide, acidity values, refractive indices, combustion energies and infrared (IR) spectra. The addition of 3 ppm $Cu^{2+}$ to PFO oil shortened the induction period by 12%. The oxidation of BNO and PRO exhibited first order kinetics in the production of hydroperoxide ($RO_2H$), up to the maximum values of the concentration of $RO_2H$. On the other hand, the oxidation of PFO and PFO + $Cu^{2+}$ displayed first-order kinetics at higher concentrations of $RO_2H$ and possibly half-order kinetics at low hydroperoxide concentrations in the first 15 days. Therefore, the 3 oils studied and PFO + $Cu^{2+}$ did not show the same stability pattern over the 115 days of the experiment. The application of kinetic data, a side from the other parameters, allows the definition of 2 different stability patterns. From 0-15 days the oxidation rates led to the following order of stability: PFO + $Cu^{2+}$ < PFO < BNO < PRO. From the 15th day to the end of the period corresponding to the maximum concentration; Ceylon of $RO_2H$, the rate constants

led to the pattern: PFO + $Cu^{2+}$ < BNO < PFO < PRO. Considering the whole period of the experiment, the changes in viscosity and the values of the induction periods point toward the first-mentioned stability pattern, demonstrating that without kinetic data these 2 parameters are insufficient to determine such patterns.

Key words: Rubber seed; Rubber seed oil; Brazil nut; Oil stability; Oil oxidation; Brazil

38 **Composition of para-rubber-seed oil**
Pickles, Samuel S and Hayworth, William P
*Analyst*, 36:1911.491-492.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed oil; Chemical composition

39 **Composition of para-rubber-seed-oil**
Tuason, Angelita M and Cruz, Aurelio O
*The Philippine Journal of Science*, 82(4):1953. 341-344.

On the composition of para-rubber seeds, expressed from Philippine plants, it consists principally of the glycerides of linolenic, linoleic, oleic and saturated acids and is very similar in composition to the rubber-seed oil from plants grown in Sumatra. It has twice the linolenic glyceride content but a higher percentage of saturated glycerides, compared with Philippine lumbang oil (from *Aleurites moluccana*).The oil belongs to the same class as linseed oil and has drying properties.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed oil; Rubber seed kernel; Chemical composition; Philippines

40 **Conservation of the germination power of *Hevea brasiliensis* seeds**
Mian, K
*Revue Generale des Caoutchoucs et Plastiques*, 61 (651): 1985. 73-77.

Key words: Seed storage; Germination; Ivory coast

41 **Content and availability of nutrients in rubber seed meal**
Nwokolo, Emmanuel and Akpapunam, Maurice
*Tropical Science*, 26:1986.83-88.

(AGRICOLA. 1984-12/91)

Key words: Rubber seed; Rubber seed meal; Nutritive value

42 **Current work at the University of Liverpool on potential sources of drying oils**
Hilditch, T P

*Paint Technology*, 13(154):1948. 398-400.

Key words: Rubber seed; Rubber seed oil; Drying

43 **The cyanogenic glucosides and glucosidases of rubber seed kernel**
Mallika, G V; Jansz, E R; Pieris, Nirmala M and Abeyasekara, A M

*Journal of the National Science Council of Sri Lanka*, 19(2): 1991. 99-106.

This study indicates that small amounts of lotaustralin are also present. Behaviour of linamarase (EC 3.2.1.21) from rubber seed kernel indicated the presence of multiple enzymes similar to that of the linamarases of manioc rind. The pH optimum and activation energy of the enzyme was found to be approximately 6.2 (with a shoulder at 5.4) and 10.1-10.3 Kcal, mole$^{-1}$ respectively. Activity appeared to decline on dilution.

Key words: *Hevea brasiliensis*; Rubber seed kernel; Cyanogenic glucoside; Linamarase; Sri Lanka

44 **Danger of hydrocyanic acid content of *Hevea* seed products used for fodder**
Bredemann, G

*Tropenpflanzer*, 34: 1931. 249.

(RRIM Bibliography. No.10 Bibliography on Rubber seed oil)

Key words: *Hevea*; Rubber seed products; Hydrocyanic acid; Fodder

45 **Developmental anatomy of germinating seed of *Hevea***
Premakumari, D and Sobhana, P

*Indian Journal of Natural Rubber Research*, 8(1): 1995. 8-12.

Developmental aspects of germinating embryo of *Hevea* were studied with emphasis to the growth changes at the pre-emergence stage. The shoot pole of the mature embryo is a dome shaped meristem consisting of a unilayered protoderm, a hypodermal region, the procambium and ground meristem. Prolaticifer initials are distributed in all the three zones below the protoderm and in the cotyledons. The root pole is blunt and undifferentiated. Vascular differentiation is basipetal in the shoot axis starting with laticifer differentiation followed by sieve tube and xylem formation in the order. Primary laticifers are articulated and anastomosing. Root differentiation is irregular. Lateral root development advances before the initiation of tap root development.

Key words: *Hevea brasiliensis*; Rubber seed; Germination; Laticifer; India

46 **The development of a rubber seed processing technology for the production of vegetable oil and animal feed: Phase 1. Literature review, field studies, laboratory tests and product and process development perspectives**

Vogt, H F T and Todt, K H

Project Report No, US/GLO/81/103, UNIDO, Vienna, 1987, 172 p.
(http://www.unido.org/data/ida/016271.cfm)

Expert report on processing of rubber oilseeds (*Hevea brasiliensis*) for the production of vegetable oils and animal feed-covers (1) information gathered from literature (2) field study in Sri Lanka (3) laboratory research and testing with special reference to (a) rubber seed oil (b) filtering of such oil (c) composition of rubber seed meal.

Key words: Rubber seed; Seed processing; Oil seed plant; Vegetable oil; Animal feed; Sri Lanka

47 **Development of a rubber seed processing technology for the production of vegetable oil and animal feed: Phase I. Final report**

UNIDO, Project Report No,US/GLO/81/103, Vienna, 1986.
(http://www.unido.org/data/ida/016006.cfm)

Final report on vegetable oils and animal feed production based on processing of rubber oilseeds- (1) surveys relevant literature and documentation (2) presents a field study from Sri Lanka considering technical and economic aspects of producing rubber seed oil and cake (3) covers laboratory research and testing, with attention to: separation and refining; chemical analysis; quality control; storage; oil filtering; composition of rubber seed meal (4) proposed pilot plant trials.

Key words: Rubber seed; Seed processing; Rubber seed oil; Vegetable oil; Animal feed; Feed production; Oil seed plant; Sri Lanka

48 **Development of local raw materials for the rubber industry**

Rajapakse, R A

*Journal of the National Science Council of Sri Lanka*, 6(2): 1978. 129-135.

This paper describes the possibility of developing rubber compounding ingredients such as anti-oxidants, stearic acid, resins, reinforcing fillers and accelerators from locally available materials such as cashew nut shell liquid, rubber seed oil, paddy hull ash, lignin etc. Since rubber seed oil contains a higher proportion of unsaturated higher fatty acids, hydrogenation of the fatty acids from rubber seed oil is expected to yield about 80% of stearic acid.

Key words: Rubber seed; Rubber seed oil; Raw materials; Paddy hull ash; Clay; Sri Lanka

## 49 Development of non-edible oils for use in the Nigerian surface coating industry with particular reference to rubber (*Hevea brasiliensis*) seed oil for manufacture of air drying oil modified alkyds

Adefarati, F B

*In: Industrial Utilization of Natural Rubber (Hevea braziliensis) Seed, Latex and Wood: Proceedings of National Conference.*(Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 27-38.

The utilization of edible oils for industrial purposes should be discontinued and discouraged in Nigeria for two obvious and important reasons: (i) Short supplies leading to competition with food (ii) Scarce foreign exchange to import these oils. There is, therefore, urgent need to investigate and develop available non-edible oils for use in the manufacture of alkyd resins. Rubber seed oil has been reported to have as its constituents, 30-35% of linoleic acid and 21-24% of linolenic acid, giving a property similar to a semi-drying oil such as soyabean oil. Rubber seed oil, when alkali refined, could therefore be used in the preparation of air-drying oil modified alkyd. Air-drying alkyds occupy an important place in the paint industry and the demand is estimated at about 16, 000 tons (50% solid resin) of which approximately 2,500 tons of vegetable oil would be needed for the poly-condensation reaction. Rubber seed oil could, therefore, be adopted as a total or partial replacement for the currently used traditional edible oils such as soyabean oil or linseed oil in this industry. Another indigenous oil is tobacco seed oil derived from the seeds of *Nicotiana tabacum*, which has the required properties of semi-drying oils and is available locally in massive quantities. The potential of this oil should also be investigated and developed.

Key words: Rubber seed; Rubber seed oil; Surface coatings; Alkyd resin; Non edible oil; Vegetable oil; Blend; Nigeria

## 50 Development of rubber seed oil and damar resin based paints

UNIDO Project DP/VIE/86/040

(http://www.unido.org/Data/Project/Project.cfm?c=1111)

Project responds to urgent need based on: Importance of anti-corrosive paints development using indigenous materials; Necessity to enlarge utilization of rubber seed oil and damar resin for local manufacture of high performance products to substitute import and to promote through this natural rubber cultivation. The large number of users of the paints in public and private sectors e.g. in ship and boat construction and repairing, food processing machinery and equipment, building construction etc. Project responds to this need through establishment of institutional and laboratory capacity for rubber seed oil and damar resin investigation as basic materials for further paints development.

Key words: Rubber seed oil; Paint; Anti-corrosion

51 **Dietary utilization of rubber seed oil by growing chicks**
Nwokolo, E and Sim, J

*Tropical Science*, 28(3): 1988.147-152.

Key words: Rubber seed; Rubber seed oil; Fatty acid; Waste utilization; Broiler chicken; Growth rate; Feed evaluation

52 **Digestibility experiments with sheep: Para rubber seed cake**
Auld, S J M

*Journal of Agricultural Science*, 5: 1912-13. 429-433.
(Cited by Selle, Celia Margarita, *et al.*, 1983)

Key words: Rubber seed; Rubber seed cake; Digestibility

53 **Digestibility studies in growing pig fed diets based on Cambodian rubber seed and soybeans supplemented with water spinach *ad libitum***
Pech Sovanno; Ly, J; Pok Samkol and Preston, T R

(http://www.utafoundation.org/utacambod/msc99thes/sovapaper2.htm)

A digestibility trial was conducted on the experimental farm at the University of Tropical Agriculture (UTA), Phnom Penh, to evaluate the nutritive value of diets composed of either Cambodian full-fat rubber (*Hevea brasiliensis*) seed meal or full-fat extruded soybeans using 16 Mong Cai Large White pigs. Rubber seeds of unknown falling day and storage period, and soybeans were used as sources of protein and oil in this study, with meal from dried cassava roots, cultivated on the red soil from Kampong Cham province, as carbohydrate source. Fresh water spinach (*Ipomoea acuatica*) was given *ad libitum* as a supplementary protein-rich forage. A 2 x 2 x 2 factorial arrangement was used to study the effect of protein/oil source (full-fat rubber seed meal or full-fat soybean meal). DL-methionine supplementation (0 or 0.3%) and animal live weight (40 or 60 kg). Average crude protein content of the rations as fed was 13.1±1.05% in dry basis and voluntary intake of water spinach was 22.3±2.6 and 16.2±1.4% of the daily dry matter intake for animals of 40 and 60 kg live weight, respectively. There was no significant interaction ($P>0.05$) amongst any of the factors for digestibility indices. There was no significant influence of animal live weight on any of the digestibility coefficients. The diet with full-fat rubber seed meal had a lower DM and organic matter digestibility, compared with the soybean diet, but there was no oil seed source effect on N digestibility, which was always low. Digestibility indices appeared to be higher for diets supplemented with DL-methionine, but this effect only tended to be significant ($P<0.10$) for organic matter digestibility. The high crude fibre proportion in rations containing full-fat rubber seed meal (on average 24.8% in dry basis) had a highly significant ($P<0.001$), negative influence in digestibility of DM and organic matter ($R^2$ 0.73 and 0.75, respectively) but there was no influence of dietary crude fibre on N digestibility. It is concluded that a sensible decrease in dry matter digestibility does not necessarily imply a decrease in energy availability to the animals due to the high crude fat content of these same diets (on average 12.5 ± 0.74% in dry basis). It could be suggested

that little if any N is linked to the cell walls in rubber seed since in this experiment full-fat rubber seeds accounted for approximately 34% of the rations.

Key words: Rubber seed; Rubber seed cake; Full-fat rubber seed; Water spinach; Digestibility; Nitrogen; Organic matter; Cambodia

54 **Distribution of selected clonal seed by the Indian Rubber Board during 1950**
Cherian, P P

*The Indian Rubber Board Bulletin*, 1(1): 1951. 3-7.

Key words: Rubber seed; Seed collection; Seedling nurseries; India

55 **The economics of extracting *Hevea* seed oil**
Wilbaux, R

*Bulletin Agricole du Congo Belge*, 39:1948. 601-608.
(Horticultural Abstracts, 18: 1948. 3083)

Key words: *Hevea brasiliensis*; Rubber seed oil; Oil extraction

56 **Effect of feeding rubber seed cake on the growth of kankrej calves**
Pande, M B; Talpada, P M; Patel, B H and Shukla, P C

*Indian Journal of Dairy Science*, 32(3): 1979. 280-282.
(AGRICOLA. 1979-1984)

Key words: Rubber seed cake; Feed composition; Growth; Calves; Digestibility; India

57 **Effect of feeding rubber seed cake to growing calves on dry matter and nutrients utilization**
Talpada, P M; Pande, M B; Patel, B H and Shukla, P C

*Gujarat Agricultural University Research Journal*, 5(2): 1980. 40-43.

The attempt was made to study the nutrients utilization by growing animals fed a ration containing 0,15 and 30 per cent level of rubber seed cake in the concentrate mixture. For this a metabolism trial was conducted on male Kankrej calves. The results on per cent dry matter consumption indicated 2.34 to 2.39 kg/day/100 kg body weight showing thereby that animals consumed sufficient amount of ration containing rubber seed cake. The digestibility of most of the proximate nutrients did not show marked difference between the treatments. The balance data revealed that nitrogen retention decreased with increasing levels of rubber seed cake in the ration. However, the differences were found to be non significant. The phosphorous balance was positive under all the treatments. Similarly the calcium retention was positive under all the treatments and showed reverse trend than that of nitrogen retention, but the differences were not significant. Thus overall result of

rubber seed cake feeding indicate that there was no adverse effect on digestibility and balance. Hence, it was concluded that rubber seed cake can be incorporated in the concentrate mixture of growing calves upto 30% level.

Key words: Rubber seed; Rubber seed cake; Feed composition; Digestibility; Growth; Calves

58 **Effect of feeding rubber seed meal- based diets on performance and serum thiocyanate level of growing-finishing pigs Duroc**
Ong, H K and Radem, J
*MARDI Research Bulletin*, 9(1): 1981. 78-82.
(AGRICOLA. 1979-1984)

Key words: Rubber seed meal; Pig diet; Serum thiocyanate; Malaysia

59 **Effect of fermentation of seed on the chemical properties and fatty acid profile of rubber seed oil**
Ugwuanyi, J Obeta and Njoku, Obioma U
*Indian Journal of Natural Rubber Research*, 9(2): 1996. 75-81.

Rubber (*Hevea brasiliensis*) seeds were boiled and fermented with mixed culture and pure culture of *Bacillus licheniformis*. Following fermentation, saponification value of the oil increased while its iodine value, acid value and unsaponifiable matter decreased; per cent yield of total lipid decreased while cyanide was undetectable. Percentage content of palmitic, stearic and oleic acids increased while that of linoleic and linolenic acids decreased. Behenic and myristic acids were undetectable after fermentation. The implication of these fermentative modifications for the improvement of rubber seed and its oil for human consumption, agricultural and industrial use are discussed.

Key words: Rubber seed oil; Chemical composition; Fatty acid; Fermentation; *Hevea brasiliensis*; *Bacillus licheniformis*; Nigeria

60 **Effect of fungicide treatment and storage conditions on the quality of *Hevea* seeds**
Silvio Moure Cicero; Julio Marcos Filho and Francisco Ferraz de Toledo
*Anais da E.S.A "Luiz de Queiroz"* XLIII: 1980. 763-785.

*Hevea* seeds are usually gathered in the state of Sao Paulo from February till March/April; the months that follow are typically colder and drier, therefore inadequate for nursery plants. It is then desirable to store the seeds until September/October. The viability of *Hevea* seeds decreases rapidly with time when stored under natural conditions. This paper reports the results of a trial in which a fungicide treatment and three storage conditions

were applied to *Hevea* seeds with the purpose of observing their quality after pre-determined periods. Two experiments were carried out utilizing seeds collected in plantations in the 1983 and 1984. Germination tests, average height average green and dry weights of the plants were determined at four dates in 1983 and five in 1984. These datas were set at intervals of two months. Benlate and Captan fungicides were found to be inadequate as *Hevea* seeds treatment. Seeds of good physiological quality with moisture content over 30% could be stored for a period of six months under standard conditions.

Key words: *Hevea*; Rubber seed; Seed storage; Fungicide treatment; Seed quality; Brazil

61 **Effect of gamma rays on rubber seed germination, seedling growth and morphology**
Markose, V C; Panikkar, A O N; Annamma, Y and Bhaskaran Nair, V K

*Journal of the Rubber Research Institute of Sri Lanka*, 54: 1977. 50-64.

Key words: *Hevea brasiliensis*; Rubber seed; Seed germination; Gamma rays; Seedling vigour; Root development; India

62 **The effect of method of seed sowing on percentage germination and growth of seedlings**
Seneviratne, P; Zoysa, L and de Alwis, M N

*Bulletin of the Rubber Research Institute of Sri Lanka*, 42: 2000.49-55.

Key words: Rubber seed; Seed sowing; Seed germination; Growth; Sri Lanka

63 **The effect of moisture content and particle size on physical properties of local feedstuff: Angle of response floating rate and higroscopic factors**
Khalil

*Media Peternakan*, 22(1): 1999. 33-42. (AGRIS. 1999-2002/06)

The objectives of the experiment were to measure three physical properties (angle of response, floating rate, and hygroscopic factor) of local feedstuff and to study the effect of moisture content and particle size on the physical properties. Twenty five kinds of feedstuff which were divided in 5 groups according to their nutritional function in the animal diet and obtained from local producers or market were used as samples in the experiment. The feed samples of about 27 kg each were prepared by grinding into 3 different particle size, i.e. normal, medium, (screen: 3 mm) and small (1 mm). The particle size was not changed for the meal-form feedstuff. The feed of each particle size were then subdivided into 3 groups and their moisture content was adjusted into 3 different levels, i.e. normal, high (2 percent higher than the normal) and low (2 percent lower than the normal). After that, the physical properties were measured for 3 times as replications. The data were statistically analyzed by using variance analysis in a completely randomized factorial design. The mean value were then compared by using least significant different (P lower than 0.05). The

results of the experiment showed that energy feed sources in the normal form had the lowest mean value of angle of response (20.2 degree) with the highest coefficient of variation (cv) (76.7 percent). The highest mean value of angle of response was on the contrary found in forages and roughages (37-57 degree) with the cv value of 20.5 percent. Some energy and plant protein feed sources (rice brand, cassava pulp, coconut meal, rubber seed meal and kapok seed meal) had high value of hygroscopic moisture content and particle size. In general, the value of angle of response, floating rate and hygroscopic factor increased significantly, when the moisture content and particle size of the feedstuff were reduced.

Key words: Rubber seed; Rubber seed meal; Hygroscopic factor; Moisture content; Mineral nutrition; Indonesia

64 **Effect of para rubber seed meal on the performance of growing pig (15-20 kg.) (Large White)**

Siriwathananukul, Yuthana

Thesis, M.S. in Agriculture, Kasetsart University, Bangkok, Thailand, 1982, 104 p.
(AGRIS. 1981-1985)

Key words: *Hevea brasiliensis*; Rubber seed meal; Digestibility; Feed meals; Growth; Pig diet; Thailand

65 **Effect of para rubber-seed meal on the performance of sow in gestating and lactating period**

Phadungsak-Chino; Nam-Sirisathian and Uthai-Kanto

Research Report, Dept. of Livestock Development, National Swine Research and Training Center, Bangkok, Thailand, 1982, pp.19-27.
(AGRIS. 1993-1994)

Key words: *Hevea brasiliensis*; Rubber seed meal; Oil seed cakes; Animal feed; Growth rate; Thailand

66 **The effect of processing on the nutritional value of rubber seed oil meal for layers**

Narahari, D; Venugopal, K; Venkataramanujam,V and Kothandaraman, P

*Indian Journal of Poultry Science*, 21(3): 1986. 208-214.

White leghorn layers were fed diets containing undecorticated rubber seed oil meal (URSOM), autoclaved undecorticated rubber seed oil meal (AURSOM), and fermented undecorticated rubber seed oil meal (FURSOM) at 0,15 and 30% levels and decorticated rubber seed oil meal (DRSOM) at 10 and 20% levels from 20-40 weeks of age. The performance of control layers, in terms of weight gain, egg production, feed efficiency and net feed efficiency index was superior as compared to other dietary treatments; except the 10% DRSOM group, which recorded more or less comparable values to that of control.

Higher levels (20 and 30%) of inclusion of DRSOM, URSOM, AURSOM and FURSOM had resulted in poor laying house performance. While the production performance of 15% URSOM, AURSOM and FURSOM treatments were intermediate. Mortality, egg quality, performance efficiency index and the feed cost per dozen eggs did not reveal any definite pattern, based on the dietary treatments. Autoclaving and fermentation had failed to improve the nutritional value of URSOM in layers.

Key words: Rubber seed oil; Rubber seed meal; Growth; Nutrition; White leghorn layers; India

## 67 Effect of replacing cottonseed-cake by rubber seed-cake in concentrate mixture of cows on yield and composition of milk

Amrithkumar, M N; Sundareshan, K and Sampath, S R

*Indian Journal of Animal Sciences*, 55(12): 1985. 1064-1070.

The effect of replacing 20% of cottonseed-cake by that of rubber seedcake in the concentrate mixture of 8 Jersey x Tharparkar cows on its milk yield and composition was studied. The cows were fed fodder maize (*Zea mays*) and concentrate mixture to meet their requirement of maintenance and production. There was no significant difference in their DMI, DCPI and TDNI/unit metabolic weight. The DCP and TDN contents of the ration fed to control group were 8.09 and 63.39%, while in experimental group these were 9.12 and 61.4% respectively. Average milk yields in cows of control and experimental groups were 8.77 and 9.96 kg respectively. The ME utilized by the cows/kg FCM in control and experimental groups were 1.21 and 1.23 Meal respectively. The feed costs to produce 1 kg milk in control and experimental groups were Re 0.68 and Re 0.65 respectively. The study indicated that rubber seed-cake can safely replace cottonseed-cake in the concentrate mixture without affecting milk yield.

Key words: Rubber seed; Rubber seed cake; Cotton seed cake; Cattle feed; Milk production; Nutrition; Digestibility; India

## 68 Effect of rubber seed meal on hatchability of hens' eggs

Buvanendran, V

*Tropical Agriculturist*, 127: 1971. 111-115.

Rubber seed meal has been shown to be a satisfactory substitute for coconut cake in broiler and layer diets in Sri Lanka, up to 20-25% levels. The weight gained in broilers or the egg production in the case of layers was not significantly affected by using rubber seed meal at the above level. Fertility and hatchability are two major components of reproduction in poultry. The hatchability of eggs was compared from hens receiving different levels of rubber seed meal in their rations. Increasing levels of the meal in the maternal diets caused an increase in embryonic mortality. The study indicated that rubber seed meal in the

form it is manufactured depresses hatchability and hence is unsuitable for use in poultry breeder diets.

Key words: Rubber seed; Rubber seed meal; Hatchability; Hens'eggs; Broiler chicken; Sri Lanka

69 **The effect of seed season and parental age on the quality of high stump rubber seed**

Rotiq, M

*Jurnal Penelitian-Pertanian-Terapan (Indonesia)*, No.3: 1998. 23-27.

(AGRIS. 1999-2001/08)

Key words: *Hevea brasiliensis*; Rubber seed; Seed season; Parental age; Stumps; Seedlings; Indonesia

70 **Effect of storage of seeds on quality of rubber seed oil**

Aigbodion, A I

*Indian Journal of Natural Rubber Research*, 7(2): 1994. 141-143.

In this study efforts were made to determine the effect of seed storage on oil quality. Oil samples were extracted from rubber seeds which were dried and stored under ambient conditions for a period of one year and from fresh seeds of the same year after drying. Properties of the two oil samples and the fatty acid composition were determined. Results indicated that the quality of the oil extracted is affected by the storage of seeds.

Key words: Rubber seed; Rubber seed oil; Seed storage; Nigeria

71 **Effect of supplement synthetic amino acids in dehulled and alkali treated para rubber seed meal for early-weaning pig diets**

Jaruwat-Nutdechanun

Thesis, M.Sc. in Agriculture, Kasetsart University, Bangkok, Thailand, 1991, 51 p.

(AGRIS. 1995-1996)

Fifty barrows and fifty female (Landarce x Large white) pigs which were weaned at 4 weeks of age were divided into 5 groups (Treatments) with 5 replicates of 4 pigs each containing equal number of both sexes in randomized complete block design. The diets were: T1-A control diet, T2- Dehulled para rubber seed meal (D.R.M), T3-Alkali treated, D.R.M., T4-Supplemented with 0.30 percent lysine and 0.15 percent methionine, D.R.M and T5-Alkali treated and supplemented with 0.30 percent lysine and 0.15 percent methionine, D.R.M. The average daily gain (ADG) of T3 was statistically significantly ($P<0.05$) lower than that of the other treatments. The feed conversion ratio (FCR), of T1 was highly significantly ($P<0.01$) lower than most of the other treatments except that

of T4. The average daily feed intake (ADFI) of T2 was significantly ($P<0.05$) higher than T1 and T3. ADFI of T1 was significantly ($P<0.05$) lower than T2 and T4. ADFI of T3 was not significant difference in T1, T4 and T5 but lower than T2 ($p<0.05$). Whereas feed cost per weight gain was not statistically significant. Six barrows of the same breed with approximately 50 kilograms body weight were used to determine the digestibility of dehulled para rubber seed meal and alkali-treated, dehulled para rubber seed meal. The digestibility for dry matter and crude protein were 71.78 and 68.98 percent for D.R.M and 72.00 and 71.93 percent for alkali-treated. The diets containing 15 percent dehulled para rubber seed meal with supplement lysine and methionine had no effect on the performance of early-weaning pig.

Key words: *Hevea brasiliensis*; Rubber seed meal; Amino acid; Pig diet; Growth rate; Thailand

## 72 Effect of triacontanol application on germination and early growth of rubber seedlings

Sugondo, B

*Risalah-Penelitian-Pusat-Penelitian-Perkebunan-Getas (Indonesia)*, No.16: 1990. 9-22.
(AGRIS. 1/97-2/98)

An experiment about the influence of soaking length in Triacontanol solution on the germination and early growth of storage rubber seed was conducted at Getas RIEC in 1986. The objectives of this research are to know the influence of length of soaking and triacontanol concentration on the germination and early growth of storage rubber seeds. This research was implemented with the use of completed Randomized Block Design with factorial analysis which include two factors: length of soaking (H) and triacontanol concentration (P). These factors include four levels with three replications. The result of this research can be simplified as follows. 1. There is no interaction between length of soaking and triacontanol concentration on the seed germination and early growth of rubber seedling. 2. The triacontanol treatment at concentration 5; 7.5 and 10 ppm gave bad effect (delayed characteristic) on the germination and early growth of rubber seedling compared to control.

Key words: *Hevea brasiliensis*; Seedlings; Triacontanol; Germination; Growth; Soaking; Indonesia

## 73 Effects of different levels of rubber seed meal on weight and length of femur and tibia of broilers

Thawipon-Pralomkarn; Suraphon-Choldumrongkul and Sripongpun, Sirichai

*Songklanakarin Journal of Science and Technology*. 5(1):1983.13-17.
(AGRIS. 1981-1985)

Key words: Rubber seed meal; Animal feed; Growth; Broiler chicken; Thailand

74 **Effects of rubber seed meal on the performance of mature chicken**
Rajaguru, A S B

*RRISL Bulletin*, 8: 1973. 39-45.

Investigation on the effects of rubber seed meal (RSM) in maturity of pullets, egg production, egg size, shell quality, hatchability, livability of chicks hatched out and semen quality of the cocks were carried out. The pullets that were raised on 10%, 20%, 30% and 40% rubber seed meal in diets from the third month of age matured late, but the egg production was normal. However, the increase of rubber seed meal in diets lowered egg size, shell thickness, hatchability of incubated eggs and the weight of the chicks hatched out. It was also observed that the rubber seed meal increases the percentage of infertile eggs that were produced. The RSM had no effect on the quality of semen of the cocks used for artificial insemination. These effects may be due to an amino acid imbalance of RSM that lowers the biological value of proteins in diets and the presence of an antifertility factor which has not been identified yet. The results indicated that RSM should not be used in breeder rations. In layer rations, it could be used only up to 20% level.

Key words: Rubber seed; Rubber seed meal; Broiler chicken; Egg production; Sri Lanka

75 **Effect of using rubber seed meal on performance of quail (*Coturnix- coturnix japonica)***
Latif, S A; Jamarun, N and Yunitasri

*Jurnal Peternakan dan Lingkungan*, 5(2): 1999. 28-32.
(AGRIS. 1999-2001/08)

An experiment to determine the effect of using rubber seed meal on performance of quail (*Coturnix-coturnix japonica*) was conducted at Faculty of Animal Science, Andalas University. Two hundred head of quails age of one day (doq) was used until the age of 6 weeks to determine the growth rate of quail. Five rations were formulated as treatment those contain of rubber seed meal as A : 0, B : 1 percent, C : 3 percent and E : 4 percent in total rations. The treatments were arranged to have almost similar of crude protein and energy content. The data were calculated by completely randomized design in 5 treatments with 4 replications for each treatment. Each replication consist of 10 head of quails. The result of experiment showed that no significantly different (P more than 0.05) among the treatment means on feed consumption, growth rate, and feed conversion (efficiency), but the data showed that treatments with rubber seed meal indicated decrease for feed consumption and growth rate of quails compared to control.

Key words: *Hevea brasiliensis;* Rubber seed meal; Growth rate; Feed consumption; Nutritive value; Quails ration; Indonesia

76 **Effects of water storage on seed germination and seedling growth of rubber (*Hevea brasiliensis* Muell Arg.)**
Mercykutty, V C; Premakumari, D; Thomas, Vinoth and Saraswathyamma, C K

*The Planter*, 72: 1996. 367-373.

Fresh rubber seeds stored under ambient conditions in water gave 45 per cent germination

even after 20 days as compared to zero germination of seeds stored under open air conditions. The water storage treatment was better than the open air storage for seed moisture content, germination percentage and all growth attributes except for number of lateral roots.

Key words: Rubber seed; Water storage; Germination; Moisture content; India

77 **The energy value for and nutritive value of para-rubber seed for rats**
Fetuga, B L; Essien, A I; Babatunde, G M and Oyenuga, V A
*Archives of Animal Nutrition*, 45(1): 1993. 71-78.
(AGRIS. 1995-1996)

Key words: *Hevea brasiliensis*; Rubber seed meal; Energy value; Digestibility; Nutritive value; Rat feed; Nigeria

78 **Epoxidation of rubber seed oil**
Vijayagopalan, K and Gopalakrishnan, K S
*Rubber Board Bulletin*, 11(2): 1971. 52-54.

Crude rubber seed oil was epoxidised to produce epoxidised rubber seed oil having an oxirane content of about 4.5%. Parameters such as ratio of acetic acid to oil, hydrogen peroxide to oil, time, temperature, catalyst type and concentration etc. were found to have a profound influence on the level of epoxidation. The authors reported that use of 0.5 mole ratio for acetic acid to oil, 1.5 mole ratio for hydrogen peroxide to oil, temperature in the range 60-65°C, sulphuric acid catalyst and reaction time of 14h were the ideal conditions for producing epoxidised rubber seed oil having an oxirane content of about 4.5%.

Key words: Rubber seed oil; Epoxidation; India

79 **Epoxidation of rubber seed oil**
Coomarasamy, A and Kandasamy, T
*Paper presented at 32nd annual SLASS Session*, Jan 1977. No. 10.
(Cited by Coomarasamy, A., 1977.)

Key words: Rubber seed oil; Epoxidation; Sri Lanka

80 **Epoxidation of rubber seed oil with performic acid**
Aigbodion, A I; Okieimen, F E; Bakare, I O and Abbey, C N
*Journal of the Rubber Research Institute of Sri Lanka*, 84:2001.18-24.

A study of the epoxidation of rubber seed oil with peroxyformic acid generated *in situ* by the reaction of 30% hydrogen peroxide with formic acid, was carried out at 303, 323,

333 and 343 K. Epoxidation of rubber seed oil by performic acid is favoured by increase in temperature forming a product of high oxirane content. Kinetic analysis of the data shows that rate of epoxidation increases with temperature and the value of the rate constant (k) is of the order of $10^{-5}$ L $mol^{-1}$ $s^{-1}$. The activation energy ($E_a$) and enthalpy ($\Delta H$) of activation were found to be 57.0 KJ $mol^{-1}$ and 54.3 KJ $mol^{-1}$ respectively. The kinetic data obtained from this study were compared with results from epoxidation of rubber seed oil with peracetic acid.

Key words: Rubber seed oil; Epoxidation; Performic acid; Oxirane; Kinetics; Nigeria

81 **Estimates of rubber (*Hevea brasiliensis*) seed production in Nigeria**
Nwankwo, B A; Aigbekaen, E O and Sagay, G A

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 78-87.

Estimates of annual seed production of *Hevea brasiliensis* in Nigeria carried out in 6 estates indicated a gross national total yield of 42,980,000 kg, of seed containing 13,929,818 kg of *Hevea* seed oil and 13,388,270 kg of seed cake. Clone PB 5/51 yielded 424.4 kg/ha in Nigeria compared with only 65.5 kg/ha previously reported for the same clone in Malaysia. Clonal differences in yield were considerably high. Better illuminated plots positioned on the periphery of the plantations gave significantly higher seed yield than those lying in the poorly illuminated interior. This signifies a potential for improved yield with more widely spaced planting.

Key words: Rubber seed; Seed production; Nigeria

82 **Estimation of dilute solution viscosity parameters of rubber seed oil alkyds**
Okieimen, F E and Aigbodion, A I

*IRRDB Symposium on the Technology and End uses of Natural Rubber,* 6 November 1996, Beruwela, Sri Lanka, pp.113-116.

Viscosity measurements were carried out in MEK and DMF for rubber seed oil alkyds having oil content of 20%(I), 30%(II), 35%(III), 40%(IV), 50%(V), and 60%(VI). Viscosity molecular weights, intrinsic viscosities and viscosity parameters, K and a characteristics for both polymers and solvents were determined. Generally, solubility properties were found to depend on the molecular weight and polarity of the alkyds and solvent. Intrinsic viscosities of the rubber seed oil alkyds were larger in DMF than in MEK suggesting DMF to be a better solvent than MEK for these. Molecular weights determined for the alkyds range from 441 for sample III to 1323 for sample V. The viscosity molecular weights are in reasonable agreement with the values determined for samples II-V in MEK and samples I-IV in DMF. The values of Huggin's constant for these alkyds were also determined. Data reported also suggests that rubber seed oil alkyds tend

to tolerate relatively basic solvents such as DMF. Fractionation of the alkyds was considered with respect to their molecular weight and polarity and results show that low molecular weight species constitute a greater proportion of the alkyds.

Key words: Rubber se5ed oil; Viscosity; Alkyd resin; Molecular weight; Nigeria

## 83 Evaluation of layer diet formulated from non-conventional feeding stuffs

Ravindran, V

*British Poultry Science*, 36(1): 1995. 165-170.
(AGRICOLA.)

A layer diet, the formulation of which was based on several non-conventional feeding stuffs, was evaluated at the research station and under small farm conditions in Sri Lanka. The new feeding stuffs included finger millet, rice polishings, rubber seed meal, cassava leaf meal, ipil ipil leaf meal and dried poultry manure. A commercial mash, that is normally used on the farm, served as the control. The performance and egg quality characteristics were similar between the test and control diets, the only exception being the egg yolk colour which was improved ($P<0.05$) by feeding the test diet. Food cost per dozen eggs was lowered by feeding the test diet. It is possible to formulate layer diets using non-conventional feeding stuffs, achieve acceptable production and lower the food costs under small farm conditions in tropical developing countries.

Key words: Rubber seed meal; Hen feeding; Poultry manure; Feed evaluation; Egg quality; Sri Lanka

## 84 Evaluation of rubber (*Hevea brasiliensis*) seed cake for promoting growth in calves

Viswanathan, T V; Ananthasubramaniam, C R and Menachery, Maggie

*The Indian Journal of Nutrition and Dietetics*, 16: 1979. 383-389.

An investigation spread over a period of six months was carried out to evaluate the feeding value of rubber seed cake using 24 Jersey x Sindhi calves of 8 to 14 months of age. The calves were divided and distributed under three dietary treatments $T_1$, $T_2$ and $T_3$ and were fed on concentrate mixtures containing 0, 15 and 30 per cent levels of RSC respectively replacing cotton seed cake in the ration. It was found that the ration containing RSC at 30 per cent ($T_3$) level promoted better weight gain, body size, digestibility of nutrients and feed efficiency when compared to treatments $T_1$ and $T_2$. All animals maintained proper health as evidenced by normal haematological values as well as nitrogen and mineral balances. It was also observed that the cost of concentrate feed was 14 per cent lower for kg body weight gain when RSC was incorporated at 30 per cent level in the concentrate mixture of growing calves. A critical evaluation of the overall results obtained during the present investigation indicated that RSC can be profitably incorporated at 30 per cent level in the concentrate mixture for growing calves.

Key words: *Hevea brasiliensis*; Rubber seed cake; Growth; Feed utilization; Calves; Body weight; India

85 **Evaluation of rubber nursery planting methods, by direct sowing in the field, without seed bed and transplanting**

Pereira, A V and Pereira, E B C

*Pesquisa Agropecuaria Brasileira*, 33(7): 1998. 1061-1065.
(Horticultural Abstracts, 69(3): 1999. 2592)

Field trials were carried out in April-May 1991 in Goias state, Brazil, to evaluate the direct sowing of *Hevea brasiliensis* seeds in the field. Seeds were sown in small planting holes or shallow furrows (4-5 cm deep) and were covered with a thin layer of soil or sawdust (4 treatment combinations). Controls were raised using the traditional method of a seed bed followed by transplanting. Treatments were compared in terms of the cumulative percentage of normal seedlings between 10 and 40 days after sowing and in terms of labour and materials costs. It was found that direct sowing in shallow furrows covered lightly with soil was technically and economically superior to the other methods (including traditional practice).

Key words: *Hevea brasiliensis*; Rubber seed; Planting material; Sowing; Brazil

86 **Evaluation of some chemical and nutritional characteristics of the rubber seed *Hevea brasiliensis***

Selle, Celia Margarita; Gonzalez de Mejia, Elvira; Elias, Luiz G and Bressani, Ricardo

*Archivos Latino Americanos De Nutrition*, 33(4): 1983. 884-901.

Some chemical and nutritional characteristics of the rubber seed *Hevea brasiliensis* were studied. The protein content, its amino acid composition as well as the iron, calcium, phosphorous and cyanide (free and bound) concentrations, were determined in the dehulled seed. The effect of soaking, cooking, soaking-cooking and cooking-fat extraction procedure of the seed on the cyanide content and its *in vivo* protein utilization, was also evaluated. The protein quality was biologically assessed using the protein efficiency ratio (PER). The protein content of the seed was 18%, and the most limiting amino acid was threonine, with a chemical score of 71.6. The iron, calcium and phosphorous contents were 6.2,109 and 429 mg/100g, respectively. Its fat content was 48% with a total energy value of 702 kcal/100g (2,948Kj/100g). The total cyanide content in the fresh seed was 130-230mg/100g; 6% was in the free form and 94% as bound cyanide. The most effective treatment for reducing the cyanide content was found to be 20 hours of soaking in water, combined with one hour of cooking. The raw seed had a low nutritive value and produced weight loss and death when fed to rats. The protein value, however, improved upon the seed treatment, reaching PER values close to those found in traditional cereals such as corn. It is therefore concluded that the seed of *Hevea brasiliensis* is a good source of energy, calcium, valine, isoleucine, phenylalanine and tyrosine. In contrast, it is poor source of theronine,

leucine and lysine. Its cyanide content is high, but when removed by treatment, such as soaking in water, cooking or fat extraction, the protein utilization can be improved.

Key words: *Hevea brasiliensis;* Rubber seed; Protein content; Nutritive value; Biological evaluation; Chemical composition; Rat feed; Guatemala

87 **Examination of hybrid rubber seed oil**
Badami, R C, *et al.*

*Journal of the Oil Technological Association*, 8: 1976. 37-38.
(Cited by Prasad, N B L and Azeemoddin, G.)

Key words: Rubber seed; Rubber seed oil

88 **Examination of rubber seed oil for use in coating compositions**
Aslam, M and Imam, H

*Pakistan Journal of Scientific and Industrial Research*, 1: 1958. 224- 227.

Key words: Rubber seed oil; Coating composition; Acid value; Varnishes; Pakistan

89 **Examination of the oils from *Manihot ceara* and *Funtumia elastica* and a comparison of their properties with those of linseed and *Hevea* oils**
Rideal, S and Acland, L H D

*Analyst*, 38:1913. 259-264.

Key words: *Hevea brasiliensis; Funtumia elastica;* Rubber seed oil; Linseed oil; Oil analysis

90 **Experiment on long term storage and long distance transportation of rubber seed**
Soewitooetomo, M S

*Second Technical Meeting on Estate Crops*, 15-17 Sept. 1981, Sukarta, Indonesia, pp. 16. (AGRIS. 1981-1985)

Key words: Rubber seed; Seed storage; Seed transport; Marketing

91 **The extraction of rubber seed oil by expeller and the characteristic of oil quality**
Santosa, Agus Mudji; Alfa, Ary Achyar; Silam and Panji, Chilwand

*Indonesian Rubber Conference and IRRDB Symposium*, 12-14 Sept. 2000, Bogor, Indonesia, pp. 43.

Indonesia has the largest rubber estate area in the world. According to Directorate General of Estate, total area in 1996 was 3, 534,581 ha, where the rubber seed production was predicted about 402, 370, 39 tons. Therefore, the potentiality of rubber seed production

in Indonesia is great. The rubber seed comprises about 50.74% hard shell and 49.26% kernel. The oil content of dried kernel (15% moisture) is 50.56%. Based on the highest yield and capacity expeller, the best treatment of this research was combination between of unheating and hulls addition 35%. This treatment resulted yield 36.04%, expeller capacity 6.82 kg/hr, expelling efficiency 79.10%, specific power 0.49 kWh/kg, residue oil in cake 15.73%, moisture content 0.09%, colour 6.00, transmittance 57.50%, acid value 9.92, FFA 4.91%, iodine value 139.55, peroxide value 9.93,saponification value 206.48 and production cost Rp5,162.01/kg.

Key words: Rubber seed oil; Oil extraction; Oil quality; Expeller; Oil content

92 Factice from oil of *Putranjiva roxburghii*

Nag, A; Chaki, T K and De, K B

*Journal of the American Oil Chemists' Society*, 72(3): 1995. 391-393.

(AGRICOLA.)

Key words: *Putranjiva roxburghii;* Rubber seed oil; Factice; Physico-chemical properties; India

93 Factice from rubber seed oil

Vijayagopalan, K

*Rubber Board Bulletin*, 11(2): 1971. 48-51.

In order to explore the possibilities of more and more commercial utilization of rubber seed oil, sulphur factice was prepared from crude rubber seed oil as well as blown rubber seed oil. Different proportions of sulphur was used and different temperatures were employed. Diethanolamine or M.B.T was tried as catalysts. With crude rubber seed oil 15-20 parts of sulphur may be employed, while for blown oil 15 parts was found to be suitable. In presence of diethanol amine a higher temperature may be preferred and a product with comparatively low free sulphur could be obtained. 5 phr and 10 phr of a typical product was incorporated into a tread typemix and the effect of factice loading on the cure characteristics and physical properties of the vulcanizates were evaluated. The properties were comparable to those of a commercial factice. The ageing characteristics of the vulcanizates were considerably improved by factice incorporation.

Key words: Rubber seed; Rubber seed oil; Factice; India

94 Feasibility of using rubber seeds as animal feed supplement

Eka, O U

*West African Journal of Biological and Applied Chemistry*, 19(2): 1976. 22-24.

(Abstracts on Tropical Agriculture, 3(2):1977.12888)

This investigation aimed at establishing whether rubber seeds can serve as feed or feed

supplement for animals, particularly chicken. Tables are presented showing proximate composition of rubber seed and of the standard feed, elemental composition of the rubber seed plus testa and of the standard feed, hydrocyanic acid content and the relative toxicity, average liveweight of chicks fed on different rations, and amino acid composition.

Key words: *Hevea brasiliensis*; Rubber seed; Energy feeds; Poultry husbandry; Broiler chicken; Nigeria

## 95 Feeding *Hevea* rubber seed meal for milk production

Ellett, Walter Beal

*Technical Bulletin, Virginia Agricultural Experiment Station*, No. 41, 1930, 12 p. (AGRICOLA. 1992-1997)

Key words: *Hevea brasiliensis;* Rubber seed meal; Dairy feeds; Cattle feed; Milk production; Virginia

## 96 Fungal species associated with the deterioration of rubber seeds and cake

Igeleke, C I and Ekpebor, S M C

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp.135-145.

Fungi associated with the deterioration of the rubber seeds were isolated using three methods viz: blotting paper, serial dilution and plating on agar medium. Seeds from the following rubber clones were studied: Tjir 1 x 16, RRIM 600, RRIM 605 and PR 107. The blotting paper method resulted in the isolation of fourteen fungal species while the serial dilution and plating on agar methods yielded six and eight species respectively. The predominant species consistently isolated from the four rubber clones were *Aspergillus fumigatus, A. flavus, A.niger, Penicillium sp., Colletotrichum sp., Helminthosporium sp., Fusarium sp.* and *Rhizopus sp.*, indicating lack of clonal variations in the fungal species associated with the different clones studied. The observed successional trend in the colonization of rubber seeds revealed *Helminthosporium sp., Collectotrichum sp.* and *Fusarium sp.* as the early colonizers, followed by the saprophytic moulds, mainly *Aspergillus spp.* and *Penicillium sp.* Using the serial dilution and plating on agar medium methods of isolation, the undefatted and defatted rubber seed cakes were also examined. The following three fungi were isolated: *Penicillium sp., Aspergillus flavus*, and *A. fumigatus*. More colonies were observed from the plating on agar method than the serial dilution method. *Aspergillus fumigatus, A.flavus, A.niger and Penicillium sp.* are known to have toxin-producing strains, making their presence in seed cake meant for livestock feeding trials dangerous. In addition, *A. flavus* and *A. niger* are lipolytic and therefore, have the ability to reduce the oil contents of seeds in

which they are present. Fungicidal seed treatments and drying of seeds before storage are suggested methods of controlling the deterioration of rubber seeds and cake during storage.

Key words: Rubber seed; Rubber seed cake; Rubber seed deterioration; Fungi isolation; Nigeria

97 **Fungi associated with biodeterioration of rubber seeds**
Okhuoya, J A and Ige, O

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 146-154.

In a fungal survey of rubber seeds from three selected rubber growing areas of Southern Nigeria, ten fungal species namely: *Aspergillus candidus, A. flavus, A.fumigatus, A. niger, A.ochraceous, A. tamarii, Drechslera hevea , Rhizopus stolonifer, Fusarium sp and Penicillium spp.* were isolated. *D. hevea* was most consistently encountered in the seeds. Isolates showed monthly variation. Seeds from Itaogbolu had the highest record of viability compared with those from Iyanomo and Akure throughout the sampling period. Viability correlated positively with moisture content. The factors reasonable for the positive correlation are discussed.

Key words: *Hevea brasiliensis*; Rubber seed; Biodeterioration; Fungi isolation; Nigeria

98 **Gossypol in rubber seed meal**
Abdullah, A S and Hutagalung, R I

*Pertanika*, 4(1): 1981. 96-98.

Key words: Rubber seed meal; Gossypol; Malaysia

99 **Growers to tap alternative sources**
*Rubber India*, 53(2): 2001. 47-48.

This paper discusses briefly the ancillary income available in India from existing rubber plantations from the by-products of rubber seeds, rubber honey and rubberwood. The estimated production of rubber seed, which can be used as a substitute for linseed oil in the manufacture of paints, is about 150 kg per hectare, the mature plantations have the potential to produce about 182 kg per hectare and the projected estimate of gross annual availability of rubberwood is 4.24 million cu m for 2010.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed oil; India

100 **Growth parameters and plasma-tissue fatty acid profiles of rats fed rubber seed oil**
Nwokolo, E N and Kitts, D D

*Food Chemistry*, 30(3):1988. 219-229.
(AGRICOLA.)

Key words: Rubber seed oil; Nutritive value; Growth rate; Blood plasma; Rat feed; Fatty acid

101 **Growth performance of cobb broilers given varying levels of rubber seed meal [Philippines]**
Salanga, L M; Olivo, C O and Aquino, R R

*Philippine Journal of Veterinary and Animal Sciences*,11(3-4):1985.31.
(AGRIS. 1986-1988)

Key words: Rubber seed; Rubber seed meal; Broiler chicken; Growth; Philippines

102 **Hammermill as a tool to unshell rubber seeds**
Hardjosuwito, Baryono and Hermansyah

*Menara Perkebunan*, 55(1): 1987.14-18.

To extract oil rubber seed kernels first of all dried rubber seed shells were crushed. Manual decortication consumed too much time and needed a high labour cost. A hammermill consisting of 72 hammers made of rubber with specific properties and a screen with 10 slits, wherein the size of each slit's aperture and the opening of feeder are respectively 2.0 x 21.0 cm and 3.0 x 21.0 cm, produced unshelled seeds with a fair quality and a good economic value. To improve the practical separation of kernels from rubber seed shells and unshelled seeds, a wire case sieve with an aperture of 1.1 x 1.1 cm and a total size of 35.0 x 85.0 cm had been utilized. This hammermill runned on a 1 hp electrical motor with a capacity of about 462 kg of rubber seeds per hour, and only 6.8% seeds were left unshelled.

Key words: Rubber seed; Rubber seed oil extraction; Hammermill; Indonesia

103 ***Hevea* (rubber) seeds for human food**
Wheeler, Louis Cutter

*RRISL Bulletin*, 13: 1978. 17-21.

Although the seeds of the rubber tree (*Hevea brasiliensis*) are poisonous, detoxification can be carried out at home without any special equipment, making available this food, relatively high in protein. Natural rubber is the 2nd most important export crop of Sri Lanka and it is estimated that more than 7000 tons of rubber seed meal can be produced annually, after the oil has been extracted. The way to remove the cyanic poison is described, also how it is done in Indonesia and in the Amazonian region. A study is planned in the USA

on the nutritional quality of the seeds and on the possible means of inactivating the toxins.

Key words: *Hevea*; Rubber seed; Human food; Nutrition

104 *Hevea* seed. Pt I.
Wycherley, P R

*The Planter*, 47 (544): 1971. 291-298.
(Horticultural Abstracts, 1972. 2577)

Key words: *Hevea brasiliensis*; Rubber seed; Seed production; Malaya

105 *Hevea* seed. Pt. II.
Wycherley, P R

*The Planter*, 47 (545): 1971. 345-350.

Key words: *Hevea brasiliensis*; Rubber seed; Seed fall; Clonal variation; Malaya

106 *Hevea* seed. Pt. III.
Wycherley, P R

*The Planter*, 47 (546): 1971. 405-410.

This part covers *Hevea* seed storage and processing. The revised mean estimate of number of seeds/kg is 205. The seeds deteriorate rapidly in storage, evolving HCN, unless sterilized and/or dried. The seed oil is a possible substitute for linseed oil, and the meal is nutritious. Under Malaysian conditions, however, the use of the seed for purposes other than planting is unlikely to be profitable.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed oil; Seed viability; Seed storage; Malaya

107 *Hevea* seed as feed supplement for sheep
*Warta Penelitian dan Pengembangan Pertanian* (*Indonesia*),14(2): 1992.10.
(AGRIS. 1993-1994)

Key words: *Hevea brasiliensis*; Rubber seed; Feed supplement; Chemical composition; Sheep feed; Indonesia

108 *Hevea* seed: Its characteristics, collection and germination
Husin, Sakhibun bin Mohd

*Planters' Bulletin*, 202: 1990. 3-8.

Key words: *Hevea brasiliensis*; Rubber seed; Seed collection; Seed germination; Seed fall; Malaya

## 109 Improving the nutritive value of Nigerian rubber kernel (*Hevea brasiliensis*) products through processing. I. Chemical and nutritional composition

Agunbiade, J A; Wiseman, J and Cole, D J A

*Tropical Agriculture*, 72(4): 1995. 308-314.

Rubber seeds were decorticated and the resulting kernels processed by sun-drying, oven-drying, roasting, autoclaving, and soaking. The meals (full-fat and fat-extracted) were analysed for proximate components, gross energy (GE), and amino acid contents. The acid-ether extract fractions of rubber kernel meal were analysed for fatty acid constituents. Mean GE of full-fat rubber kernel meal was 27.6 MJ $kg^{-1}$ dry matter (DM) while crude protein content ranged from 168 to 223 g $kg^{-1}$ in the full-fat samples with the corresponding values for the fat-extracted samples being 285-362 g $kg^{-1}$. Amino acid profile of rubber kernel meal indicated high levels of arginine, valine, leucine and phenylalanine in that order; moderate levels of lysine and threonine; and low levels of tryptophan, cystine, and methionine. Rubber kernel oil was high in linoleic (364 g $kg^{-1}$ oil) and linolenic (313 g $kg^{-1}$oil) acids. The chemical compositions of the rubber kernel products are discussed in relation to processing methods. The potential value and implications of using rubber kernel products as animal feed are also highlighted.

Key words: *Hevea brasiliensis;* Rubber seed; Rubber seed kernel; Seed processing; Nutrition; Amino acid; Fatty acid

## 110 Improving the nutritive value of Nigerian rubber kernel (*Hevea brasiliensis*) products through processing. II. Apparent nutrient and metabolizable energy values

Agunbiade, J A; Wiseman, J and Cole, D J A

*Tropical Agriculture*, 73(2): 1996.124-132.

A metabolism trial was designed to investigate the effect of method of processing (raw, sundrying, oven-drying, soaking, autoclaving and roasting), rate of inclusion (ROI), and method of estimation (regression or single-level assay) on apparent nutrient and metabolizable energy value of full-fat and fat-extracted rubber kernel meals and oil using 264 seven-day-old Ross broiler chicks. The oil and full-fat meals were incorporated at levels to provide 40, 80, and 120 g $kg^{-1}$ of added oil in the basal diet. Fat-extracted, meals were also included at the equivalent levels in the full-fat meals. Apparent metabolizable energy (AME) values were not significantly influenced by ROI with the values determined by regression being more precise than those estimated by single-level assay. Heat treatment generally improved AME, and for the full-fat meals, moist heat-processing (autoclaving or soaking prior to oven-drying) was more effective, than dry heating (oven-drying and roasting). The AME of the roasted full-fat was 16.1 MJ $kg^{-1}$ dry matter (DM) while the mean value of soaked and autoclaved full-fat (21.3 MJ $kg^{-1}$ DM), was significantly greater than the mean of oven-dried and roasted full-fat meals (18.7 MJ $kg^{-1}$ DM). Rubber kernel oil had an AME value of 35.3 MJ $kg^{-1}$ DM. An improvement in energy and nutritive value brought about by processing suggests inhibition of inherent deleterious factors, the specific nature

and definite levels of which would require further investigations for effective use of rubber kernel products as feed ingredients for non-ruminants.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed kernel; Seed processing; Nutritive value; Broiler chicken

111 **Influence of flowering and fruiting patterns on rubber (*Hevea brasiliensis*) seed production**

Olopade, E O and Salawu, R A

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed.Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 72-77.

Most of the studies on *Hevea brasiliensis* have been on latex production whereas seed production and utilisation have received little attention. The single brief period of the crop's annual flowering and fruiting pattern in Nigeria is a serious limitation to seed production set which ranges from mere 0.26% to 1.6% in open field pollinated plants. Higher fruit sets of 3%-8% have been obtained through hand pollinations. *Hevea brasiliensis* exhibits much genetic variability and this could be exploited to the advantage of better seed productivity along with high late yield. Such factors as fertilizer application, natural agents of pollination, and plant density are also limitations to seed production in rubber. This study throws light on the flowering and fruiting biology of the rubber tree. The genetic and environmental factors which influence seed production are also discussed.

Key words: *Hevea brasiliensis*; Seed production; Flowering pattern; Fruiting pattern; Nigeria

112 **The influence of position in rubber seed germination on the germination vigour and seedling growth**

Indraty, I S and Sutardi

*Second Technical Meeting on Estate Crops*, 15-17 Sept. 1981, Sukarta, Indonesia, 9 p. (AGRIS. 1981-1985)

Key words: Rubber seed; Seed germination; Plant production; Growth

113 **The influence of processing and storage on hydrogen cyanide and tannin contents of para-rubber seed and its products**

Narahari, D and Kothandaraman, P

*Animal Feed Science and Technology*, 9(4): 1983. 319-323.

Para-rubber seed and its products, including the autoclaved and fermented oil meals, were assayed for HCN content at post-harvest intervals from 1 week to 9 months of storage at room temperature. The tannin content of all these products was also estimated after 3 months of storage. Rubber seed and its kernels contained 638 and 749 mg HCN/kg,

respectively, 1 week after harvest; these values gradually diminished to 25.3 and 26.7 mg/kg, respectively, after 9 months storage. The rate of reduction in HCN levels was fast for the 2 months of storage and slower later. The HCN levels in other rubber seed products also declined during storage. Thus storage at room temperature for a minimum period of 2 months appeared to be an effective method of reducing the HCN content of rubber seed and its products to safe levels. The tannin levels in rubber seed and its products were low (0.42-0.53%) and within the safety levels for incorporation in livestock feeds. Moreover, the tannins were confined to the shell portion of the rubber seeds. Thus decortication appeared to be a satisfactory method for eliminating the tannins in rubber seeds, but increased the HCN levels slightly. Oil extraction and autoclaving failed to reduce the HCN and tannin levels, but fermentation successfully reduced both HCN and tannin levels in the rubber seed and its products.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed kernel; Seed processing; HCN content; Tannin content; India

## 114 Influence of rubber kernel oil meal on the performance of white leghorn pullets

Narahari, D; Venugopal, K and Kothandaraman, P

*Cheiron*, 14(1): 1985. 19-22.

Rubber seed meal could be used up to 40% level in the diet of three month old pullets without affecting the growth and efficiency, but later showed low feed in take and feather picking. To verify this and to arrive at a safe level of rubber seed meal, white leghorn replacement pullets of 9-20 weeks of age were fed diets containing 0, 5, 10 and 15 % levels of rubber kernel oil meal, replacing groundnut oil meal. The results indicated that rubber kernel oil meal could be safely as a source of vegetable protein up to 15% level in grower mashes without any adverse effect on growth rate, feed efficiency, livability and age at sexual maturity.

Key words: Rubber seed kernel; Rubber seed meal; White leghorn pullets; Poultry diet; India

## 115 Influence of seed size and orientation of placement on seed quality characteristics of rubber (*Hevea brasiliensis* Muell-Arg.)

Gunasekaran, M; Krishnasamy, V; Lakshmi, S and Nargis, S

*Orissa Journal of Horticulture*, 27(1): 1999. 4-7.

(Horticultural Abstracts, 70(5): 2000.576)

In studies carried out in Coimbatore, Tamil Nadu, India, small, medium and large rubber, cv. RRIM 600, seeds (1.61, 2.05 and 2.50 cm in diameter, respectively) were sown in sand in a horizontal (micropylar end facing sideways), vertical (micropylar end upwards) or inverted (micropylar end downwards) position. Small seeds sown in a horizontal position had the highest percentage germination (88%) and produced the largest and most vigorous seedlings. Large seeds had the lowest percentage germination.

Key words: *Hevea brasiliensis*; Rubber seed; Seed quality; Seed size

116 *In situ* epoxidation of rubber seed oil by peracetic acid
Aigbodion, A I; Okieimen, F E and Bakare, I O

*Nigerian Journal of Applied Science*, 17: 1999. 27-36.

*In situ* epoxidation of rubber seed oil (RSO) with peracetic at 30, 50, 60 and 70°C was carried out. Product of high epoxide content having commercial value as plasticizer/stabilizer for poly (vinyl chloride), (PVC), natural rubber and other applications can be obtained by this *in situ* technique. Mole ratios of acetic acid and hydrogen peroxide to oil and reaction temperature are critical factors for obtaining product of high epoxide content. Consequently, mole ratio of acetic acid to oil ≥ 0.40 and hydrogen peroxide to oil ≥ 2.23 were found to be optimum necessary for epoxidation of rubber seed oil. Study of temperature effect shows that rate of epoxidation of rubber seed oil increases with temperature. However, at reaction temperature ≥ 60°C, rate of oxirane cleavage or hydroxylation reaction is high. Highest epoxide content of 4.3 was obtained at temperature of 50°C with less oxirane cleavage but at longer time of reaction. Correlation of 30°C, % oxirane with reaction times at various temperatures show that at temperature > 30° C, % oxirane of 3.0, 3.8 and 3.7 were obtained before on-set of oxirane cleavage when rubber seed oil was epoxidised at 50, 60 and 70°C respectively. These correspond to 4, 2 1/2 and 1 1/2 hr of reaction respectively. The rate constants estimated at the different temperatures are of the order of $10^{-6}$ litre $mol^{-1}$ $sec^{-1}$. The activation energy, $E_a$ of producing epoxidised rubber seed oil found in this study is 15.73k cal $mol^{-1}$ and the enthalpy of activation are 15.13, 15.09, 15.07 and 15.05 k cal $mol^{-1}$ at 30, 50, 60 and 70° C.

Key words: Rubber seed oil; Epoxidation; Kinetics; Oxirane; Nigeria

117 Investigation of network formation in drying oils by dilute solution viscometry
Ibemesi, J A

*Journal of the American Oil Chemists' Society*, 66(7): 1989. 974-978.

Dilute solution viscometry was used to monitor the drying of the oils of linseed (*Linum usitstissimum* L.), rubber (*Hevea brasiliensis* [Kunth] Muell. Arg.). soybean (*Glysine max* (L) Merr) and melon (*Colocynthis vulgaris* Schrad) with a view to gain insight into the mode of network formation prior to the gel point. Intrinsic viscosity values obtained show a rise and fall pattern which was attributed to the occurrence of inter and intramolecular crosslinking. Reduced viscosity values of the solutions of the oils (in both their oxidized and unoxidized forms) show a rise with dilution, indicating the occurrence of major structural changes in the system.

Key words: *Hevea brasiliensis;* Rubber seed oil; Linseed oil; Drying; Plant oils; Viscosity

118 An investigation on oil of rubber seed (*Hevea brasiliensis*)
Njoku, Obioma U; Ononogbu, I C and Owusu, Ansah J Y

*Journal of the Rubber Research Institute of Sri Lanka*,78:1996.52-59.

Oil from seeds of *Hevea brasiliensis* traditionally used as thickening agent for saurce

respectively, 1 week after harvest; these values gradually diminished to 25.3 and 26.7 mg/kg, respectively, after 9 months storage. The rate of reduction in HCN levels was fast for the 2 months of storage and slower later. The HCN levels in other rubber seed products also declined during storage. Thus storage at room temperature for a minimum period of 2 months appeared to be an effective method of reducing the HCN content of rubber seed and its products to safe levels. The tannin levels in rubber seed and its products were low (0.42-0.53%) and within the safety levels for incorporation in livestock feeds. Moreover, the tannins were confined to the shell portion of the rubber seeds. Thus decortication appeared to be a satisfactory method for eliminating the tannins in rubber seeds, but increased the HCN levels slightly. Oil extraction and autoclaving failed to reduce the HCN and tannin levels, but fermentation successfully reduced both HCN and tannin levels in the rubber seed and its products.

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Oil from seeds of *Hevea brasiliensis* traditionally used as thickening agent for saurce

preparation was isolated, and its physical and chemical characteristics determined. Saponification yielded saturated and unsaturated fatty acids which were separated by preferential crystallization using organic solvents. Methanol, Ethanol, Hexane and Acetone were found effective solvents in this regard. Gas liquid chromatography (GLC) revealed large amounts of C18 fatty acids as well as traces of other fatty acids. The iodine values show that the solvents used in this study gave excellent yields of fatty acids with acetone being the most effective as a crystallization solvent to oil ratio 3:1 at 5°C.

Key words: *Hevea brasiliensis;* Rubber seed oil; Fatty acid; Physico-chemical properties

## 119 Investigation on rubber seed oil

Alam, M N; Faruq, M O; Hossain, M E and Alam, M S

*Bangladesh Journal of Scientific and Industrial Research*, 17(3-4): 1982. 200-204.

Oil from locally available rubber seeds in Bangladesh has been isolated and its physical and chemical characteristics determined. The fatty acids of the rubber seed oil can be separated into different fractions of varying fatty acids content by the method of urea complex formation. Addition of success quantities of urea to the mixture of fatty acids, give fractions with predominance in a particular type of fatty acid. The fatty acids thus separated consist of both saturated and unsaturated fatty acids. About 85% of the fatty acids are unsaturated and the major component is oleic acid followed by linoleic acid. Rubber seed oil can be a source of extraction of oleic acid for industrial use.

Key words: *Hevea brasiliensis;* Rubber seed oil; Fatty acid; Bangladesh

## 120 An investigation on the medical use of rubber seed oil

Chaoran, Liu; Mingying, Wang; Liang, Yang; Guozhen, Chen and Chaocai, Tang

*Chinese Journal of Tropical Crops*, 1(1): 1980. 88-96.

The rubber seed oil is rich in polyunsaturated fat, with 36% linoleic acid, 24% linolenic acid and some other unsaturated fatty acids. In recent years, we have demonstrated that the serum cholesterol and triglyceride levels of normal rats fed with rubber seed oil diet were lower than those of the rats fed with common diet. The lipidemia-reducing effect of the seed oil have been further demonstrated in both experimental hyperlipidemic animals (rats and rabbits) and hyperlipoproteinemic patients. We have also found that some people who usually consumed this oil (for at least 6 months) had lower serum lipid levels (either cholesterol or triglyceride) as compared with those who usually consumed other oils. Moreover, our study has also proved that rubber seed oil not only inhibited the development of aortic atherosclerosis in rabbits but also accelerated its regression to some extent. Possible mechanisms of the lipidemia-reducing effect of the oil have been discussed.

Key words: Rubber seed oil; Medical use; China

121 **Juvenile characters and seed morphology of certain modern *Hevea* clones**
Mercykutty, V C; Varghese, Y A ; Licy, J and Panikkar, A O N

*Indian Journal of Natural Rubber Research*, 4(1): 1991. 16-25.

Nine modern clones of *Hevea brasiliensis* were morphologically characterised at the age of 14 months, planted in the field at a spacing of 6.7 x 3.4 m. Morphological parameters studied were nature of buds and leaf scars, shape of leaf storey and characteristics of petioles, petiolules and leaflets. The observations were confirmed with nursery plants (60 x 60 cm spacing) of the same age. Seed morphology was also used to identify the clonal trees. Clones vary in respect of the different characters studied. A combination of different characters has to be taken into consideration for the identification of clones at young age.

Key words: *Hevea brasiliensis*; Rubber seed; Juvenile characters; Morphological parameters; Clone identification; India

122 **Kinetics of the preparation of rubber seed oil alkyds**
Aigbodion, A I and Okieimen, F E

*European Polymer Journal*, 32(9):1996. 1105-1108.

The kinetics of the polyesterification of glycerol, phthalic anhydride and rubber seed oil leading to the formation of alkyd resins were studied at temperatures between 230 and 250°C. Six samples of the resin having oil contents of 20%(I), 30%(II), 35%(III), 40%(IV), 50%(V) and 60%(VI) were prepared. The extent of reaction was monitored by determining the acid value of aliquots of the reaction mixture at various intervals of time and by measuring the volume of water evolved. The extent of reaction ($P_A$)and average degree of polymerization (DP) were calculated from end group analysis of aliquots of the reaction mixture withdrawn at various intervals of time. The initial reaction rates followed second order kinetics and thereafter deviations were observed. The average degree of polymerization calculated in the region of deviation from second order kinetics suggests the occurrence of chain branching at relatively short intervals along the polymer chain. The second order rate constants were found to be of the order of $10^{-5}$g (mg KOH)$^{-1}$min$^{-1}$.

Key words: Rubber seed oil; Alkyd resin; Polyesterification; Nigeria

123 **Long term trials with rubber (*Hevea brasiliensis*) seed cake on milch cows**
James, C S; Ananthasubramaniam, C R and Viswanathan, T V

*Kerala Journal of Veterinary Science*, 11(1): 1980.1-6.

An experiment was carried out in twelve cross-bred (Jersey x Sindhi) lactating cows by feeding respectively with rubber seed cake at 0, 25% wt/wt basis and 25% isoprotenic isocaloric basis replacing coconut cake for a period of 200 days to study the effect of incorporation of rubber seed cake in the dairy concentrate ration. Data on milk yield, composition of milk and butter characteristics did not reveal any significant differences

between the groups suggesting that rubber seed cake can be beneficially incorporated in the dairy concentrate mixture without producing any deleterious effects either on the quantity or on the quality of milk or butter produced.

Key words: Rubber seed; Rubber seed cake; Feeding value; Cattle feed; India

## 124 Loss of oil from *Hevea* seed: A variation having phyletic and economic implications

Baldwin, J T

*Journal of Heredity*, 40:1949. 47-49.
(Horticultural Abstracts, 19: 1949. 2488)

The seeds of certain species of *Hevea* were found to make greasy patches on the herbarium sheets resulting from loss of oil. *H. rigidifolia and H. kunthiana*, seeds of which are especially selected as food by the Amazonian native, were outstanding in this respect. Loss of oil also occurred in occasional trees of *H. brasiliensis, H. benthamiana and H. guianensis*, good rubber producing species. It is suggested that this character might be introduced into plantation rubber, so that the seeds could be used as a by-product, and also that certain trees of *H. rigidifolia* and *H. kunthiana* might form a basis for a seed-oil industry. This character of oil loss is shown to throw light on the genetical relationships of *Hevea* species.

Key words: *Hevea brasiliensis*; Rubber seed; Oil loss; Genetical relationship

## 125 Manufacture of dark factice from rubber seed oil

Fernando, M R N

*Rubber Research Institute Ceylon Quarterly Journal*, 47: 1971. 59-64.

Attempts were made to prepare dark factice from rubber seed oil and sulphur under different conditions. The factice samples thus prepared were analysed for the amount of free unreacted oil by the acetone extract method and for the free sulphur content. Best result was obtained when aerated rubber seed oil at 150°C was treated with 25% sulphur and 10% sodium carbonate. The factice thus prepared is almost identical in properties to the calendar factice of 790 A made by the Anchor Chemical Company Ltd. The factice was used in manufacturing extruded rubber tubing and very satisfactory results were obtained.

Key words: Rubber seed oil; Dark factice; Fatty acid; Sri Lanka

## 126 Marketing rubber seed

Grist, D H

*Malaysian Agriculture Journal*, 17: 1929. 39-46.

Key words: Rubber seed; Seed collection; Seed marketing; Seed packing

## 127 Marketing strategies for rubber seed oil and cake

Ogowewo, N

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp.109-119.

The paper stresses the difficulty in designing marketing strategies for rubber seed oil and cake in Nigeria in view of the fact that production is not yet commercialised. However it identifies merchandising, physical distribution and facilitation functions as elements of the potential marketing strategies that might be adopted and suggests a marketing structure similar to that prevailing in the rubber coagula trade. Under this structure rubber seed producers as suppliers are linked to the end users of rubber seed oil and cake (oil paint industry and livestock feed millers respectively) either directly or through the rubber seed oil millers and Nigerian Rubber Board. The latter has a monopoly of export marketing of rubber seed oil and cake. The paper points to inadequacy of seed supplies, poor storage and ineffective pricing as the likely marketing problems and advocates strengthening of the relevant research and development institutions to ensure effective marketing of the rubber seed oil and cake following commercialisation of production.

Key words: Rubber seed oil; Rubber seed cake; Seed marketing; Nigeria

## 128 Measurement of lipase activity in rubber (*Hevea brasiliensis*) seed

Njoku, O U; Ononogbu, I C and Eneh, F U

*Journal of the American Oil Chemists' Society,* 73(11): 1996.1471-1473.

Lipase activity in para rubber (*Hevea brasiliensis*) seed was measured by monitoring the release of free fatty acid by lipolysis of the endogenous lipid in a crushed sample of seed incubated at 37.5°C for 30 min. Free fatty acid was determined colorimetrically by a modified copper soap method. Fresh seeds showed the highest lipase activity. Drying the seeds at 60°C inactivated the enzyme. Drying of the seed at this temperature may be useful as a pretreatment for extraction of oil from the seed.

Key words: Rubber seed; Rubber seed oil; *Hevea brasiliensis*; Oil extraction; Lipase; Nigeria

## 129 Measurement of metabolizable energy value of rubber seed powder and its utilization in formulate ration for growing ducks and local chickens

Sutrisna, R

*Jurnal Penelitian Pertanian Terapan,* No.2: 1998. 23-27.
(AGRIS. 1999-2002/06)

The first experiment has been done to determine the metabolizable energy value of rubber seed powder and comparing its value for ducks and chickens. Five local Indonesian female

ducks and five female chickens were used in the experiment. The metabolizable energy was used to formulate ration for feeding trial in 48 ducks and 48 chickens at 2-8 weeks age. The second experiment was to study the responsibility of rubber seed level (0, 5, 10, 15 percent) in the ration. The completely random design was used in the experiment with 2 x 4 factorial experiment. The first factor ducks and chickens species (S) and the second factor was ration that used four level rubber seed powder 0, 5, 10, 15 percent (R) in the ration. The result of the experiment based on the observation and statistical test can be concluded that: there is no interaction between species and rubber seed powder level, but species significantly affected to feed conversion, feed consumption and the average weekly weight gain. The best consumption and conversion of ration were R3 (15 percent rubber seed powder level) treatment.

Key words: Rubber seed; Powder; Rations; Energy value; Ducks; Broiler chicken; Growth; Indonesia

## 130 Mechanism of hypolipidemic effect of rubber seed oil- Its effect on cholesterol tolerant test in rhesus monkey

Chaoran, Liu; Guozhen, Chen; Yunshan, Li; Longshun, Chen; Chaocai, Tang and Zhixiong, Zhang

*Chinese Journal of Tropical Crops*, 4(2):1983. 35-38.

Rubber seed oil is one of the plant oils rich in polyunsaturated fats. We have demonstrated that it has some hypolipidemic effects both in experimental hyperlipoidemic animals and in hyperlipoidemic patients. The present study was performed on 30 Rhesus monkeys (Macaca mulatta) which were divided into four groups. Group 1, received lard (20 ml) and 2 g cholestrol, Group 2, rubber seed oil (20 ml) and cholestrol (2 g), Group 3, R-PuF (20 ml) and cholestrol (2 g), Group 4, normal saline (20 ml) alone. Following the overnight fasting, the blood samples were obtained for total cholestrol (T-ch), triglyceride (TG) and high density lipoprotein cholestrol (HDL-ch). T-ch, TG and HDL-ch levels were determined repeatedly at 1, 2, 4 and 8 hours after the administration of a single dose of oral drugs. The results showed that following the administration of a single dose of drugs, the T-ch peak level was higher in Group 1 than in Group 2 and 3, but the blood T-ch level decreased more rapidly in Group 2 and 3 than in Group 1. In addition, lard was able to decrease HDL-ch level two hours after the administration of a single dose while rubber seed oil and R-PuF were able to increase it at the same time. These results suggested that R-PuF might be a main hypolipidemic component of rubber seed oil.

Key words: Rubber seed oil; Hypolipidemic effect; Cholestrol tolerant test; Rhesus monkeys; China

## 131 Metabolizable energy of rubber seed meal in poultry diets

Siriwardene, J A de S and Nugara, D

*Ceylon Veterinary Journal*, 20(3): 1972. 61-63.

In this study metabolizable energy value of rubber seed meal in poultry diet was determined.

For this purpose one-day old white leghorn cockerel chicks were selected and they were fed by a commercial chick starter diet until two weeks of age. They were then individually weighed and divided into four groups and fed by four different experimental diets prepared by incorporating different levels of a basal diet low in protein and rubber seed meal at varying proportions for a period of two weeks. After the experimental period the chicks were weighed to record the feed consumed. The feed and the faecal samples were analysed for moisture, crude protein content, gross energy and chromic oxide. The metabolizable energy value of each of the experimental diets was determined by applying the Sibbald and Slinger equation. The mean value for metamobilizable energy was found to be 1788 k.cals/kg. This value is similar to that of expeller coconut meal which is 1764 k.cal/kg and thus confirms the usefulness of rubber seed meal as a substitute for coconut meal in poultry feeds. No toxic manifestations were observed as a result of feeding rubber seed meal even at the 60% level.

Key words: Rubber seed meal; Poultry diet; Metabolizable energy; Sri Lanka

132 ***Mucuna cochinchinensis* (as a legume cover in the interrow of rubber seed production studies (in Peninsular Malaysia)**

Chee, Y K; Lee, K A; Phang, A K; Leong, M W and Ismail, Bin Ibrahim

*Proceedings of Legumes in the Tropics,* 13-17 Nov. 1979, Serdang, Malaysia, pp. 43-50.

(AGRIS. 1981-1985)

Key words: *Mucuna cochinchinensis*; *Hevea brasiliensis*; Rubber seed; Cover crops; Malaysia

133 **New fats for the soap kettle**

Hausman, M

*Soap,* 13(2): 1937. 28, 37, 73.

(RRIM Bibliography. No.10 Bibliography on Rubber seed oil)

Key words: Rubber seed oil; Soap manufacture

134 **New utilization of vegetable oils**

Nag, A; Bhattacharya, S and De, K B

*Journal of the American Oil Chemists' Society,*72(12):1995.1591-1593.

(AGRICOLA.)

Key words: Rubber seed oil; Vegetable oil; Diesel; Plasticizers; Fuel; Vulcanized oil; Industrial application

135 **Nigerian para rubber seed meal as an energy and protein source for rats fed soybean meal or peanut meal supplemented diets**

Orok, E J and Bowland, J P

*Canadian Journal of Animal Science,* 54 (June): 1974. 239-246.

Proximate, amino acid and fatty acid analyses were conducted on a sample of para rubber

(*Hevea brasiliensis*) seeds (RS) obtained from Nigeria. The nutritive value of RS meal (RSM) for weanling Sprague-Dawley rats was tested with soyabean meal (SBM)-or peanut meal (PNM)-supplemented diets fed at three protein levels (20, 16 and 12%), by including in the diets 7.4 to 12.4% meal prepared from either fresh or autoclaved decorticated RS. The feeding period was 4 wk, in the last week of which energy and nitrogen digestibilities were determined followed by carcass analyses for protein, fat and ash. Kernels represented 57.0% of undecorticated RS meal from decorticated RS contained 3.9% moisture, 6.50 kcal gross energy/g, 43.3% crude fat, 18.3% crude protein, 3.8% crude fiber, 3.1% ash and 27.5% nitrogen-free extract. Rate of gain, energy and nitrogen digestibilities and carcass composition of rats fed diets containing RSM were comparable to those on the respective diets without RSM. Average food intake of rats fed RSM supplemented diets was lower ($p<0.01$) than that of rats on the SBM-supplemented diet. This lower consumption of diets containing RSM was consistent with their higher DE and ME (kcal/g food). Autoclaving RS had no consistent effects on the various measurements.

Key words: *Hevea brasiliensis*; Rubber seed meal; Chemical composition; Rat diet; Nutritive value; Nigeria

## 136 Non-edible oil from rubber seed

Haridasan, V

*Commerce*, 141(3602): 1980. 16-18.

Key words: Rubber seed; Non edible oil; India

## 137 A note on the feeding value of rubber (*Hevea brasiliensis*) seed cake for cattle

Ananthasubramaniam, C R; Viswanathan, T V and Menachery, Maggie

*Kerala Journal of Veterinary Science*, 10(2): 1979. 282-285.

Rubber seed cake, the by-product of rubber seed oil industry was subjected to feeding trials in cattle in order to find out its nutritive value. The cake possesses a DCP of 15.0 percent and a TDN of 65.8 percent. The HCN content of the material was found to be only 8.7 mg per 100 g. The results indicated that rubber seed cake can form a potential feed source for cattle.

Key words: Rubber seed; Rubber seed cake; Feeding value; Cattle feed; India

## 138 Nutrient characterization of some feedstuffs of Sri Lanka crude protein of cassava, sesame, coconut oil, rubber seed, sweetpotato leaf meal

Ravindran, V; Kornegay, E T; Webb, K E and Rajaguru, A S B

*Journal of National Agricultural Society Ceylon*, 19: 1982 19-32.
(AGRICOLA. 1979-1984)

Key words: Rubber seed meal; Nutrition; Animal nutrition; Oil seed cakes; Industrial by products; Sri Lanka

## 139 Nutritional and industrial qualities of rubber seed oil

Abalaka, J A; Ameh, D D and Abedoja, F A

*Nigerian Journal of Technological Research*, 1:1989. 21-24.
(Cited by Aigbodion, A I., 1994)

Key words: Rubber seed oil; Nutrition; Industrial use; Nigeria

## 140 Nutritional and toxicological evaluation of rubber seed oil

Gandhi, V M; Cherian, K M and Mulky, M J

*Journal of the American Oil Chemists' Society*, 67(11):1990.883-886.

Rubber (*Hevea brasiliensis*) seed oil (RSO) is available in India (Ca. 4500 tons per year) and is used mainly as a drying oil. The oil does not contain any unusual fatty acids, and it is a rich source of essential fatty acids $C_{18:2}$ and $C_{18:3}$ that make 52% of its total fatty acid composition. Acute toxic potential in rats and the systemic effects and nutritional quality were assessed in a 13 week feeding study in weanling albino rats using a diet containing RSO or groundnut oil (GNO) (as the control) at a 10% level as the sole source of dietary fat. RSO did not manifest any acute toxic potential. Food consumption, growth rate and feed efficiency ratio of rats fed RSO were similar to those fed GNO. The digestibility of this oil was found to be 97%, as compared to 94% for GNO. There were no macroscopic or microscopic lesions in any of the organs which could be ascribed to the RSO incorporation in the diet. Thus the current data show that RSO could be used for edible purposes. However, it will be necessary to process the oil to achieve deodorization and to remove free fatty acids to make it organoleptically acceptable.

Key words: *Hevea brasiliensis*; Rubber seed oil; Fat digestibility; Nutrition; Toxicology; Rat feed; India

## 141 Nutritional assessment of rubber seed meal with broiler chicks

Nwokolo, Emmanuel; Bragg, Darrell and Sim, Jeong

*Tropical Science* (UK), 27(3):1987.195-204.

Proximate component, mineral, amino acid and fatty acid composition of rubber seed meal were determined, using whole and defatted rubber seed meals. Mineral and amino acid availability (true digestibility) determinations were made utilizing broiler chick assays. A growth trial in which 50% of dietary protein was supplied by rubber seed meal (RSM), soya bean meal (SBM), groundnut meal (GNM) or by combinations of these ingredients with RSM, was conducted. Analytical results indicated that rubber seed meal had a very high content of potassium, a high content of phosphorous and magnesium, and a moderate content of calcium. The content of micro-elements, zinc and iron, was very much higher than usually encountered in oil seed meals. RSM was low in lysine, the sulphur amino acids, and many other amino acids, in comparison with soya bean meal. Average amino

acid availability was moderately high (80.3%) but less than 93.3% in soy bean meal. Rubber seed oil had a high content of polyunsaturated fatty acids, with an exceptionally high level of linolenic acid. Broiler chicks fed RSM diets performed significantly less well than those fed SBM diets. Performance on RSM diets was similar to that on GNM or RSM/GNM/melon seed meal combinations.

Key words: *Hevea brasiliensis*; Rubber seed meal; Amino acid; Fatty acid; Mineral nutrition; Nutritive value; Broiler chicken; Canada

## 142 Nutritional evaluation of selected Nigerian rubber seed products: A chemical approach

Ukhun, M E and Uwatse, G M

*Plant Foods for Human Nutrition*, 38(4): 1988.309-318.
(Abstracts on Tropical Agriculture, 15(1):1990. 69345)

In Nigeria, 4 rubber seed products (whole and shelled rubber seed flours and oils) were subjected to various chemical analyses to provide a basis for their nutritional evaluation. The shelled rubber seed oil was stored for 4 weeks under different temperatures, light and dark conditions and at water activities of 0.33 and 0.95, to assess the changes in some of its indices of nutritional quality. The rubber seed products can meet, to varying degrees, the recommended daily requirements for various nutrients such as protein, fat and mineral elements. The shelled rubber seed oil also promises to be a valuable edible oil with a very low saturated/unsaturated fatty acid ratio and which is rich in the essential fatty acid, linoleic acid. Dark storage, non-extreme temperature, and a water activity of 0.33 were relatively effective in maintaining the nutritive aspects of the shelled rubber seed oil.

Key words: *Hevea brasiliensis*; Rubber seed oil; Rubber seed meal; Nutritive value; Storage quality; Storage condition; Physico-chemical properties; Nigeria

## 143 Nutritional value of [*Hevea*] rubber seed meal in livestock [in Malaysia]

Toh, K S and Chia, S K

*Feedingstuffs for Livestock in South East Asia: Proceedings of a Symposium*, 17-19 Oct. 1977, Kuala Lumpur, Malaysia, pp. 345-351.
(AGRIS. 1975-1980)

Key words: Rubber seed; Rubber seed meal; Nutrition; Livestock; Malaysia

## 144 Nutritional value of protein and oil in rubber seed (*Hevea brasiliensis*)

Bressani, R; Elias, L G; Ayuso, T; Rosal, O; Braham, J E and Zuniga, J

*Turrialba*, 33(1): 1983. 61-66.

The chemical and nutritional nature of oil and protein as found in rubber seeds is reported.

The raw dehydrated seed contains about 17.6 % protein and about 36.7 % crude oil. The amino acid content of the protein was compared with that of other oil seed sources. It is observed that the amino acid content of the protein in rubber seed is deficient in lysine, sulphur amino acids and tryptophan. Extrusion cooking improved the protein quality of the product and also removed HCN from the seed. For feeding trials on rats the extruded product was fed full-fat or hexane extracted. Physicochemical characteristics of the oil showed that the oil has a high concentration of C18:2 fatty acids. Nutritive value of the oil was determined by rat growth performance. Results indicated that when fed at a high level (20%) in the diet, it is toxic. At 10% level and for adult rats a digestibility of 84% was noted, which increased to 93% on heating. These values are slightly lower than those found for cottonseed oil. The results of the study shows that rubber seed has potential in animal nutrition and in oil industry.

Key words: *Hevea brasiliensis*; Rubber seed oil; Protein quality; Nutritive value; Chemical composition; Guatemala

## 145 Nutritional value of rubber seed proteins

Giok, L T; Samsudin, Husaini and Tarwojo, I

*American Journal of Clinical Nutrition*, 20(1): 1967. 300-303.

(Cited by Wheeler, Louis Cutter, 1978)

Key words: Rubber seed; Rubber seed meal; Nutrition; Seed protein

## 146 Nutritive value of rubber seed (*Hevea brasiliensis*) meal and oil. I. Rubber seed meal versus soybean meal as sources of protein in semipurified diets for rats

Babatunde, Gabriel M and Pond, Wilson G

*Nutrition Reports International*, 36(3):1987. 617-630.

Two 21-day experiments were conducted with female weanling rats to compare rubber seed meal (RSM) versus soybean meal (SBM) as sources of protein. In the first experiment, the two protein sources supplied 15% crude protein. In the second experiment, these sources of proteins were used in combinations such that 25%, 50%, 75%, or 100% of the protein from SBM was replaced with RSM protein. The 100% RSM protein diet was unsupplemented or supplemented with the most limiting amino acids, lysine and methionine up to the NRC recommended level. Growth performance, some organ weights and hematological traits were used as criteria of response. In Exp. 1 and 2, rats fed SBM diets had significantly better growth, feed efficiency and protein efficiency ratio, than those fed RSM. Kidney weights were smaller and spleen and reproductive tracts were larger when expressed as percentages of body weights in rats fed SBM than in those fed RSM. Rats fed SBM had significantly higher plasma albumin, total protein and significantly lower plasma urea than rats fed RSM. Replacement of SBM protein with RSM protein beyond the 50% level significantly reduced the performance of rats, while the

supplementation of the 100% RSM diet with lysine and methionine significantly improved the performance of rats compared to the unsupplemented counterpart and produced performance close to that of rats fed the SBM protein diet. It is concluded that RSM can supply up to 50% of the total protein in a diet without detrimental effects on body weight gain.

Key words: *Hevea brasiliensis*; Rubber seed meal; Rubber seed oil; Soybean meal; Rat diet; Nutritive value; Chemical composition; Protein digestibility

147 **Nutritive value of rubber seed (*Hevea brasiliensis*) meal and oil. II. Rubber seed oil versus corn oil in semipurified diets for rats**

Babatunde, Gabriel M and Pond, Wilson G

*Nutrition Reports International*, 36(4): 1987. 857-865.

Two experiments were conducted to compare the responses of female weanling rats to 15% protein semipurified diets containing different levels and combinations of rubber seed oil (RSO) and corn oil (CO). The first experiment was a 2x3 factorial arrangement of treatments with two sources of oil, RSO and CO and three levels of oils, 3%, 6% and 9%. The second experiment composed of five treatments developed to provide 0, 4, 8, 12, and 16% RSO combined with 16, 12, 8, 4, and 0% CO. Each experiment lasted 21 days and all rats were caged individually and fed and watered *ad libitum*. In Exp. 1, rats fed RSO diets consumed significantly less feed and had lower feed:gain ratio and higher protein efficiency ratio (PER) than those fed the CO diets ($P<0.01$). There were no significant differences among the treatments and no interactions due to source or level of oil for the daily gains, organ weights and the hematological traits. In Exp. 2, there were no significant differences among the treatments for any of the variables examined ($P>0.05$).

Key words: *Hevea brasiliensis;* Rubber seed oil; Rubber seed meal; Rat diet; Corn oil; Chemical composition; Nutritive value; Protein digestibility

148 **Nutritive value of Nigerian rubber seed (*Hevea brasiliensis*) meal and oil. III. Performance characteristics, relative organ weights, hematocrit and plasma metabolites of growing female rats fed corn diets containing rubber seed meal, soyabean meal or casein**

Babatunde, Gabriel M and Pond, Wilson, G

*Animal Feed Science and Technology*, 20 (2): 1988. 125-133.
(AGRIS. 1986-1988)

Key words: *Hevea brasiliensis;* Rubber seed oil; Rubber seed meal; Soybean meal; Nutritive value; Rat diet; Growth

149 Nutritive value of Nigerian rubber seed (*Hevea brasiliensis*) meal and oil. IV. Effects of graded levels of rubber seed meal and oil on energy and nitrogen utilization by growing rats

Babatunde, Gabriel M and Pond, Wilson G

*Animal Feed Science and Technology*, 31: 1990. 313-321.

Two experiments were conducted to determine the effects of graded levels of rubber seed meal (RBSM) and rubber seed oil (RBSO) on energy, dry matter and nitrogen (N) digestibility, and N retention of growing rats. In the first experiment, RBSM replaced 25,50,75 and 100% of the protein contributed by the soya-bean meal (SBM) in the control diet. The 100% RBSM substitution was either unsupplemented or supplemented with amounts of DL-methionine and L-lysine calculated to make up their concentrations to the minimum recommended National Research Council levels. In the second experiment, maize oil (MO) and RBSO replaced maize starch at 3, 6 and 9% in a 2 X 3 factorial arrangement of treatments. The diets in both experiments were iso-nitrogenous, containing 17% (Experiment 1) and 15% (Experiment 2) crude protein on a fresh weight basis. In Experiment 1, significant reductions were obtained in dry matter, energy and N digestibility, in absolute N retention and in the percentage of digested N retained ($P<0.01$) as the level of RBSM increased. Supplementation of the 100% RBSM protein diet with methionine and lysine did not reduce the depressions in the digestibility of energy, dry matter and N, but it significantly improved N retention. In Experiment 2, the inclusion of RBSO at the three levels did not affect the digestibility of dry matter, N or energy, or N retention.

Key words: *Hevea brasiliensis*; Rubber seed meal; Rubber seed oil; Nutritive value; Rat diet; Nitrogen

150 Nutritive value of rubber seed (*Hevea brasiliensis*) meal: Utilization by growing pigs of semipurified diets in which rubber seed meal partially replaced soybean meal

Babatunde, Gabriel M; Pond, Wilson G and Peo, E R

*Journal of Animal Science*, 68(2): 1990. 392-397.

(AGRICOLA.)

Key words: *Hevea brasiliensis*; Rubber seed meal; Nutritive value; Energy digestibility; Nutrition; Pig diet

151 Nutritive value of rubber seed meal and oil: Reproductive performance of female rats fed soybean meal versus rubber seed meal diets

Babatunde, Gabriel M and Pond, Wilson G

*Nutrition Reports International*, 39(2): 1989. 305-312.

(AGRICOLA.)

Forty-two female Sprague-Dawley rats (179 g initial liveweight, age 7 to 8 weeks) were used to investigate the effects of feeding diets containing combinations of soybean meal (SBM) and rubber seed meal (RSM) as the protein source on reproductive performance

from pregestation through lactation. Seven isonitogenous and isocaloric diets (17% crude protein on dry matter basis) were formulated principally from corn starch, soybean meal, rubber seed meal and oil, in such a way that diets 1 and 2 had all the protein supplied by SBM alone, while in diets 3, 4, 5 and 6, protein from RSM replaced 25%, 50%, 75% and 100%, respectively, of the SBM protein in diet 1. Diet 7 was the same as diet 6, except that it was supplemented with lysine and methionine up to the NRC-recommended levels. All rats were mated at approximately 230 g liveweight. There were significant treatment differences in the means for number of times mated, liveweight of dams before whelping, liveweight after whelping, daily gain during gestation, and pup and dam weight at weaning. There were no significant differences in the number of pups born/ litter, pup birth weight, number of pups weaned/litter, daily gain of the dams from start of the experiment to first mating, their liveweight at breeding and during lactation. The results suggest that the use of RMS at more than a 25% contribution to total protein in rats diets containing RSM and SBM as the protein sources is not satisfactory for optimum preweaning growth and survival of the pups and lactation of the dam.

Key words: *Hevea brasiliensis*; Rubber seed meal; Rubber seed oil; Soybean meal; Nutritive value; Reproductive performance; Rat

152 **The occurrence of cyanogenetic glucosides in feeding-stuffs**
Henry, Thos A and Auld, S J M

*Journal of the Society of Chemical Industry of Japan*, 27(9): 1908. 428-433.

Key words: Para rubber seed; Hydrocyanic acid; Feeding stuff; Cyanogenic glucoside

153 **Oil and the lipase-like enzyme in para rubber seed**
Iwamoto, Y

*Journal of the Society of Chemical Industry of Japan*, 33: 1930. 409B.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Para rubber seed; Rubber seed oil; Lipase

154 **Oil bromide films and their use in determining the halogen absorption**
Toms, Harold

*Analyst*, 53:1928.69-77.

Key words: Rubber seed oil; Tung oil; Bromide films; Halogen absorption

155 **The oil-content, keeping qualities and commercial possibilities of para rubber seed**
Spring, F G and Day, F W F

*Agricultural Bulletin of the Federated Malay States*, 6(5): 1918. 231-244.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Para rubber seed; Oil content; Commercial use

**156 Oil from *Hevea* seeds**
Dubosc, A
*Journal of the Society of Chemical Industry of Japan*, 38: 1919. 544A.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: *Hevea*; Rubber seed oil; Factice

**157 Oil from rubber seed**
Ashplant, Herbert
*The India Rubber Journal*, 117: 1949. 347-348, 351-352.

Key words: Rubber seed; Seed collection; Seed transport; Labour, Malaysia

**158 Oil from rubber seed**
Cant, F van
*India Rubber World*, March: 1930. 91.
(RRIM Bibliography. No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Oil extraction; Rubber seed oil

**159 Oil from rubber seeds**
Dayaratne, W C
*RRISL Bulletin*, 8:1975. 20-21.

Rubber seed contains 25% oil and about 29% protein to be exploited for conversion to useful products such as alkyd resins, soaps, paints, proteins and animal feed. From 250,000 acres of rubber plantation, it is possible to collect seeds to yield 4000 M.T. of oil and 7000 M.T. of high protein seed cake. Alkyd resin manufactured from rubber seed oil can replace the imported resins and the import of oils such as linseed, castor and soybean for producing resins for industrial use, can be cut down to save foreign exchange. Collection of rubber seed is expected to generate part-time job also to so many people.

Key words: Rubber seed; Rubber seed oil; Industrial use; Sri Lanka

**160 Oil from rubber seeds**
*India Rubber Journal*, 115:1948. 553-554.
(RRIM Bibliography. No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed oil

161 **Oil from rubber seeds**
Graham, W & Co.
*India Rubber Journal*, 44: 1911.18.
(RRIM Bibliography. No.10. Bibliography on Rubber seed oil)
Key words: Rubber seed; Rubber seed oil

162 **Oil from rubber tree seeds**
*Agricultural Bulletin of the Straits Settlements and Federated Malay States*, 9:1910. 493-495.
Key words: Rubber seed; Rubber seed oil

163 **Oil seeds: Para rubber seed**
*Bulletin of the Imperial Institute*,12: 1914. 346.
Key words: Para rubber seed; Rubber seed oil

164 **On the utilization of rubber seed oil cakes in compound feed for rearing plymouth chicks**
Doan-Xuan-Truc
*Khoa- Hoc-va-Ky-Thuat-Nong-Nghiep (Vietnam)*, No. 2: 1986. 79-81.
(AGRIS. 1986-1988)
Key words: Rubber seed; Rubber seed oil; Rubber seed cake; Broiler chicken;Vietnam

165 **Oxygen absorption characteristics of blends of fatty acids from seed oils of rubber, watermelon, soyabean and linseed**
Ochigbo, S S and Ibemesi, J A
*Indian Journal of Natural Rubber Research*, 7(2): 1994.107-113.
Oxygen-induced polymerisation of blends of fatty acids from rubber seed (RSA), watermelon seed (MSA) soyabean (SBA) and linseed (LSA) was done with a view to optimising the drying performance of the semidrying ones for development of alkyd resin paint binders. The results obtained showed two types of behaviour in oxygen absorption: a linear response by LSA/RSA and SBA/RSA blends in which oxygen absorbed increased directly with the amount of the more drying fatty acid; and a synergistic response by MSA/RSA, MSA/LSA blends in which oxygen absorption showed optimum values between 40-50 wt. per cent of MSA. This behaviour by MSA holds good promise for development of alkyd resins.
Key words: Rubber seed oil; Oxygen absorption; Fatty-acid blend; Melon seed oil; Soybean; Linseed; Alkyd resin

## 166 Paraquat, vegetable oils, copper and other elements as stimulators of latex production in rubber

Moraes, V H F

*Pesquisa Agropecuaria Brasileira*, 13(4): 1978. 17-26.
(Horticultural Abstracts, 50: 1980.133)

Studies were carried out to find cheap and easily available substitutes for conventional latex stimulators. In trials with wild-growing rubber trees paraquat stimulated latex production but caused serious damage to regenerating bark. Linseed oil, rubber seed oil or oil from seeds of *Carapa guianensis* was applied alone or with Cu, Ca, Mg, Mn, Zn and/or $PO_4$. Vegetable oils alone gave yield increases of up to 80% and the small additional yield increases due to incorporation of minor elements did not compensate for the labour yield increases due to mix them with the oil.

Key words: Rubber seed oil; Linseed oil; Vegetable oil; Latex stimulators; Brazil

## 167 Para rubber seed

Carruthers, J B

*Agricultural Bulletin of the Straits Settlements and Federated Malay States*, 6:1907. 383-385.

Key words: Para rubber seed

## 168 Para rubber seed as a source of oil and feeding-cake

*Bulletin of the Imperial Institute*, 17: 1919. 543-571.

In this paper, the Imperial Institute, made an attempt to examine the commercial potential of natural rubber seed as a source of additional income to the rubber plantation sector. Two types of by-products are recovered from rubber seed namely, oil and cake. The commercial potential is assessed based on the factors encompassing the availability, cost of procurement, technical feasibility compared to cotton seed and linseed, which are highly used for industrial purposes, and marketing. It is revealed that though rubber seed is available in plenty, the procurement is not economical as it is constrained by climate, cover crops, hilly terrain, lower prices and marketing. The technical feasibility of rubber seed oil has been examined in the manufacture of paints, varnishes, linoleum and soft soaps. It is understood that except in the manufacture of soap, in all other cases rubber seed oil is found to be technically not suitable compared to its substitutes like cotton and linseed oils. Since the substitutes are available at relatively lowers prices, the prospects of marketing of rubber seed oil is also found to be sceptical. However, the study revealed that the rubber seed cake has a great market potential as cattle feed and manure as it is comparable with its substitutes in terms of price and technical properties. In this context, it is suggested

that greater R & D efforts should be targeted to explore the possibilities of technical superiority of rubber seed oil over its substitutes in a wide range of industrial uses.

Key words: Rubber seed; Seed collection; Seed transport; Rubber seed oil; Rubber seed cake; Feeding stuff; Industrial use

169 **Para rubber seed oil**
Jamieson, G S and Baughman, W F

*Analyst*, 56:1931.61.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Para rubber; Rubber seed oil

170 **Para rubber seed oil; A by-product of increasing importance**
*India Rubber World*, Dec: 1930. 73.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Para rubber; Rubber seed oil; Rubber seed cake; Cattle feed

171 **Para rubber tree seed oil**
Uchida, So

*Journal of the Society of Chemical Industry of Japan*, 35(21): 1916. 1089-1090.

Key words: Para rubber; Rubber seed oil

172 **Performance of dwarf sheep fed elephant grass (*Pennisetum purpureum*) and concentrate supplements containing rubber seed as substitute for cotton seed cake**
Njwe, R M and Chifon, M K

*World Review of Animal Production*, 26(1): 1991. 43-46.
(AGRICOLA.)

Key words: Rubber seed cake; Cotton seed cake; Nitrogen; Digestibility; Nutrition; West African dwarf sheep; Cameroon

173 **Performance traits of growing pigs fed diets based on Cambodian rubber seeds and soybeans supplemented with water spinach**
Sovanno, Pech; Samkol, Pok; Ly, J and Preston, T R

(http://www.utafoundation.org/utacambod/msc99thes/sovapaper1.htm)

A 2 x 2 factorial arrangement was used to study the effect of two sources of oilseeds (full-

fat rubber seed and full-fat soybean) and two levels of DL-methionine (None or 0.3% of the daily feed ration) on performance traits of pigs given a diet formulated with cassava root meal and dried fresh water fish with fresh water spinach (*Ipomoea aquatica*) *ad libitum*. Sixteen Mong Cai Large White female and castrate male pigs weighing on average 24.4 kg initial live weight, and housed in individual pens, were allotted at random to the four experimental treatments. There was no significant interactions between oilseed source and DL-methionine supplementation in any evaluated trait except for DM conversion ratio, due to higher values in the soybean supplemented diet, possibly due to an inefficient extrusion process of the beans. After 12 weeks of trial there was no influence of oilseed source nor supplementation with DL-methionine on feed intake, final weight or average daily gain. Average feed intake was rather low, possibly attributable to the bulky characteristics of the water spinach. Water spinach contributed on average 18.7% to total daily dry feed intake. Crude protein content in the dry mixed feed was 11.5% in dry basis. The incorporation of water spinach to the daily ration increased the concentration of crude protein to 13.5% in the average feed consumed. It is suggested that full-fat rubber seeds can be included in substantial proportions in diets for growing pigs in the range of 25-60 kg with no deleterious effect on performance traits. Water spinach can contribute to increase the protein content of the diet when administered *ad libitum* to growing pigs. Both locally available sources of protein can contribute to save protein consumption from other conventional sources.

Key words: Rubber seed; Cassava root meal; Soybean; Water spinach; DL-methionine; Performance traits; Cambodia

## 174 Physical and chemical characteristics of refined vegetable oils from rubber seed (*Hevea brasiliensis*) and bread-fruit (*Artocarpus altilis*)

Achinewhu, S C and Akpapunam, M A

*Qualitas Plantarum Plant Foods for Human Nutrition*, 35: 1985. 103-107.

Crude vegetable oil obtained by solvent extraction from rubber seed (*Hevea brasiliensis*) and breadfruit (*Artocarpus altilis*) were subjected to alkali refining (neutralisation), degumming and bleaching. At each stage of refining, the crude and the refined oil were analysed for their physical and chemical characteristics notably specific gravity, moisture and volatile matter content, saponification, iodine values, peroxide value, unsaponifiable matter, fatty acids and free fatty acids. Results showed an improvement in the quality of the oil after refining. Refining decreased the free fatty acids and peroxide value, which are some of the characteristics that determine stability. There was a very slight decrease in saponification value and unsaponifiables matter after refining. Refining did not have much effect on the fatty acid composition except slight non-consistent decreases in saturated and unsaturated fatty acids. There was no decrease in iodine value.

Key words: *Hevea brasiliensis*; Rubber seed, Rubber seed oil; Breadfruit; Physico-chemical properties; Chemical composition; Refined oils; Vegetable oil

175 **Physiological considerations on the mineral composition of *Hevea* seeds**
Beaufils, E R

*Oleagineux*, 11: 1956. 379-384.
(Hoticultural Abstracts, 26: 1956. 467)

Key words: *Hevea brasiliensis*; Rubber seed; Mineral nutrition

176 **Physiological quality of rubber tree seed treated with benomyl during storage**
Vieira, R D; Bergamaschi, M C M and Minohara, L

*Scientia Agricola*, 52(1): 1995. 151-157.

After rubber tree (*Hevea brasiliensis* Muell. arg.) seeds reach the physiological maturity, there is a relatively dry and cold period in the State of Sao Paulo, which led to the present work, in order to evaluate environmental conditions that maintain physiological seed quality. The physiological quality of rubber tree seeds, treated with benomyl (0.1%) and stored in plastic bags, was studied up to 5 months, during 87/88. The seed bags were kept under laboratory conditions during the whole storage period. To evaluate physiological seed quality, germination and vigor (germination speed and seedling length) tests were performed. Germination and germination speed were measured at 30°C, as well as under environmental conditions. There was no treatment effect on the maintenance of seed quality during storage. The germination, germination speed and seedling length were reduced as the storage period increased. The germination values were low since the beginning, which could be attributed to the low moisture content (25.4%) of the seeds. The germination test for rubber tree seeds can be performed using sand as substrate at 30° C and the final count made at the 20 th day after planting.

Key words: Rubber seed; Seed quality; Seed storage; Germination; Seedling vigour; Benomyl treatment; Brazil

177 **Planting rubber seeds**
Cherian, P P

*Planters' Chronicle*, 76(8): 1981. 378-379.

Key words: *Hevea brasiliensis*; Rubber seed; Planting methods; Germination; India

178 **Possibility on the utilization of rubber seed for the ration of layers**
Soejono, M and Soedomo

*Bulletin Fakultas Peternakan Universitas Gadjah Mada (Indonesia)*, 1(1): 1977.3-11.
(AGRIS. 1981-1985)

Key words: *Hevea brasiliensis*; Rubber seed; Animal nutrition; Feeding stuff; Broiler chicken; Indonesia

179 **Post-transplantation growth of *Phalaenopsis* hybrid seedlings in community pots**
Seeni, S and Latha, P G

*Journal of the Orchid Society of India*, 4(1-2): 1990. 127-133.

Axenic seedlings of *Phalaenopsis* 'Fire Water Ponce', derived from green pod cultures were transplanted into 2" clay community pots filled with gravel, broken clay tiles, charcoal, fern roots, coconut shells, coir waste, rubber seed husks, jute fibres, cassava pith, thermocole, coconut husks, rubber seed coats, wood shavings, mango tree bark, grass roots, charcoal + brick, coconut peduncle segments or moss. Acclimatization of the seedlings to ambient conditions at out-of-flask stage and pre-treatment of the seedlings, pots and potting media with a fungicide or other agents were not required to ensure near 100% survival. Among the various potting media tried, in an order of priority, broken tile pieces, charcoal chips, dried stem cuttings of cassava, outer shells of rubber seeds, and coconut husks supported the establishment and subsequent growth of the seedlings. Foliar applications of fertilizer mixtures revealed that a combination of commercial diammonium phosphate and potassium nitrate (20:10:10 N:P:K) was by far the best source of nutrition for the growing seedlings.

Key words: Rubber seed coat; Rubber seed husks; Coir waste; Growing media; *Phalaenopsis*; Post-transplantation; India

180 **The potentialities of rubber seed collection and its utilisation in Sri Lanka**
Nadarajah, M; Abeysinghe, Ariya; Dayaratne, W C and Tharmalingam, R

*RRISL Bulletin*, 8: 1973. 9-21.

The main commercial products obtained from the rubber seed are its oil and meal. The processing of rubber seed oil involves collection, storage and milling of rubber seeds, extraction and refinement of oil. It is used in the manufacture of soaps, paints, alkyd resins, factice etc. Rubber seed meal can be used as animal food. The prospects of rubber seed collection and its utilisation in Sri Lanka are discussed. It would be preferable if the rubber seed oil would be converted to alkyd resin both for local use and for export. Sri Lanka can well claim to be the first country in the World to have pioneered the commercial use of rubber seed oil in alkyd resin manufacture. The potential use of rubber seed oil has also described in this article.

Key words: Rubber seed; Seed collection; Seed export; Seed storage; Industrial use; Factice; Soap manufacture; Alkyd resin; Sri Lanka

181 **Potential use of rubber seed oil as an energy supplement for growing chickens**
Rajaguru, A S B

*Journal of the National Agricultural Society of Ceylon*, 11-12 :1974-1975. 115-119.

R.S.O. was used upto 8% level in broiler rations without causing any deleterious effects.

In fact growth responses and feed efficiency similar to the control rations carrying coconut oil at 2% and 4% level were obtained when R.S.O was used at 2%, 4% and 8% levels. Lack of significance in the difference of feed intake of the two experiments indicate that R.S.O does not alter the palatability of rations. The data suggests that R.S.O. has a considerable potential as an edible oil if properly evaluated.

Key words: Rubber seed; Fatty acid; Rubber seed oil; Energy supplement; Broiler chicken; Sri Lanka

## 182 Potential value of rubber seed

Udomsakdhi, B; Munsakul, S and Sthapitanonda

*Thai Journal of Agricultural Science*, 7(4): 1974. 259-271.
(Horticultural Abstracts, 46: 1976. 4005)

Calculations based on the total area of rubber cultivated (4 609 276 rai, where 1 rai=0.16 ha) indicate a large yearly production of rubber seed (230 434 t). Only a small fraction of seed has been commercially exploited for oil and meal. Various potential uses of rubber seed are outlined.

Key words: Rubber seed; Rubber seed oil; Rubber seed meal; Seed utilization; Commercial application; Thailand

## 183 Potting media and post-transplantation growth of *Dendrobium* hybrid seedlings

Suresh Kumar, P K

*Journal of the Orchid Society of India*, 6(1-2): 1992. 131-133.

One-year-old hybrid seedlings raised *in vitro*, each with 4 leaves and 5 roots, were transplanted directly or after treatment with 0.1% Dithane M-45 [Mancozeb] into 2-inch community pots containing 10 different media that had been treated with Dithane M-45. The materials comprised broken tiles, charcoal, coconut husks, coconut shells, fern roots, grass roots, gravel, moss, rubber seed husks and wood shavings. Data are tabulated on seedling survival (%), and growth parameters assessed after 9 months in nursery conditions of temperature between 29 and 35°C, RH between 70 and 90%, and illumination between 1000 and 1500 lx at pot level. Seedlings were watered daily and sprayed with an NPK nutrient solution on alternate days. Charcoal, followed by fern roots and rubber seed husks, gave the best results. Coconut husks, wood shavings, moss and grass roots were the least satisfactory. Since charcoal and fern roots are, respectively, expensive and difficult to obtain (because of increasing forest clearance), it is recommended that rubber seed husks, gravel and coconut shells be used as cheap and abundant substitutes.

Key words: Rubber seed husks; Growing media; *Dendrobium*; Post-transplantation; India

184 **Preliminary evaluation of rubber seed meal as protein supplement in pig rations in Cameroon**
Njwe, R M and Tueho
*World Review of Animal Production*, 30(1/2): 1995. 89-93.
(AGRICOLA. 1992-1997)

Key words: Rubber seed meal; Feed intake; Pigs; Protein supplement; Cameroon

185 **A preliminary note on the production of improved seed of rubber (*Hevea brasiliensis* Mull-Arg) in India**
Bhaskaran Nair, V K and Oommen Koshy, P
*Rubber Board Bulletin*, 9(1):1966. 22-29.

Key words: *Hevea brasiliensis*; Rubber seed; Seed production; Polyclonal seed garden; India

186 **Preliminary studies on preparation of lubricating greases from bleached rubber seed oil**
Njoku, O U and Ononogbu, I C
*Indian Journal of Natural Rubber Research*, 8(2): 1995. 140-141.

Rubber seed oil was extracted from seeds of three clones (Tjir 1, RRIM 501 and RRIM 601) using petroleum ether (40-60°C). Blending of the oil was carried out using Fuller's earth. Physical and chemical characteristics of bleached oil were determined. Lubricating greases were prepared from the oils. It is observed that the texture and colour of the greases were comparable. Storage period had a marked effect on the texture of the grease produced.

Key words: Rubber seed oil; Bleaching; Lubricating greases; Physico-chemical properties; Nigeria

187 **Preliminary studies on the preparation of rubber seed oil alkyds**
Aigbodion, A I
*Indian Journal of Natural Rubber Research*, 4(2):1991. 114-117.

Three samples of alkyd resins having 45, 52 and 62 per cent of oil were prepared using phthalic anhydride, glycerol and rubber seed oil extracted by a screw press. Progress of the reaction was followed by measurement of the acid value of the reaction mixture at 30 min intervals. The monoglyceride formed did not make a clear solution in methanol(1:3) due to presence of impurities in the oil and the dark colour of the oil resulted in the formation of dark coloured alkyds. Extents of esterification calculated at the time when there was a sharp decrease in acid value were 69.92, 77.82 and 61.48 per cent for the three samples. The calculated degrees of polymerization indicated formation of appreciable high molecular

weight resins. The finished alkyds were soluble in xylene (3:2 dilution). The resins were of good quality, but their properties varied with the oil content.

Key words: Rubber seed oil; Alkyd resin; Gelation; Nigeria

**188 Preliminary study on levels of rubber seed meal for broiler rations (to determine nutritional value and hydrocyanic acid of rubber seed meal).**
Sirichai, Sripongpun; Winai, Pralomkarn and Utsa, Chandumpai

*Songklanakarin Journal of Science and Technology, Thailand*, 5(2): 1983. 131-135.
(AGRIS. 1981-1985)

Key words: Rubber seed meal; Hydrocyanic acid; Toxicity; Broiler chicken; Nutrition; Thailand

**189 A preliminary study on natural rubber seed oil for diesel engine fuel in Thailand**
Takeda, Y and Komcompunt, C

*Japanese Journal of Tropical Agriculture*, 29(3): 1985. 173-175.
(AGRIS. 1986-1988)

Key words: Rubber seed oil; Diesel; Fuel; Thailand

**190 Preparation, analysis and applications of rubber seed oil and its derivatives in surface coatings**
Aigbodion, A I and Pillai, C K S

*Progress in Organic Coatings*, 38(3-4):2000. 187-192.

Rubber seed oil (RSO) and its derivatives, heated rubber seed oil (HRSO) and alkyd resins were evaluated as binders in air-drying solvent and waterborne coatings. HRSO was obtained by heating RSO at 300±5°C until the desired viscosity. Acid value of RSO (53) is somewhat high. The major saturated fatty acids are palmitic (10.2%) and stearic (8.7%) while the main unsaturated fatty acids are oleic (24.6%), linoleic (39.6%) and linolenic (16.3%). Naturally, RSO is semi-drying and heating enhances its drying ability. GPC analysis reveals that RSO consists of a rather high molecular weight fraction that is rarely found in commonly known vegetable oils. The average molecular weight of RSO is higher than that of HRSO with the latter narrower in molecular weight distribution. Low molecular weight species constitute greater proportion of the alkyds and their number average molecular weights range between 1379 and 3304 which are comparable to those of commercial alkyds. The narrower the size distribution the better the quality of these alkyds as binders. Physico-chemical properties of solvent-borne alkyds vary with oil length (OL) and they are optimum at 50% OL. Water-borne alkyds investigated show that the sample with lower oil content contains lower volatile organic content. All the alkyd samples

and HRSO are fairly resistant to water and alkali, while they are virtually unaffected by acid and salt solutions. However, samples IV and V (water-borne alkyds) are more resistant than their solvent-borne counter parts (samples I-III) but exhibited lower scratch/ gouge pencil hardness.

Key words: Rubber seed oil; Alkyd resin; Surface coatings; Volatile organic content; Solvent-borne coatings; Water-borne coatings; Nigeria

## 191 Preparation and characterisation of activated carbon from agricultural wastes

Rengaraj, S; Arabindoo, Banumathi and Murugesan, V

*Indian Journal of Chemical Technology*, 6(1): 1999. 1-4.

Solid waste disposal has become a major problem in India. Either it has to be disposed safely or used for the recovery of valuable materials. As agricultural wastes like myrobalan, rubber seed coat, cashewnut sheath, palm seed coat, palm tree flower and pongam seed coat comprise of cellulose and lignin, they may act as good adsorbents. Therefore these wastes have been exploited for the preparation of activated carbon employing various techniques. Their characterisation studies such as bulk density, moisture content, ash content, fixed carbon content, matter soluble in water, matter soluble in acid, pH, decolourising power, phenol number, ion exchange capacity, iron content and surface area have been carried out to assess the suitability of these carbons as adsorbents in the treatment of water and wastewater. The results obtained show them to be good adsorbents for both organics and inorganics. The present study reveals the recovery of valuable adsorbents from readily and cheaply available agricultural wastes.

Key words: Rubber seed; Agricultural wastes; Activated carbon; Cashewnut sheath; Myrobalan; Palm seed coat; India

## 192 Preparation and characterization of rubber seed oil alkyds

Aigbodion, A I and Okieimen, F E

*Journal of the Rubber Research Institute of Sri Lanka*, 75(1): 1995. 31-38.

Preparation of rubber seed oil alkyds were carried out to furnish more information on process control and quality of the finished alkyds. Six samples of alkyds formulated to contain 20% (I), 30% (II), 35% (III), 40% (IV), 50% (V) and 60% (VI) oil content were prepared from phthalic anhydride, glycerol and rubber seed oil using the monoglyceride method. Acid values were determined for in-process samples withdrawn at various stages of the reaction. The extent of reaction and degrees of polymerization were calculated from end-group analysis. The results suggest that end-group analysis could be used to monitor progress of reaction. The reaction occurred in two phases due to the different reactives of primary and secondary hydroxyls or glycerol with carboxyl groups. Essentially, linear chain molecules are formed in phase one while crosslinking of the chains occur in phase two. Characteristics such as colour, acid value, iodine value, saponification value and percent non-volatile matter of the final alkyds depend on the rate and extent of esterification as

deduced from acid value. The level of unsaturation in the final alkyds depends on the amount of oil used.

Key words: Rubber seed oil; Alkyd resin; Polymerization; Nigeria

### 193 Preservation and germination of *Hevea* seeds

Mian, K

*Revue Generale des Caoutchoucs et Plastiques*, 63(662): 1986.95-98.
(RAPRA. 327569)

Key words: *Hevea brasiliensis*; Rubber seed; Seed preservation; Germination

### 194 Problems associated with the estimation of cyanide in rubber seed kernel

Mallika, G V; Jansz, E R; Pieris, Nirmala M and Abeysekera, A M

*Journal of the National Science Council of Sri Lanka*, 21(1): 1993. 153-156.

The cyanide content of rubber seeds was estimated by autolysis or hydrolysis techniques. Autolysis of random seed samples yielded total cyanide contents ranging from 100 to 4000 mg/kg. Six samples collected from the same field, one day after seed fall (in an attempt to limit the variation), yielded an average cyanide content of 1819 mg/kg. Comparison of seeds from the same fruit found wide variations in cyanide content, e.g. 15-1897 mg/kg in one fruit, indicating a need for large seed samples. An optimum sample size of 6-8 g is suggested. Hydrolysis with trichloroacetic acid [TCA] for 4 h yielded <3% of the total cyanide. Using 2M $H_2SO_4$ at room temperature also yielded very little. Acid reflux for 30 h yielded the full amount, but autolysis took only 2 h to do the same. Adding exogenous linamarase to distilled autolysate residue did not release any further cyanide.

Key words: Rubber seed kernel; Cyanogenic glucoside ; Acid hydrolysis; Sri Lanka

### 195 Problems of preserving rubber seed in storage

Santoso, B and Basuki

*In: Second Technical Meeting on Estate Crops*, 15-17 Sept. 1981, Sukarta, Indonesia, Pt 15, 23 p.
(AGRIS. 1981-1985)

Key words: Rubber seed; Seed storage; Indonesia

### 196 Problems of rubber seed storage (*Hevea brasiliensis*)

Ang, B B

*In: Seed Technology in the Tropics, 1st National Seed Symposium*, 1976, pp. 117-122.
(AGRICOLA. 1970-1978)

Key words: Rubber seed; Seed storage

197 **Processability characteristics and physico-mechanical properties of natural rubber modified with rubber seed oil and epoxidized rubber seed oil**
Aigbodion, A I; Menon, A R R and Pillai, C K S

*Journal of Applied Polymer Science*, 77: 2000. 1413-1418.

The processability characteristics and physico-mechanical properties of natural rubber (NR) modified with raw rubber seed oil and epoxidized rubber seed oil have been studied. The modified mixes showed higher scorch time and lower cure rate, crosslink density, and ultimate state of cure compared to an un-modified mix. The thermal stability of the vulcanizates was practically unaffected by the modification.

Key words: Natural rubber; Rubber seed oil; Epoxidised rubber seed oil; Processability; Physico-mechanical properties; Plasticizers

198 **Processing, analysis and utilization of rubber (*Hevea brasiliensis*) seed oil and cake**
Uzu, F O; Ihenyen, G A; Chukwuma, F and Imoebe, S O

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference*. (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp.19-26.

Three processing methods for obtaining rubber seed oil solvent extraction, expression and rendering were studied. The results showed that solvent extraction was better than expression method followed by rendering in terms of efficiency of oil recovery. A combination of expression and solvent extraction was recommended. Chemical analysis of the seed showed that the seed without shell contains 42.63% oil, 22.30% protein, 23.39% carbohydrates, 4.31% fibre and 3.5% minerals. The cake after oil extraction contained 29.36% protein, 56.57% carbohydrate, 4.20% fibre and 2.90% minerals. The seed oil is a semidrying oil with the following properties sp.gr 0.9185, Refractive index 1.4, iodine value 145.80, Saponification value 192.20, unsaponifiable matter 1.14%, FFA 15.45, moisture and volatile matter 4.30 and Dirt 0.30. The oil contains 20% Saturated FFA, 23% Oleic, 32.5% Linoleic and 22.5% Linolenic. The oil is similar to linseed oil and can partly replace linseed oil in industrial processes. The seed cake contains tolerable quantities of cyanogenic glucoside and can be used as livestock concentrate after drying and toasting.

Key words: Rubber seed oil; Rubber seed cake; Oil extraction; Chemical composition; Fatty acid; Nigeria

199 **Processing of *Hevea brasiliensis* (rubber seed) and *Carthamus tinctorius* (Safflower-seed) for recovery of oil**
Prasad, L V and Lakshmi Vara

*Khadi and Village Industries Commission Report*, Bombay, 1960, 12 p.
(AGRICOLA. 1998-2001/03)

Key words: Rubber seed oil; Safflower oil; Seed processing; India

200 Processing of *Hevea brasiliensis* (rubber seed) and extraction of its oil by hydraulic press
Prasad, L V and Lakshmi Vara
*Khadi and Village Industries Commission Report*, Bombay, 1960, 16 p.
(AGRICOLA. 1998-2001/03)

Key words: Rubber seed oil; Seed processing; Hydraulic press; Oil extraction; India

201 Production and use of *Hevea* seed cake
Enderlin, L and Bras, J le
*Revue Botanique Appliquee*, 17: 1937. 175, 268.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed cake

202 The production and utilization of rubber seeds and the approval of seed collection areas
Mohd Noor Abdul Ghani; Ong, S H and Subramaniam, S
*In: Seed Technology in the Tropics, 1st National Seed Symposium*, 1976, pp. 237-245.
(AGRICOLA. 1970-1978)

Key words: Rubber seed; Seed production; Seed utilization; Seed collection; Malaysia

203 Production of biodiesel using rubber [*Hevea brasiliensis* (Kunth. Muell.)] seed oil
Ikwuagwu, O E; Ononogbu, I C and Njoku, O U
*Industrial Crops and Products*, 12(1): 2000.57-62.

Rubber (*Hevea brasiliensis*) seed oil was extracted, and its physical and chemical characteristics determined. The crude oil was bleached and the ester-fuel (methyl-ester) was prepared by *trans*-esterification with 6-molar excess of methanol using sodium hydroxide as a catalyst. Methyl ester yield and fuel properties of the oil (crude and bleached) and its methyl ester were determined and compared to that of commercial diesel fuel. The analysis of properties in comparison to commercial diesel fuel showed that *trans*-methylation improved the fuel properties of the oil. The viscosity was substantially reduced from 37.85 to 6.29 cSt. Calculated cetane index (increased from 34.00 to 44.81), other fuel properties were also found to be improved. The results supports the choice of monosters, in place of straight rubber seed oil, as having better potential for use as alternative diesel fuel. However, oxidative stability was reduced by *trans*-methylation.

Key words: *Hevea brasiliensis*; Rubber seed oil; Biodiesel; Methylester; Diesel; Nigeria

204 **Production of oil from *Hevea* seeds**

*Tropenpflanzer*, 32: 1929. 474.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed oil

205 **Production of particle boards from bioresources**

Akaranta, O

*Bioresource Technology*, 75(1): 2000. 87-89.
(HORTCD. 1989-2002/06)

Particle boards of 1.2 cm thickness were prepared from rubber seed pods, cashew shells, alone or in 5 blends, using an adhesive resin based on cashew shell liquid. Performance evaluation showed that the boards satisfied the ASTM specifications for construction-grade building boards. The blending strength, water resistance and swelling ratio of the boards were better than those obtained for a commercial board. The results also showed that cashew nuts can be fully exploited by producing cashew shell liquid for adhesive resins and spent shells which can be used as a source of lignocellulosic material for particle boards.

Key words: Rubber seed pods; Particle boards; Agricultural by-products; Cashew shells

206 **Production of rubber seed oil**

*Industrial and Engineering Chemistry*, Jan. 20: 1929.9.

Key words: Rubber seed oil: Soap manufacture

207 **Productivity potentials of rubber seed**

Nadarajapillai, N and Wijewantha, Ronald T

*Rubber Research Institute of Ceylon Bulletin*, 2(1/2): 1967. 8-17.

The productivity potentials of rubber seed in Ceylon is reviewed. All the tallow imported for the manufacture of soap could be replaced by rubber seed oil. The rubber seed cake can be used as a fertilizer and as animal feed. The cake is rich in protein and its nutritive value is comparable to that of linseed cake and cotton seed cake. The HCN content of the cake can be reduced by reducing the moisture content of the kernel and by increasing the period of storage. Experiments have shown that adequately dried kernel could be kept without an appreciable deterioration up to six months if humidity during storage period is kept under control. The joint project of Rubber Research Institute of Ceylon with Lever Brothers (Ceylon) limited for studying the commercial possibility and economics of oil extraction is also described.

Key words: *Hevea brasiliensis*; Rubber seed oil; Rubber seed cake; HCN content; Seed collection; Seed storage; Ceylon

## 208 Progress in the chemistry and technology of non-traditional oilseeds/oils

Bringi, N V

*Journal of the Oil Technologist's Association of India*, 20(1):1988.2-9.
(HORTCD. 1989-2001/03)

This paper gives brief descriptions of the chemistry and processing (or biosynthesis) technology of various non-traditional seed oils (mostly from tree species): sal [*Shorea robusta*], used as a component of cocoa butter substitute; mowrah [*Madhuca longifolia*]; an edible fat; karanja [*Pongamia pinnata*], an oil mainly used for soaps, and after sulfonation in leather processing; neem [*Azadirachta indica*], an oil used mainly for edibles, soaps, and in insecticidal and cytotoxic preparations; kusum [*Schleichera*], a hard oil used mainly for soap, but possessing insecticidal properties; and oils from various lesser known species-kamala (*Mallotus philippensis*), *Trewia nudiflora, Sapium sebiferum,* malkanguni (*Celastrus paniculatus*), ratanjyot (*Jatropha curcas*), rubber (*Hevea brasiliensis*), thumba (*Citrullus colocynthis*), palash (*Butea frondosa* [*B. monosperma*]), undi (*Calophyllum inophyllum*) and nahor (*Mesua ferrea*)

Key words: Rubber seed oil; Plant oils; Soap manufacture

## 209 Properties and potential of rubber seed oil

Eka, O U

*West African Journal of Biological and Applied Chemistry*, 20(3):1977. 45-54.

This paper describes the constituents and the physical and chemical properties of rubber seed oil produced in Nigeria. The analysis conducted indicated that the rubber seed has 22.6% lipid, 62.81% carbohydrates, 12.25% proteins, 2.35% ash and 3.10% water contents. It has a melting point of 2.6-2.7°C and specific gravity of 0.94 at 25°C. Properties such as saponification value, iodine value, hydrocyanic level, acid value, free fatty acid content, unsaponifiable matter, peroxide value, etc. were also estimated. Chromatographic estimation of lipid in rubber seed oil indicated that it contained 8.3% stearic acid, 21.0% oleic acid, 38.2% linoleic acid, 24.3% linolenic acid, 7.0% palmitic acid and 0.3% unidentified material. From these properties, it is evident that the rubber seed oil could be used in application such as paints, soaps, cold creams and surface coatings.

Key words: Rubber seed oil; Phospholipids; Thin-layer chromatography; Wax products; Industrial use; Saponification; Chemical composition; Fatty acid; Methylation; Nigeria

## 210 Prospects for the use of rubber seed meal for feeding pigs and poultry [in Peninsular Malaysia]

Ong, H K and Yeong, S W

*Feedingstuffs for Livestock in South East Asia: Proceedings of a Symposium*, 17-19 Oct. 1977, Serdang, Selangor, Malaysia. pp.337-344.
(AGRIS. 1975-1980)

Key words: Rubber seed meal; Pig diet; Poultry diet; Malaysia

211 **Prospects of rubber seed oil in leather industry**
Vijayalakshmy, K; Baskar, Geetha; Parthasarathy, K; Rao, V V M and Rajadurai, S

*Supplement on Leather Processing*, Oct 25:1988. 1-3.

Rubber seed oil available in India to the tune of 4000 tonnes per annum has good scope as a lubricant in leather making. This oil similar to linseed oil and tobacco seed oil in its composition can be suitably modified to obtain water emulsifiable oil products. The developed products are evaluated for their performance on leathers as fatliquors for their physico-chemical characteristics.

Key words: Rubber seed oil; Leather industry; Fatliquor; India

212 **Pure rubber seed oil as a substitute for linseed oil in foundry core binders**
Greene, L W and Leaper, J M F

*Oil and Soap*, 10:1933. 28.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed oil; Linseed oil; Core binders

213 **Quantitative and commercial implications of seed size variation in rubber (*Hevea brasiliensis*) clones**
Agbaka, Adindu C

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 96-108.

As rubber (*Hevea brasiliensis*) seeds become economically important, seed size variations observed for several *Hevea brasiliensis* clones is being evaluated from a commercial stand point. Twelve clones were studied, and both inter-clonal and intra-clonal variations were observed for: (i) Seedsize grades; (ii) Whole seed and kernel weights; (iii) Shelling percentage; (iv) Seed oil yield; and (v) Percent defatted seed cake remains. Four seed grades were identified which showed overall intraclonal distribution of 0.4% (grade 1), 66.41% (grade 2),17.19% (grade 3), and 12.93% (grade 4). Seedsize grade weight variations were highly significant for the twelve clones. Mean whole seed weight variation showed a range of 1.32g between clones GT 1 (3.25g) and RRIM 623 (4.57 g) while mean kernel weight variation ranged from 1.81g for GT 1 to 2.72g for Tjir 1 from 1,000 seeds. There was a shelling percentage range from 52.52% for RRIM 623 to 65.54% for RRIM 623. The commercial implications of these variations are discussed quantitatively.

Key words: *Hevea brasiliensis;* Rubber seed; Seed size; Seed grading; Seed collection; Shelling percentage; Defatted cake; Nigeria

214 Repellent effects of some plant oils on *Hemiberlesia pitysophila Takagi*
Wu, M L and Liu, X Q

*Entomological Knowledge*, 31(1): 1994. 28-30.
(HORTCD. 1989-2001/03)

Key words: Rubber seed oil; Plant oils; Margosa oil; Repellents; China

215 Report on the constituents of the seeds of *Hevea brasiliensis* and their commercial uses
Dunstan, W R

*Agricultural Bulletin of the Straits Settlements and Federated Malay States*, 3:1904. 44-47.

Key words: *Hevea brasiliensis*; Rubber seed; Seed composition; Commercial use; Malaya

216 Researches in applied chemistry. I. Study of the rubber-tree seed
Siqueira, R de; Pechnik, E and Guernelli, O

*Chemical Abstracts*, 48: 1954. Ab No.5313.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Nutrition

217 Research on the dietary value of rubber seed oil
*Chinese Journal of Tropical Crops*, 2(1): 1981. 91-100.

Based on the experiments done by Beijing Labour Hygiene Institute, further research on the dietary value of rubber seed oil was made from 1975 to 1976. 258 rats and 125 mice were divided into two groups fed on the diet containing 10% and 20% rubber seed oil respectively, while the control group was fed on a diet containing 10% or 20% peanut oil. The results can be summarised as:-(i). The nutritive value of rubber seed oil was slightly higher than that of peanut oil. (ii). The feeding on the diet containing 10% or 20% rubber seed oil for a long time showed no harmful effects on growth, propagation, liver function, serum protein, serum lipid, serum calcium and morphological changes of liver, kidney, heart, lungs, digestive tube, etc. (iii). The cytogenetic observations showed that there were no latent genetic adverse effects. (iv). The feeding on 10% or 20% rubber seed oil would cause a decrease in the concentration of serum lipids. It is concluded that rubber seed oil is a new source of dietary oil.

Key words: Rubber seed oil; Pea nut oil; Rat diet; Dietary oil; China

218 Results of storage test with seeds of *Hevea brasiliensis*
Ong Thian Pa and Lauw Ing Koen

*Menara Perkebunan*, 31:1962. 59-70.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: *Hevea brasiliensis*; Seed storage

219 Rubber (*Hevea brasiliensis*) seed meal: A potential material for live stock diets in Nigeria

Onuwaje, O U and Imoukhuede, S K

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 47-53.

Rubber seeds were collected, dried, decorticated and milled, and the resultant rubber seed meal (RSM) was subjected to proximate analysis and to feeding trials as protein supplement in poultry pullet and layer ration. Defatted and undefatted RSM were compared with regular commercial poultry mash purchased from the open market. Proximate analysis revealed that both defatted and undefatted RSM contain acceptable levels of protein, crude fibre, soluble minerals and vitamins. The amino acids-alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, leucine, lysine, proline, serine, tryptophan and valine were present. Weight for weight, proline constitutes 0.02% while others were present in less than 0.001%. Weight gain and egg production per bird as well as the physical appearance of birds and eggs were identical for RSM and commercial feed. Percent (%) albumin, yolk, shell and egg weight were quantitatively similar for all feeds. Over a 10-week period average weight gains increased from 83.40 gm to 1.83 kg per bird for undefatted RSM. There is an indication that RSM is a worthy source of protein for livestock feeds; and industrial cum Institutional research cooperation is required to place RSM in the livestock feed market.

Key words: *Hevea brasiliensis*; Rubber seed meal; Livestock; Nutrition; Nigeria

220 Rubber seed

Dow, E A

*India Rubber World*, Dec.: 1936. 35.

(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed oil

221 Rubber seed

Muralidhara, H G and Madhusoodana Rao, I

*Indian Oil and Soaps Journal*, 35(1):1970. 155-158.

Key words: Rubber seed; Chemical composition; Seed collection; Industrial use; India

222 Rubber seed and its oil

Bhushan, D

*Indian Oil Seeds Journal*, 2(3):1958. 35-37.

The extraction of rubber seed oil, its chemical properties and fatty acid composition is described. The free fatty acid content of oil from freshly harvested seeds is less than 0.5%

which increases on storage of unsterilized kernels. Rubber seed oil, low in free fatty acid content could be produced by, collection of fresh seeds, decortication (for removal of shell), steam sterilisation of kernels and drying the kernels in kiln/ sun. Oil is obtained from treated kernels by solvent extraction. The requirements in a rubber seed oil factory is similar to a groundnut oil factory. About 35% of the fatty acid composition is linoleic acid. The possible uses of rubber seed oil in soap making, paint manufacturing and cattle food are described.

Key words: Rubber seed oil; Seed collection; Oil extraction; Chemical composition; Fatty acid; Industrial use; India

## 223 Rubber seed and oil: Studies on Indian rubber seed and rubber seed oil. I. Availability of seed, characteristics and composition of seed and oil

Azeemoddin, G and Thirumala Rao, S D

*Rubber Board Bulletin*, 6(2): 1962. 59-68.

A study was conducted on availability of rubber seeds and the characteristics and composition of rubber seeds and fresh harvested seeds were analysed. The area under rubber plantation by the close of 1960 was over 3 lakh acres. The annual availability of seeds was estimated to be 30,000 tons on the basis of an assumed seed production of 1 ton per 10 acres. The average cost was worked out as 1,300 per ton of rubber seed. The peak seed fall season is from July to August. The average weight of fresh rubber seed is 4gm on a moisture free basis. The average shell and kernel contents are 41.7 percent and 58.3 percent respectively. Moisture distribution in the whole seed is predominantly in the kernel. Oil content of kernel on an average was 42 percent. The oil characteristics from extraction of predried kernels with light petroleum ether was yellow to brown with a mean iodine value of 136.0. Rubber seed oil is used for both edible and industrial purposes. In the context of the non-utilisation of rubber seeds in India for oil processing, the study highlighted the potential for rubber seed processing in the country.

Key words: Rubber seed; Seed production; Seed collection; Seed utilization; Rubber seed oil; Chemical composition; India

## 224 Rubber seed as a by-product

*Rubber Age*, 40: 1937. 291.

(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed by- products; Commercial use

## 225 Rubber seed as a by-product

Wicherley, W

*Tropical Agriculturist*, 40:1913. 311-313.

(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed by-products

226 **Rubber seed cake as a feedstuff**
Pope, Felix T

*The Malayan Tin and Rubber Journal*, 20(2): 1931. 170.

Key words: Rubber seed cake; Feeding stuff; Cattle feed

227 **Rubber seed as a feed supplement for pig production**
Sovanno, Pech

Thesis, Master of Science, Royal University of Agriculture, Phnom Penh city, Cambodia.

Literature relating to use of rubber seeds in pig diets has been reviewed. Two experiments have been carried out. The first was a growth study with 16 pigs, conducted at the research farm of the University of Tropical Agriculture (UTA), Phnom Penh City, Cambodia, to evaluate the effect of feeding full-fat rubber seed meal and full-fat soybean meal on productive performance of pigs. The second experiment was a study of digestibility indices using the acid-insoluble ash method, on the same pigs and diets on 2 occasions, at 40 and at 60 kg live weight. A 2 x 2 factorial arrangement was used to study the effect of two sources of oil seeds (full fat rubber seed and full fat soybean) and two levels of DL-methionine (0.3% of the daily feed ration) on performance traits of pigs given a diet formulated with cassava root meal and dried fresh water fish with fresh water spinach (*Ipomoea acuatica*) *ad libitum*. Sixteen Mong Cai large white female and castrate male pigs weighing on average 24.4 kg initial live weight, and housed in individual pens, were allotted at random to the four experimental treatments. There was no significant interaction between oilseed source and DL-methionine supplementation in any evaluated trait except for DM conversion ratio, due to higher values in the soybean supplemented diet, possibly due to an inefficient extrusion process of the beans. After 12 weeks of trial there was no influence of oilseed source nor supplementation with DL-methionine on feed intake, final weight or average daily gain. Average feed intake was rather low, possibly due to the bulk characteristics of the water spinach. Water spinach contributed on average 18.7% to total daily dry feed intake. Crude protein content in the dry mixed feed was 11.5% in dry basis. The incorporation of water spinach to the daily ration increased the concentration of crude protein to 13.5% in the average feed consumed. It is suggested that full-fat rubber seeds can be included in substantial proportions in diets for growing pigs in the range of 25-60 kg with no deleterious effect on performance traits. Water spinach can contribute to increase the protein content of the diet when administrated *ad libitum* to growing pigs. Both locally available sources of protein can contribute to save protein consumption from other conventional sources. There was no significant interaction amongst any of the factors for digestibility indices. There was no significant influence of animal live weight on any of the digestibility coefficients. The diet with full-fat rubber seed meal had a lower DM and organic matter digestibility, compared with the soybean diet, but there was no oilseed source effect on N digestibility, which was always low. Digestibility indices appeared to be higher for diets supplemented with DL-methionine, but this effect only tended to be significant for organic matter digestibility. The high crude fibre proportion

in rations containing full-fat rubber seed meal (on average 24.8% in dry basis) had a highly significant negative influence in digestibility of DM and organic matter ($R^2$ 0.73 and 0.75, respectively) but there was no influence of dietary crude fibre on N digestibility. It is concluded that a sensible decrease in dry matter digestibility does not necessarily imply a decrease in energy availability to the animals due to the high crude fat content of these same diets (on average 12.5± 0.74% in dry basis). It could be suggested that little if any N is linked to the cell walls in rubber seed since in this experiment full-fat rubber seeds accounted for approximately 34% of the rations.

Key words: Rubber seed; Rubber seed meal; Soybean; Water spinach; Digestibility; Nitrogen; Organic matter; Pig diet; Cambodia

## 228 Rubber seed for oil

*India Rubber Journal*, 80:1930. 163.

(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed oil

## 229 Rubber seed (for oil production)

Philpott, M W

*Quarterly Circular Ceylon Rubber Research Scheme*, 24: 1947.36-38.

(Horticultural Abstracts, 1948. 661)

Key words: Rubber seed; Seed production; Industrial use; Seed collection; Ceylon

## 230 Rubber seed: Its biological and industrial applications- A review

Thomas, Vinoth; Mercykutty, V C and Saraswathyamma, C K

*The Planter*, 74 (869): 1998. 437-443.

Rubber seeds are utilised primarily for raising root stock for the propagation of high yielding varieties through budding. Seeds collected from well maintained polyclonal garden are recommended as planting material especially in non-traditional rubber growing areas. Seed morphological characters are unique for clones and hence assume taxonomic significance. Oil and cake obtained from the rubber seed have commercial importance. Products derived from rubber seed oil (RSO) are used in paint industry, for factice, for soft soap, in medicine as antimalarial oil, and in engineering as core binders. The study on the diesel engine performance test with RSO has been reported. Rubber seed cake has nutritive value and is being used in cattle and poultry feeds. Seed cake can also be used as good manure. The edibility of rubber seed has also been mentioned.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed cake; Clone identification; Industrial application; India

231 **Rubber seed kernel as cattle food**
Sen, K C
*The India Rubber Board Bulletin*, 3: 1952. 36-37.

Key words: Rubber seed; Rubber seed kernel; Cattle feed; India

232 **Rubber seed meal in poultry diets**
Buvanendran, V and De S Siriwardene, J A
*Ceylon Veterinary Journal*, 18(2): 1970. 33-38.

Key words: Rubber seed meal; Poultry diet; Chemical composition; Broiler chicken; Growth; Amino acid; Ceylon

233 **Rubber seed meal as a protein supplement in poultry feeding**
Rajaguru, A S B and Wettimuny, S G de S
*Rubber Research Institute of Sri Lanka Bulletin*, 8: 1975. 46-54.

Rubber seed meal (R.S.M) could be used successfully for broilers depending on the source of animal protein supplement used. R.S.M. could be used satisfactorily up to a 10% level with imported meat meal supplemented with methionine and up to 20% when imported fish meal is used. With imported meat meal as a protein source, R.S.M. could be supplemented up to 40% satisfactorily in rations for pullets from 3-6 months of age. The reduction in growth response observed when the R.S.M level in the diets was increased, particularly in broilers and growers less than 3 months of age, may be attributed to an amino-acid imbalance rather than to the presence of deleterious factors as often suggested. The pale liver condition and the feather picking observed in the 40% R.S.M. group in all experiments also confirm the possibility of an amino-acid imbalance in the diets. It would appear that birds have the capacity to overcome the adverse effects caused by the higher levels of R.S.M. as they mature and are then able to maintain a normal body weight and performance up to 40% levels of R.S.M.

Key words: Rubber seed meal; Nutritive value; Poultry diet; Feed efficiency; Protein supplement; Growth; Ceylon

234 **Rubber seed meal as a protein supplement in growing swine rations**
Rajaguru, A S B and Ravindran, V
*Journal of the National Science Council of Sri Lanka*,7(2): 1979.101-104.

A study was conducted to investigate the effects of different levels of rubber seed meal on the performance of growing swine. The results indicate that rubber seed meal could be included in swine rations only up to 10% level. Poor performance of swine fed on rations

containing 20% and 30% rubber seed meal was attributed to deficiencies of lysine and sulphur amino acids, rather than to the presence of cyanogenic glucosides.

Key words: Rubber seed meal; Protein supplement; Swine feed; Sri Lanka

235 **Rubber-seed oil**

*The India Rubber Journal*, 117: 1949. 499.

Key words: Rubber seed; Rubber seed oil

236 **Rubber seed oil**

Martin, G

*Rubber Developments*, 1(2): 1964. 6-7.

Rubber seed contains about 25% oil and it is reported that an American company used about 8000M.T of this oil in 1928 for various applications. Rubber seed deteriorates very fast and the oil extracted from such seeds is inferior in quality and suitable for the production of soft soap. Raising the temperature of the seed to 100°C for a minute can prevent the deterioration of the seed and good quality oil can be prepared from it. It was estimated that the total seed production in Malaya can yield about 60,000 M.T. of oil and hence proper collection of the seeds need to be organized availing the free time of the labourers and small farmers.

Key words: Rubber seed; Seed collection; Rubber seed oil

237 **Rubber seed oil**

*Paint Manufacture*, 17(9): 1947. 291-294.

Key words: Rubber seed oil; Paint; Commercial use

238 **Rubber seed oil**

*Paint, Oil and Colour Journal*, 120: 1951. 676.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed oil

239 **Rubber seed oil**

Stock, E

*Farben-Zeitung*, 39: 1934. 1096.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed oil

240 **Rubber seed oil**
Sundralingam, A
*Chemical Age*, 59:1948. 594.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed; Rubber seed oil; Oil extraction; Ceylon

241 **Rubber seed oil**
Tsuchiya, Tomotaro and Okubo, Osamu
*Journal of the American Oil Chemists' Society*, 30(9): 1953.385.

Key words: Rubber seed; Rubber seed oil

242 **Rubber seed oil: A multipurpose additive in NR and SBR compounds**
Nandanan, V; Joseph, Rani and George, K E
*Journal of Applied Polymer Science*, 72: 1999. 487-492.

Rubber seed oil was used as a multipurpose ingredient in natural rubber (NR) and styrene butadiene rubber (SBR) compounds. The study shows that the oil, when substituted for conventional plasticiser, imparts excellent mechanical properties to NR and SBR vulcanizates. Further, it also improves aging resistance, reduces cure time, increases abrasion resistance and flex resistance, and reduces blooming.

Key words: Natural rubber; Rubber seed oil; Multipurpose additive; Styrene butadiene rubber; India

243 **Rubber seed oil analysis and its possible use**
Hardjosuwito, Baryono and Hoesnan, Aman
*Menara Perkebunan*, 44(5): 1976. 255-259.

The potentiality of rubber seed oil production in Indonesia is great since this country is one of the principal rubber growing countries in the World, in area certainly the largest. The oil content of the rubber seed is 45-50%; the oil consists of 17-22% saturated fatty acids, palmitic, stearic and arachidic, and 77-82% unsaturated fatty acids, oleic, linoleic, and linolenic. The results of an investigation into the physical and chemical properties showed that the oil is promising for the drying oil and soap industry.

Key words: Rubber seed oil; Soap manufacture; Oil quality; Physico-chemical properties; Indonesia

244 **Rubber seed oil as a substitute for diesel fuel to use in the Sri Lankan rubber plantation industry**
Perera, E D I H

Ph.D. Thesis, Reading University, UK. 1988. 250 p.
(HORTCD. 1989-2002/06)

Key words: Rubber seed; Rubber seed oil; Diesel; Plantation industry; Sri Lanka

245 **Rubber seed oil: Extraction in Sumatra**
*India Rubber Journal*, 78: 1929. 416.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed oil; Oil extraction; Sumatra

246 **Rubber seed oil factice as processing aid in rubber goods manufacture**
Maspanger, Dadi R

*Menara Perkebunan*, 55(4):1987. 80-83.

Experiment was conducted using rubber seed oil as a processing aid in the rubber goods manufacture. The effect of rubber seed oil factice on the mixing process and the extrusion process were measured. The factice was synthesized from rubber seed oil by neutralized with $Na_2CO_3$, vulcanization with 25% sulphur and oxidation at 150°C. The experimental result showed that dark factice prepared from rubber seed oil has functioned well as processing aid in rubber goods manufacture with equal result as those obtained with commercial factice.

Key words: Rubber seed oil; Factice; Processing aid; Rubber goods manufacture; Indonesia

247 **Rubber-seed oil for paint**
Sthapitanonda, Kannika; Vimolchalao, Chot; Munsakul, Supatra and Udomsakdhi, Bancha

*Journal of National Research Council Thailand*, 13(2): 1981. 27-42.

The pilot process for producing modified rubber-seed oil is the polymerization using rubber-seed oil and dicyclopentadiene (DCPD), the percentages by weight of DCPD to the oil were 20-45. The mixture were reacted in closed system at a temperature range of 270° to 280° C., the reaction time was 6 to 24 hours in an Electo-Vapor Plant which was contributed by the Denver Research Institute, to produce pressure ranging from 50 to 70 psig. The resulted oil products, according to the tests conducted by Thailand Institute of Scientific and Technological Research (TISTR) and some commercial paint companies are suitable for interior paint decoration.

Key words: Rubber seed oil; Paint; Thailand

248 **Rubber seed oils**
Achaya, K T and Seavel, A J
*Journal of the Science of Food and Agriculture*, 2: 1951. 245.
(Cited by Eka, O U., 1977)

Key words: Rubber seed; Rubber seed oil

249 **Rubber seed oil: The untapped potential source in Karnataka, India**
Jayappa, V; Shanbhag, P K; Amminally, S and Patil, K B
*Karnataka Soaps and Detergents*, 85(12): 1983. 472-474.

Rubber seeds constitute 25 to 30 percent good fatty oil which is used as a major raw material in the manufacture of soaps. Karnataka with 7000 hectares of rubber plantation area and about 13 lakh trees is so far untapped for its seeds. It is expected to yield 660 tons of seeds during the current year and 1290 tons by 1984-85. The seeds collected from various rubber plantation divisions were extracted for oil and the oils were analysed for their fatty acid composition by gas liquid chromatography. Linoleic acid was the chief fatty acid (37.55- 41.57%), other major constituents being oleic, linolenic, palmitic and stearic acids. No arachidic oil was found in the samples.

Key words: Rubber seed; Rubber seed oil; Physico-chemical properties; Soap manufacture; India

250 **Rubber seed processing for the production of vegetable oil and animal feed. Phase Two**
*UNIDO, Project Report No.US/GLO/81/103*, UNIDO, Vienna,1989, 214 p.
(http://www.unido.org/data/ida/017854.cfm)

Expert report on the processing of rubber oilseeds for vegetable oils and animal feed production-covers (1) processing steps such as drying, decortication, storage and meal and oil extraction (2) research on the possible use of rubber seed as a basis to (a) edible oils, soap, plastics, etc., and (b) feed for poultry and swine (3) the feasibility of the various possible products, regarding i.a. capital costs for pilot plants, marketing, financial aspects of large scale production, etc.

Key words: Seed processing; Vegetable oil; Feed production; Poultry diet; Swine feed

251 **Rubber seed processing industry in India. Pt I.**
Veeraputhran, S and Joseph, Toms
*Planters' Chronicle*, 96(4): 2000. 177-182.

The study provides a brief sketch of the evolution of the rubber seed processing industry in India followed by an analysis of the trends in the production of rubber seed oil and cake

from 1976-77 to 1998-99. The annual availability of rubber seeds is estimated and the factors influencing the production are explained. The primary marketing of rubber seeds in India for nurseries intended for plant propagation and processing is looked into. The processing steps are described and the study reports an oil and cake recovery of 14.6 and 23.8 per cent from seed and 36.5 and 59.5 per cent from dried kernel, the balance being wastes.

Key words: Rubber seed; Rubber seed industry; Marketing; India

252 **Rubber seed processing industry in India. Pt II.**
Veeraputhran, S and Joseph, Toms

*Planters' Chronicle*, 96(6): 2000. 281-285.

The cost of processing of rubber seed oil and cake in India is estimated using 'split-off point' approach on the basis of the information collected from the processing units in the main processing centre of Virudhunagar district in Tamil Nadu. The properties of rubber seed oil and cake are explained along with hitherto reported commercial uses. In India rubber seed oil is entirely consumed in the low quality soap manufacturing industry. Rubber seed cake is purchased mainly by the cattle rearers around the processing centres for direct feeding. The marketing of rubber seed oil and cake is explained along with a comparative analysis of the prices of comparable oils and cakes.

Key words: Rubber seed; Seed processing; Industrial application; India

253 **Rubber seed processing industry: An overview (Malayalam)**
Veeraputhran, S and Joseph, Toms

*Rubber Mithram*, May: 2000. 27-33.

Key words: Rubber seed; Rubber seed industry; Seed processing; Seed collection; Chemical composition; Seed marketing; Commercial use; India

254 **Rubber seed production in Sri Lanka and its possible effects on the rubber planting material**
Seneviratne, Priyani

*Bulletin of the Rubber Research Institute of Sri Lanka*, 36: 1997. 51-54.

Key words: Rubber seed; Seed production; Planting material; Sri Lanka

255 **The rubber seed production in Sri Lanka: Results of an islandwide survey**
Seneviratna, Priyani; Witharana, L P P and de Alwis, M N

*Journal of the Rubber Research Institute of Sri Lanka*, 82: 1999. 22-30.

Seed production of rubber plantations in certain areas of Sri Lanka has gone down to very

low levels affecting the quality of the planting material i.e. budded stump. An island wide survey was therefore conducted to gain some knowledge on the quality and the quantity of the seeds produced on different clones in different climatic regions of Sri Lanka. The results confirmed that the regional effects most probably owing to climatic and weather factors are the main causes while the clonal effect was minimum. It was evident that the seed production in dry region is far more than the country's requirement for the production of budded stumps for annual replanting programme.

Key words: *Hevea brasiliensis*; Rubber seed; Seed production; Seed quality; Sri Lanka

256 **Rubber seeds as animal feed in Liberia**
Stosic, D D and Kaykay, J M

*World Animal Review*, Jul-Sept.: 1981. 29-39.

In the development of new resources of feeds for animals, studies have been initiated in Liberia on the potential use of rubber seeds for feeding farm animals. The main objective of this work has been to develop simple, cheap methods of detoxification of the seed, which contains the glucoside linamarin as a cyanogenetic factor. This is transformed by the action on the enzyme linamarase present in the seeds into prussic acid, which, when released, is poisonous to animals, preventing the use of these seeds for feeding.

Key words: Rubber seed; Animal feed; Nutritive value; Chemical composition; Liberia

257 **Rubber seed utilization and industrial applications (Malayalam)**
Thomas, Vinoth and Mercykutty, V C

*Rubber Mithram*, 1(2):1999. 44-47.

Key words: Rubber seed; Rubber seed oil; Industrial use; India

258 **Rubber seed viability on different size and presoaking duration**
Artuti, A M; Hasan, Z and Ramilus

*Jurnal-Stigma (Indonesia)*,7(2):1999. 6-13.
(AGRIS. 1999-2001/08)

A study to identify appropriate type of seed sizes and pre soaking duration in order to high seed viability in rubber seed was done at SMK-2 Batusangkar green house, West Sumatra from August to October 1997. A factorial in Randomized Complete Block Design with three replications was used in experiment. The factors were seed sizes (Small=220 seed/488 g/ll, middle= 175 seed/462 g/l and big= 123 seed/401 g/l) and pre soaking duration (0 hour, 24 hours and 72 hours). The results showed that the highest seed viability was found in the middle or bigger sizes (5.8 g and 6.05 g seedling dry) and the seeds were presoaking in water about 48 hours (germination rate 3.39 percent/ day).

Key words: *Hevea brasiliensis*; Rubber seed; Seed viability; Seed size; Soaking; Moisture content; Indonesia

## 259 Seed biology of para rubber tree (*Hevea brasiliensis* Muell. Arg., Euphorbiaceae): A review

Thomas, Vinoth; Mercykutty, V C and Saraswathyamma, C K

*Phytomorphology*, 46(4): 1996. 335-342.

Morphology, viability, storage and germination of seeds *Hevea brasiliensis* are described. The seed is large, ovoid dorsoventral with irregular dark brown and grey lines or blotches on the seed coat. These characters are specific for each clone and used for clone identification. *Hevea* seeds are recalcitrant due to their high moisture content, and lose viability even with short term storage under optimum conditions, hence they should be planted soon after collection. Seeds of good physiological quality can be stored for up to 4 months without losing viability under specific conditions. Seed viability can be detected by germination tetrazolium, electrical conductivity or FFA tests. Seeds collected from well maintained polyclonal gardens can be utilized for genetic improvement of rubber.

Key words: *Hevea brasiliensis*; Rubber seed; Seed biology; Seed viability; India

## 260 Seed production of clones PB 86, RRIC 100 and RRIC 121 in three rubber growing areas of Sri Lanka

Seneviratne, Priyani; Nugawela, A; Amaratunge, K A G B; Karunasena, R P and Wilbert, S

*Journal of the Rubber Research Institute of Sri Lanka*, 79:1997.31-44.

The rubber seed production in wet rubber growing areas in Sri Lanka has gone down to very low levels in the recent past, affecting the culling process that should be adopted in establishing rootstock nurseries. From the three rubber growing areas studied, satisfactory seed production irrespective of the clone was observed only in Kegalle region. Regional differences may be due to direct or indirect influences of the climate and weather during flowering and pod set. Clonal differences seems to be existing in regions where climate or the weather is favourable for spread of diseases. Further, RRIC 100, being a resistant clone for *Oidium* and *Phytophthora*, produced a higher percentage of good quality seeds compared with the other two clones, PB 86 and RRIC 121 which have below average tolerance to these two diseases. However, currently country as a whole produces enough seeds to fulfil country's annual seed requirement for the production of rootstocks, provided the seeds are collected and transported without delay.

Key words: *Hevea*; Rubber seed; Seed production; Seed quality; Seed germination; Weather conditions; Disease incidence; Sri Lanka

## 261 Serum and liver lipids of rats fed rubber seed oil

Nwokolo, E; Kitts, D D and Kanhai, J

*Plant Foods for Human Nutrition*, 38(2): 1988. 145-153.
(AGRICOLA. 1984-12/91)

Key words: Rubber seed oil; Rat feed; Serum; Liver lipids

262 **A simple method for the detection of rubber seed oil in other vegetable oils**
Chatterjee, K L and Baiswara, R B

*Indian Oil and Soaps Journal*, 37: 1972. 311-312.

Key words: Rubber seed oil; Vegetable oil; India

263 **Solution behaviour of rubber seed oil-modified alkyd resins**
Aigbodion, A I; Pillai, C K S and Bakare, I O

*Indian Journal of Natural Rubber Research*, 14(1): 2001. 48-54.

Solution behaviour of rubber seed oil (RSO) alkyds having oil content of 40, 50 and 60 per cent was investigated. Viscosity measurements of the finished alkyds were carried out in toluene and dimethyl formamide (DMF) while those of samples withdrawn periodically during preparation of the alkyds were determined in toluene solution at 30±5°C. The parameters investigated include intrinsic viscosity [η], Huggins (KH), Kraemer's (KK) and Mark-Houwink-Sakurada (MHS) constants (k,k' and α). [η] values for the alkyds are found to be influenced by their capability to form hydrogen bond with solvent molecules. Hence [η] values for samples I and III with capability to form hydrogen bonds are larger in DMF (a relatively basic solvent); while [η] value for sample II with less tendency to associate with solvent molecule is larger in toluene. Values of KH and KK show no regularity in their variation with respect to the type of alkyd and solvent. MHS relationship was found to be applicable to RSO alkyds. Correlation of [η] with degree of polymerization (DP) and average molecular weight from end group analysis (Mav) showed a linear relationship. Variation in molecular weight distribution (MWD) of the alkyds as deduced from the MHS constants, k k' is of the same order as that found from polydisperity indices obtained from GPC analysis of alkyds.

Key words: Rubber seed oil; Alkyd resin; Intrinsic viscosity; Mark-Houwink-Sakurada equation; Solution behaviour

264 **Solvent extraction of the oils of rubber, melon, pumpkin and oilbean seeds**
Attah, J C and Ibemesi, J A

*Journal of the American Oil Chemists' Society*, 67(1): 1990. 25-27.
(HORTCD. 1989-2001/03)

Solvents of differing dielectric constant were used to extract oils from the seeds of rubber (*Hevea brasiliensis*), melon (*Colocynthis vulgaris*) [*Citrullus colosynthis*], fluted pumpkin (*Telfairia occidentalis*) and oilbean (*Pentaclethra macrophylla*). The aim was to examine the effect of solvent polarity on oil yield and oil properties. The oils were extracted under Soxhlet conditions with the following solvents: petroleum benzene (60-80°C), cyclohexane, isopropyl ether, ethyl acetate, tetrahydrofuran, propan-2-ol and acetone. The oils were characterized by acid number, iodine value and colour intensity determinations. The oil

yields of each seed in different solvents ranged as follows: 58.0-64.4% (pumpkin), 56.1-59.1% (melon), 40.6-48.8% (rubber) and 35.4-43.3% (oilbean). The equilibrium extracting capacity of each solvent was found to depend on the nature of the oil and the polarity of the solvent. Both factors were found to determine the acid number, iodine value and colour intensity of each oil.

Key words: Rubber seed oil; Melon seed oil; Oil extraction; Solvent extraction; Oil seed plant; Nigeria

## 265 Some nutritional and anti-nutritional characteristics of Para-rubber (*Hevea brasiliensis*) seeds

Ravindran, V and Ravindran, G

*Food Chemistry*, 30(2):1988. 93-102.
(HORTCD. 1989-2001/03)

Para rubber (*Hevea brasiliensis*) seeds were examined for their proximate analysis, detergent fibre, amino acid and mineral composition. The seeds were further analysed for the presence of antitrypsin activity, cyanide, phytate and tannins. The average composition of the seed kernel was, on a DM basis, 21.5% crude protein, 50.2% crude fat, 6.5% crude fibre, 3.6% ash and 18.2% carbohydrates. The amino acid profile, when compared with the NAS/NRC reference protein pattern, revealed deficiencies of lysine, isoleucine and threonine. The seed kernels contained reasonable amounts of trace minerals, but were poor sources of calcium and phosphorous. Fresh seed kernel samples contained toxic concentrations of cyanide (164 mg/100 g dry weight) but most of the cyanide was eliminated by storage and cooking. The relatively high content of phytate P (37.5% of total P) may be expected to aggravate further the problem of low P and to cause severe Ca and P imbalance. No antitryptic activity or tannins was detected. Because of the presence of an antifertility factor and collection and storage problems, it is concluded that rubber seeds show little promise as a human food in normal times.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed kernel; Seed composition; Nutritive value; Sri Lanka

## 266 Some studies on controlling the action of lipase and linamarase during rubber seed kernel processing

Mallika,G Vitharanage; Jansz, E R; Pieris, Nirmala M and Abeysekara, A M

*Journal of the National Science Council of Sri Lanka*, 19(2): 1991. 143-150.

Rubber seed kernel contains a lipase whose action results in free fatty acid formation and a linamarase (EC 3.2.1.21) liberating cyanide from cyanogenic glucosides. Both enzymes require moisture to act, the former a detrimental action and the latter a beneficial one. The critical path of rubber seed kernel processing appears to be collection of seeds fresh

(preventing germination induced lipases from acting) and drying to 10-12% moisture to prevent basal endogenous lipase activity and thus produce an oil low in free fatty acid. Linamarase not only acts during drying to liberate > 70% cyanide but also survives the drying and oil expelling stages of processing. The surviving endogenous enzyme activity can be utilized to detoxify rubber seed meal upon re-moistening.

Key words: Rubber seed; Rubber seed kernel; Kernel processing; Lipase activitis; Fatty acid; Cyanide content; Detoxification; Sri Lanka

267 **Storage behaviour of seeds of *Hevea brasiliensis***
Berjak, Patricia

*Journal of Natural Rubber Research*, 4(3):1989. 195-203.

Key words: *Hevea brasiliensis*; Rubber seed; Seed viability; Seed storage

268 **Storage of recalcitrant seeds: Past, present and future**
Chin, H F

*In: Tropical Tree Seed Research: ACIAR Proceedings*, Series No.28 (Ed. J W Turnbull). Forestry-Training Centre, Australia, Queensland, 1989, pp. 89-92.
(Horticultural Abstracts, 61: 1991. 1585)

Key words: Rubber seed; Cocoa seed; Seed storage; Recalcitrant seeds

269 **Storage of rubber seeds**
Georgi, C D V; Greenstreet V R and Teik, Gunn Lay

*Malayan Agricultural Journal*, 20: 1932. 164-176.

Key words: *Hevea brasiliensis*; Rubber seed; Seed storage; Malaya

270 **Strategy for effective storage of rubber seeds, oil and cake**
Okoye, W I

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference*. (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp.123-129.

The rubber tree, (*Hevea brasiliensis*) is an important economic crop in Nigeria. It has been grown in the country for over 80 years. Recent research work in Nigeria has indicated that the oil extracted from rubber seeds could be an acceptable substitute for imported oils used in the paints and leather industries. The possibility of using the seed cake in feed meals is also being intensively investigated. The greatest handicap in the use of rubber seed and its products arise from the seed storage difficulties. Experiments have, however,

shown that at a low moisture content, the unshelled seeds can store well for about 8 weeks in polythene bags and for a longer period in sharp sand in earthenware pots. Seeds subjected to 48 hours cold shock treatment, in sealed polythene bags have also been shown to store equally well. Recent research work has shown that fresh rubber seeds contain 52.86mg/100mg vitamin C. As storage in sharp sand progressed, the aflatoxin and crude protein levels in shelled seeds increased. The reverse was the case for the vitamin C and HCN contents. These parameters were constant for the unshelled seeds. As drying of seeds before storage is imperative, strict storage hygiene should be maintained to prevent further spoilage due to mould and insect pest attack. Investigations into the improved storage methods-sharp sand in earthenware pots and cold shock treatment are continuing for more conclusive results. Large containers are to be fabricated for bulk storage of seeds.

Key words: *Hevea brasiliensis*; Rubber seed; Rubber seed oil; Rubber seed cake; Seed storage; Nigeria

## 271 Studies in Indian rubber seed and rubber seed oil. II Processing

Azeemoddin, G; Kristappa, G; Thirumala Rao, S D and Reddy, B R

*Journal of the Oil Technologists' Association of India*, 7(3): 1975. 74-76.

Rubber seed was decorticated mechanically in a Kalyan type groundnut decorticator. Rubber seed, both as meats and as whole seed was cooked and crushed in a standard expeller. Oil yields varying from 9 to 13 percent were obtained as against about 24 per cent oil content in the whole seed. In our earlier paper, data on the availability, characteristics and composition of seed and oil were presented. Huge quantities of rubber seed produced in rubber plantations in Kerala and Tamil Nadu are being wasted. Rubber seed forms a potential source of oil which can be put to several industrial applications.

Key words: Rubber seed; Decortication; Rubber seed oil; India

## 272 Studies in molecular weight determination of rubber seed oil alkyds

Okieimen, F E and Aigbodion, A I

*Industrial Crops and Products*, 6: 1997. 155-161.

Molecular weights of six samples of rubber seed oil alkyds having oil content of 20% (I), 30% (II), 35% (III), 40% (IV), 50% (V), and 60% (VI) prepared with phthalic anhydride, glycerol and rubber seed oil were determined (Rast method) and calculated (endgroup analysis). Properties of the rubber seed oil were specific gravity 0.926, colour 0.5R 10Y, free fatty acid 11.29, peroxide value 0.40, saponification value 192.93, iodine value 155.56 and unsaponifiable matter (%) 0.84. Average molecular weights determined, ranged from 441.11 for sample III to 1323.33 for sample V and those calculated range from 1165.52 for sample I to 4769.52 for sample IV. Although average molecular weights calculated were found to be larger than the values determined, rast method seems to be a more reasonable method of average molecular weight determination for routine analysis. The differences observed were attributed to the assumption that only interesterification reactions

occur during alkyd preparation in calculating average molecular weights. Fractionation of the alkyds showed that rubber seed oil alkyds consist of fractions of varying molecular weights. Study of molecular weight distribution showed that species of low average molecular weight constitute greater proportion of the alkyds. Average molecular weights of the final alkyds vary with the amounts of reactants used in the preparation. Ability of a thin layer of the alkyds to air-dry was found to be dependent on solid content, viscosity of alkyd solution and level of unsaturation in the final alkyd. Thus alkyds containing 40% rubber seed oil and above were found to be air-drying while those containing lower oil content are considered suitable in formulating baked finishes or can be combined with other film-forming resins.

Key words: Rubber seed oil; Alkyd resin; Molecular weight; Viscosity; Saponification value; Drying; Polymerization; End group analysis; Nigeria

## 273 Studies in the thermal degradation of poly (vinyl chloride)

Okieimen, Felix E and Ebhoaye, Justus E

*Journal of Applied Polymer Science*, 48:1993. 1853-1858.

Thermal degradation of poly (vinyl chloride) (PVC) was studied in nitrogen atmosphere in the presence of rubber seed oil and epoxidized rubber seed oil, barium and lead soaps of rubber seed oil, and epoxidized seed oil at various temperatures. The rate of dehydrochlorination at 1% degradation and the time required to attain 1% degradation were used to assess the effect of the additives on the thermal susceptibility of PVC to dehydrochlorination. It was found that epoxidized rubber seed oil, the metal soaps of rubber seed oil, and epoxidized rubber seed oil markedly enhance the thermal stability of PVC. The order of increasing stabilizing influence was metal soaps of epoxidized rubber seed oil>metal soaps of rubber seed oil>epoxidised rubber seed oil>rubber seed oil.

Key words: Rubber seed oil; Thermal degradation; Polyvinyl chloride; Epoxidation; Metal soap; Dehydrochlorination; Nigeria

## 274 Studies in the utilization of rubber seed oil in the preparation of alkyd resins

Aigbodion, A I

Ph.D. Thesis, University of Benin, Benin City, Nigeria, 1995.

The preparation of alkyd resin with rubber seed oil, phthalic anhydride and glycerol was investigated. This study explored the effects of variation in the alkyd ingredients (formulation) and reaction conditions on the molecular weight and consequently quality of the alkyd resin. The rubber seed oil which was extracted by mechanical screw press characterized in terms of specific gravity, colour, free ratty acid content, acid value, peroxide value, saponification value, iodine value and unsaponifiable matter. The results show that the rubber seed oil is highly acidic (ffa=11.29) and tends to suggest susceptibility of the oil to possible spoilage even right in the seed due to hydrolysis before extraction. The fatty acid profile of rubber seed oil showed that the oil is made up of 20.5% saturated fatty acids

(myristic, palmitic and stearic acids) and 79.5% unsaturated alkyd acids (oleic, linoleic and linolenic acids with linoleic acid accounting for about 36.0% of the total fatty acid content). The iodine value of rubber seed oil was found to be 155 and puts the oil in the same group as linseed oil commonly used in surface coating. Alkyd resins were prepared using recipes containing various amounts of rubber seed oil, phthalic anhydride and glycerol using the alcoholysis method and working temperature ranged from 230-250°C. The reaction was monitored by the simultaneous determination of the acid value of aliquot of the reaction mixture and the volume of water evolved at various time intervals. Kinetic analysis showed that the initial stages of alkyd preparation can be described by the second order rate law and thereafter deviations from second order kinetics were observed. The point of deviation from second order kinetics occurred at the onset of gel (three-dimensional network) formation. This deviation was found to be characteristic for all the recipes used in the preparation of the alkyd resins and occurred at about the same time of reaction irrespective of the proportions of ingredients used. The extent of reaction at this region of deviation from second order kinetics ranged from 50.6% to 74.83%. The molecular weights of samples of the alkyd resin were determined by the rast method and the endgroup analysis. It was found that endgroup analysis tends to over estimate molecular weight as a result of the basic assumption that only interesterification reaction occurred. The observed difference was explained in terms of intramolecular reaction. Fractionation of samples of alkyd resin was carried out by addition of n-heptane to the solution of the alkyd in toluene (5% w/v). It was found that only a small proportion of the alkyd resin contain high molecular weight species. Viscosity measurements were carried out on fractions of the alkyd resins and of the unfractionated samples of alkyd resins in dimethyl formamide (DMF) and methyl ethyl keton (MEK). The values of intrinsic viscosity of the alkyd resin were larger in DMF than in MEK. The values of the viscosity (Huggins) parameters, k and a were determined for the samples of alkyd resins in DMF and MEK and it was found that the values of k vary from $2.14 \times 10^{-2}$ to $8.79 \times 10^{-2}$ in DMF and from $1.74 \times 10^{-2}$ to $2.34 \times 10^{-2}$ in MEK while values of $\Delta$ vary from $2.14 \times 10^{-2}$ to $8.79 \times 10^{-2}$ in MEK while values of $\Delta$ vary from 0.11 to 1.20 in DMF and from 0.12 to 1.82 in MEK. The properties of the alkyd resins such as colour, acid, value, saponification value, iodine value and solid content and the performance characteristics of the alkyd resin such as viscosity of application and drying schedules were determined. The performance characteristics show that rubber seed oil alkyd resins are comparable to commercial grade alkyd resin.

Key words: Rubber seed oil; Alkyd resin

275 **Studies on epoxidized rubber seed oil as plasticizer for acrylonitrile butadiene rubber**
Joseph, Reethamma; Alex, Rosamma; Vinod, V S; Premalatha, C K and Kuriakose, Baby

*Journal of Applied Polymer Science*, 89: 2003. 668-673.

The application of rubber seed oil (RSO) and epoxidized RSO (ERSO) as a plasticizer in acrylonitrile butadiene rubber (NBR) was studied using RSO and ERSO with different levels of epoxidization. The results indicated that ERSO could be used as a less leachable and low volatility plasticizer for NBR. The use of ERSO in NBR gave better abrasion

resistance whereas the tensile strength and tear strength were comparable to those vulcanizates that contained dioctyl phthalate as a plasticizer.

Key words: Rubber seed oil; Epoxidation; Nitrile rubber; Plasticizers; India

## 276 Studies on storage behaviour of rubber seed oil

Aigbodion, A I

*Indian Journal of Natural Rubber Research*, 12(1&2): 1999. 29-33.

Quality assessment of rubber seed oil stored in different types of containers was carried out. Oil samples were stored in metal container with inside coating, plastic container and brown coloured bottle at ordinary atmospheric conditions, for a period of six months. During storage, there was no appreciable increase in free fatty acid and peroxide values at the initial stages until after four weeks. Sample stored in metal container with coating inside showed the lowest values for both free fatty acid and peroxide and the highest for iodine after twenty four weeks of storage.

Key words: Rubber seed oil; Seed storage; Seed quality; Deterioration; Nigeria

## 277 Studies on the alcoholysis of some seed oils

Igwe, I O and Ogbobe, O

*Journal of Applied Polymer Science*, 78(10):2000.1826-1832.

Studies were carried out on the effects of time and temperature on the alcoholysis of rubber seed, melon seed, linseed, and soyabean oils. Temperatures investigated were: 200, 220, 245, and 260 degrees Celsius. The alcoholysis catalyst used was Litharge (PbO). The optimum alcoholysis temperature was found to be 245+ or -2 degrees Celsius, for each of the oils. At lower alcoholysis temperatures (less than 245 degrees Celsius), there is the preferential alcoholysis of seed oils derived from unsaturated acid; and the general alcoholysis rates were found to be in the following order: linseed oil approximately equal to rubber seed oil greater than or equal to soyabean oil approximately equal to melon seed oil. Generally, the alcohol solubility of the oils is observed to start at 42-45 percent conversion of oil to monoglycerides. The alpha-monoglyceride contents of the alcoholysis mixtures of rubber seed and linseed oils were generally similar at methanol tolerance, and higher than those of melon seed and soyabean oils.

Key words: Rubber seed oil; Soybean; Linseed oil; Monoglycerides; Alkyl hydroxide; Litharge; Alcoholysis; Nigeria

## 278 Studies on the epoxidation of rubber seed oil

Okieimen, F E; Bakare, O I and Okieimen, C O

*Industrial Crops and Products*, 15(2): 2002. 139-144.

The kinetics epoxidation of rubber seed oil (RSO) by peroxy acetic acid generated *in situ*

were studied at various temperatures. It was found that epoxidation with almost complete conversion of unsaturated carbon and negligible oxirane cleavage can be attained by the *in situ* technique. The rate constant for epoxidation of RSO was found to be of the order of $10^{-6}$ l $mol^{-1}$ $s^{-1}$ and activation energy of epoxidation of 15.7 kcal $mol^{-1}$ was determined. Some thermodynamic parameters: enthalpy, entropy and free energy activation of 15.2, 31.94 and 25.44 kcal $mol^{-1}$, respectively were obtained for the epoxidation of RSO. The kinetic and thermodynamic parameters of epoxidation obtained from this study indicate that an increase in the process temperature would increase the rate of epoxide formation.

Key words: Rubber seed oil; Epoxidation; Kinetics; Peroxyacetic acid; Nigeria

## 279 Studies on the physico-chemical properties of rubber (*Hevea brasiliensis*) seed oil and identification of different higher fatty acids of the oil and analysis of the seed cake

Mahbub-Ul-Haque Majumder, S M

*Chittagong University Studies, Part II. Science*, 14(1): 1990.31-35.

The rubber seed oil (RSO) extracted from dried seeds using petroleum ether contain a high level of unsaturation as revealed from codine number and refractive index. The viscosity and the energies of activation for flow of rubber seed oil are close to that of olive oil and soyabean oil. The fatty acids of oil separated by acid hydrolysis followed by urea complex formation shows the presence of about 85% unsaturated fatty acids, of which the major constituent is oleic acid. The seed cake obtained after removal of oil is a rich source of protein which can be used as cattle feed after purification. Oil was extracted from the seed of rubber (*Hevea brasiliensis*) and then purified. After purification its different physical and chemical constants were determined. Higher fatty acids were identified by urea-inclusion method and by thin layer chromatography. From the cake of the oil ash, protein, reducing sugar and starch contents were determined.

Key words: *Hevea brasiliensis*; Rubber seed oil; Rubber seed cake; Physico-chemical properties; Fatty acid; Bangladesh

## 280 Studies on the properties of polyesters and polyester blends of selected vegetable oils

Igwe, I O and Ogbobe, O

*Journal of Applied Polymer Science*, 75(12): 2000. 1441-1446.

Melon-seed and rubber-seed oils have been used in the synthesis of polyester resins. Results reveal that rubber-seed oil can completely be substituted for linseed and soyabean oils in the synthesis of both long and medium-oil-length polyester resins. Melon-seed oil was found to be a substitute for 50% of linseed oil and 50% of soyabean oil in the synthesis of long oil-length polyester resins. It also substituted for 15% of linseed oil and 50% of soyabean oil in the synthesis of medium oil length polyester resins.

Key words: Rubber seed oil; Vegetable oil; Surface coatings; Polyester resins; Blend; Drying; Fatty acid; Nigeria

281 **Studies on the utilisation of rubber (*Hevea brasiliensis*) seed cake as an ingredient in concentrate ration for dairy cows**
Menachery, Maggie and Ananthasubramaniam, C R
*Indian Journal of Nutrition and Dietetics*, 15: 1978. 350-355.
(Cited by James, C S., *et al.*,1980)

Key words: *Hevea brasiliensis*; Rubber seed cake; Cattle feed; India

282 **Studies on the utilisation of rubber kernel oil meal in chick starter diets**
Narahari, D; Venugopal, K and Kothandaraman, P
*Indian Journal of Poultry Science*, 19(4): 1984. 251-255.

SCWL female chicks were fed diets containing 0, 5, 10 and 15% levels of Rubber Kernel Oil Meal (RKOM) replacing Groundnut Oil Meal (GNOM) from 0-8 weeks of age with or without lysine and methionine supplementation. Body weight gain was more in amino acid supplemented groups than in unsupplemented groups, irrespective of the dietary RKOM levels. Better feed efficiency was observed in the control and in the amino acid supplemented groups. Livability was not affected by the dietary RKOM levels. Diets containing higher levels of RKOM and amino acid unsupplemented diets were cheaper than the amino acid supplemented diets. RKOM could be safely used in chick starter diets up to 15% level with lysine and methionine supplementation.

Key words: Rubber seed kernel; Rubber seed meal; Chemical composition; Poultry diet; Broiler chicken; Groundnut oil meal; India

283 **Studies on use of rubber seed oil in natural rubber latex foam production**
Joseph, Reethamma; Premalatha, C K and Kuriakose, Baby
*Proceedings of the Ninth Kerala Science Congress*, January 1997, Thiruvananthapuram, pp.1-2.

Natural rubber latex foam was prepared by using rubber seed oil soap as well as potassium oleate. Evaluation of properties indicated that the quality of the foam obtained by using rubber seed oil soap was comparable to that prepared from potassium oleate and conforms to the BIS specifications. Use of rubber seed oil soap was found to be more economical.

Key words: Rubber seed oil; Natural rubber; Latex foam production; India

284 **A study of the heritability of oil content in cotyledons of *Hevea* seedlings**
Fernando, D M; Tambiah, M S; Abeywardena, V and Samaranayake, P
*Quarterly Journal of Rubber Research Institute of Ceylon*, 47: 1970. 70-72.

Appreciable heritability was discovered in the oil content of *Hevea* cotyledons. This oil content was also found to be significantly inversely correlated with height of the seedlings.

The inverse relationship with growth suggested a hormonal mechanism and chromatographic analysis revealed an inhibitor as well as a stimulator in the oil.

Key words: *Hevea brasiliensis*; Rubber seed; Seedlings; Oil content; Heritability; Ceylon

**285 Study on blending and polymerizing of para rubber seed oil with some kinds of drying oil for industrial purpose**

Paichit-Chandrawong; Virasak-Anumbutt and Wilaisri-Limpaphayom

*Research Report in 1984: Rubber, Sericulture, Farming system*, Dept. of Agriculture, Bangkok, Thailand, 1986, pp. 2.
(AGRIS. 1993-1994)

Key words: Rubber seed oil; Blend; Polymerization; Drying; Industrial use; Thailand

**286 Study on rubber seed oil and its minor component (unsaponifiable matter) [in Thailand]**

Kato, A; Tanaka, A and Wimonsri-Thewaphalin

*Annual Report*, 1978. Ministry of Agriculture and Cooperatives, Bangkok (Thailand). Dept. of Agriculture, Agricultural Chemistry Division, pp. 346-348.
(AGRIS. 1975-1980)

Key words: Rubber seed; Rubber seed oil; Minor components; Thailand

**287 Study on the success of bud healing and post-budding growth of GT-I clone of rubber seed, taken from different mother plants, and with different seed harvesting time**

Yakup, S; Rofiq, M; Sudrajat, D and Kusumastuti, A

*Jurnal -Penelitian-Pertanian-Terapan (Indonesia)*, No.3: 1998. 8-13.
(AGRIS. 1999-2001/08)

Budding is the most common method and widely used by nurseryman in propagation nursery stock of rubber (*Hevea brasiliensis* Muell Arg). But the budding is often unsuccessfully, because of the unsuitable techniques of budding, physiological factors and plant environment. This study is aimed at to study the success of bud healing and postbudding growth of rubber GT-1 was conducted as an experiment at Kebun Politeknik Pertanian Bandar Lampung from December 1997 up to May 1998. The treatment combination consisted of three levels of stock plant age (8, 12, 20) years old and three levels of seed-picking time (early, middle and end) during one cycle of generative period. Complete randomized block design was arranged in 3 x 3 factorial treatment design with three replications. The result showed that seed which derived from 14 years old stock

plant was the most valuable rootstock material compared to those derived from 8 and 20 years old stock plant. Those facts were indicated by the presence of bud healing, stem diameter and plant height. Whereas the seed-picking time was not significantly different to all parameters. There was no interaction between stock plants age and seed-picking time on bud healing successful and post budding growth of GT-1 rubber.

Key words: *Hevea brasiliensis*; Rubber seed; Budding; Seedlings; Growth; Mother plant; Indonesia

288 **Substitutes of para rubber seed meal for soybean meal in broiler ration**
Samret-Asasuk

Thesis, M.Sc. in biology, Kasetsart University, Bangkok, Thailand, 1992.
(AGRIS. 1/97-2/98)

Key words: Rubber seed meal; Soybean meal; Broiler chicken; Thailand

289 **Substitution of cotton seed cake by rubber seed cake in the feeding of broilers**
Endeley, H N L; Tchoumboue, J and Tchouken, M D

*Proceedings of an International Symposium*, 30 Nov-2 Dec: 1983, Wageningen, Netherlands, pp. 67-68.
(AGRIS. 1981-1985)

Key words: Rubber seed cake; Animal nutrition; Cotton seed cake; Broiler chicken

290 **Supply of *Hevea* seed for rootstocks production**
Indraty, I S

*Risalah-Penelitian (Indonesia)*, No.13: 1987. 30-37.
(AGRIS. 1993-1994)

Key words: *Hevea brasiliensis*; Rubber seed; Rootstock; Indonesia

291 **Synthesis and molecular weight characterization of rubber seed oil-modified alkyd resins**
Aigbodion, A I and Pillai, C K S

*Journal of Applied Polymer Science*, 79:2001. 2431-2438.

Alkyd resins of 40% (I), 50% (II), and 60% (III) oil length (OL) were prepared with rubber seed oil (RSO), phthalic anhydride (PA),and glycerol (GLY), employing the two-stage alcoholysis method. Changes in the physical characteristics of the reaction medium were monitored by determination of the acid value and the number-average molecular weight, $\bar{M}n$, of in-process samples withdrawn at different stages of the reaction. The mode of variation of these properties denotes that the preparation of RSO alkyds is complex.

Molecular weight averages and the molecular weight distribution (MWD) of the finished alkyds were determined by GPC, cryoscopy, and end-group analysis. Molecular weight averages and the MWD vary with differences in the formulation, with the sample II exhibiting the narrowest size distribution. Values of $\bar{M}n$ with the corresponding polydispersities in brackets are 3234 (1.91), 1379(1.56), and 3304 (2.56) for samples I,II and III respectively. $\bar{M}n$ values obtained by cryoscopy are comparable to those obtained by gel permeation chromatography (GPO), while endgroup analysis seems to grossly overestimate their molecular weights. Correlation of $\bar{M}n$ and the MWD with the quality of the finished alkyds shows that the narrower the size distribution the better the quality of the alkyd. Properties such as the rate of drying and resistance of the alkyds are optimum at 50% OL.

Key words: Rubber seed oil; Molecular weight; Cryoscopy; Alkyd resin; End group analysis

## 292 Synthesis, characterisation and evaluation of heated rubber seed oil and rubber seed oil-modified alkyd resins as binders in surface coatings

Aigbodion, A I; Pillai, C K S; Bakare, I O and Yahaya, L E

*Indian Journal of Chemical Technology*, 8(Sept): 2001. 378-384.

Rubber seed oil (RSO) heated at 300±5° C for six hours and RSO-modified alkyd resins were evaluated as binders for surface coatings. During heating of rubber seed oil, the bulk viscosity varied exponentially with time. GPC analysis showed that RSO consists of a very high molecular weight fraction that is uncommon in vegetable oil in addition to free fatty acid, mono- di-, tri-glycerides and oligomeric tryglycerides. Values of $\bar{M}n$ and $\bar{M}_w$ of 7393 and 13076 respectively were found for RSO. Heated rubber seed oil (HRSO) gave $\bar{M}n$ of 475 and $\bar{M}_w$ of 599; while RSO- modified alkyd samples of oil contents respectively. HRSO is narrowest in size distribution compared to RSO and all the alkyd samples as indicated by their polydispersity indices. RSO was found to be semi-drying as the film remained tacky after long period (about 48h) of exposure. Heating enhanced its drying ability. The HRSO films exhibited reasonable pencil hardness and excellent resistance to acid and salt solution but poor resistance to alkali solution compared to the alkyd samples. The drying ability and chemical resistance of HRSO and RSO-modified alkyd were greatly enhanced by modification with cashewnut shell liquid-formaldehyde resin (10% w/w).

Key words: Rubber seed oil; Alkyd resin; Binders; Surface coatings; Drying; Nigeria

## 293 Temperature effects on the extraction of rubber and melon seed oils

Ibemesi, J A and Attah, J C

*Journal of the American Oil Chemists' Society*, 67(7): 1990.443-445.
(HORTCD. 1989-2001/09)

Oils were extracted from the seeds of rubber (*Hevea brasiliensis*) and melon (*Colocynthis vulgaris* {*Citrullus colocynthis*} using different solvents at varying temperatures. The objective was to determine temperature coefficients (n) for enhanced oil removal and the enthalpy

changes accompanying the extraction process. Values of n, obtained from the slopes of the plots of the natural logarithm of equilibrium oil yield against T 10, showed that oil yield increased by a factor of about 1.10 for every 10°C rise in temperature. Also, n values were used to predict oil yields at other temperatures by knowing the oil yield at a given temperature. Enthalpy changes (DELTAH) in the extraction of both oils were determined using the Arrhenius equation. The DELTAH values obtained were in the range of 4-13.3 kJ $mol^{-1}$, indicating the physical nature of oil extraction by a solvent.

Key words: Rubber seed oil; Melon seed oil; Oil extraction; Temperature

## 294 Thermal dehydrochlorination of PVC in the presence of metal soaps derived from rubber seed oil

Okieimen, Felix E and Ebhoaye, Justus E

*European Polymer Journal*, 28(11): 1992. 1423-1425.

Thermal dehydrochlorination of PVC was studied in nitrogen in the presence of 3wt% of the barium, cadmium and lead soaps from rubber seed oil. The time required for dehydrochlorination to attain 1% ($t_{DH}$) and the rates of dehydrochlorination at 1% degradation ($R_{DH}$) in the presence of the metal soaps were compared with values obtained with metal soaps from oleic and linoleic acids. The results from these kinetic studies, together with the data from viscosity measurements of the degraded samples in cyclohexanone, show that the soaps from rubber seed oil are relatively effective in suppressing thermal dehydrochlorination of PVC and also that chain scission was a predominant reaction during the degradation of PVC in the presence of the metal soaps.

Key words: Rubber seed oil; PVC; Dehydrochlorination; Thermal degradation; Metal soap; Nigeria

## 295 Thermal dehydrochlorination of PVC in the presence of rubber seed oil

Okieimen, F E and Ebhoaye, J E

*Angewandte Makromolekulare Chemie*, No 206:1993. 11-20.
(Rapra Abstracts. 476440)

Dehydrochlorination rates of PVC in nitrogen atmosphere were determined in the presence of rubber seed oil, epoxidised rubber seed oil, barium soap of rubber seed oil fatty acids and barium soap of epoxidised fatty acid of rubber seed oil.

Key words: Rubber seed oil; Dehydrochlorination; Thermal degradation; PVC

## 296 Toxicological studies of the rubber (*Hevea brasiliensis*) seed oil

Njoku, O U and Ononogbu, I C

*West African Journal of Biological Science*, 4(2):1996. 135-140.

Toxicological studies were carried out on rubber (*Hevea brasiliensis*) seed oil. The study

includes estimation of the cyanide content using a simple method that involves extraction of linamarase from cassava cortex to liberate the cyanide in the oil, and the detection of mycotoxins. The fresh oil contained no mycotoxins (Aflatoxin and ochratoxin) and had low cyanide concentration (0.009-0.013 ppm). The implication of this study is a strong recommendation for use of this unconventional vegetable oil in animal experiments and a gradual introduction in the vegetable oil market.

Key words: Rubber seed oil; Toxicology; Mycotoxins; Nigeria

## 297 True protein digestibility, metabolisation energy content and toxicity of raw and processed rubber (*Hevea brasiliensis*) seed meal for pullet chicks

Nwokolo, E

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference.* (Ed. Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp. 62-69.

Fresh milled rubber seeds and hydraulic-pressed rubber seed cake were used in a series of experiments to determine true protein digestibility, metabolizable energy content and potential toxicity of the material in poultry nutrition. Test pullet chicks (2 weeks old) were fed undefatted untoasted, undefatted toasted, defatted untoasted, defatted toasted as well as hydraulic-pressed rubber seed meal. N-hexane was used in defatting the seed meals. True protein digestibility and metabolizable energy determinations each lasted seven days. Potential toxicity was determined through chemical analysis for HCN and phytic acid, gross and macroscopic examination of liver and pancreas of test birds fed rubber seed meal for 14 days. Reference was also made to published literature on toxic components of rubber seed meal. Results of these biological evaluations are discussed.

Key words: *Hevea brasiliensis*; Rubber seed meal; Protein digestibility; Toxicity; Pullet chicks; Metabolizable energy

## 298 Unconventional sources of food: Chemical composition of rubber seed (*Hevea brasiliensis*)

Achinewhu, S C

*Food Chemistry*, 21(1): 1986. 17-25.
(Horticultural Abstracts, 56(12): 1986.10187)

Rubber seeds contained moisture 6.3, crude protein 18.2, fat 21.8,fibre 1.2, ash 2.8 and total carbohydrate 49.4%. The seed was rich in cystine 3.7, methionine 2.5 and valine 6.6% of protein. Sucrose was 65% of soluble carbohydrate. Studies to assess the nutritive value of the seeds are in progress.

Key words: *Hevea brasiliensis*; Rubber seed; Nutritive value; Chemical composition

299 **Underexploited tropical feedingstuffs for poultry**
D'mello, J P F

*World Review of Animal Production*, [illegible](3): 1987. 37-43.
(Abstracts on Tropical Agriculture, 16(3): 1990. 70000)

Recent nutritional data pertaining to tropical grain legumes, miscellaneous seeds and by-products of tree crops, cereal by-products, roots, tubers and leaf meals are reviewed. The toxic constituents of these feedstuffs and methods of detoxication and enhancement of the nutritional value are also discussed. The development of suitable detoxification procedures has ensured significant roles in the future for several legume grains, rubber seed meal, mango seed meal, stabilized rice bran and cassava root meal. The prospects for other underexploited feedstuffs depend upon the development of effective methods for the inactivation of a number of heat stable antinutritional factors present in these raw materials. The scope for any significant role for leaf meals in poultry diets now appears to be diminishing despite recent advances in detoxification.

Key words: Rubber seed meal; Feeding stuff; Poultry

300 **Use of *Hevea* seed (oil, kernel flour, cake)**
*Revue Generale des Caoutchoucs et Plastiques*, No.629: 1983. 69-70.
(AGRIS. 1981-1985)

Key words: Rubber seed; Rubber seed oil; Rubber seed kernel; Rubber seed cake; Feed composition; France

301 **The use of low-temperature crystallisation in the determination of component acids of liquid fats. II. Fats which contain linolenic as well as linoleic acid and oleic acids**
Gunstone, F D and Hilditch, T P

*Journal of the Society of Chemical Industry*, 65: 1946. 8-13.

Key words: Rubber seed oil; Linseed oil; Acid content; Drying; Paint; Fatty acid; Low-temperature crystallisation; Saponification value

302 **Use of rubber derivatives and rubber seed oil in paints**
Coomarasamy, A

*RRISL Bulletin*, 12(1):1977. 75-82.

This paper describes the use of natural rubber and rubber seed oil as binders for paints. Binder in paint is a polymeric material or a pre-polymer, which polymerizes into a polymeric network on the surface after application. Methyl methacrylate grafted natural rubber latex

can be used as a partial substitute for costly synthetic polyvinyl acetate latex in emulsion paints. The authors also describe use of chlorinated rubber and cyclised rubber, prepared from low protein natural rubber, for the production of quick drying chemical resistant paints. Alkyd resins prepared from rubber seed oil is reported to be in use by the paint industry in Sri Lanka. Rubber seed oil after reacting with maleic anhydride is used in printing inks. Epoxidised rubber seed oil could be used as a plasticizer/stabilizer for chlorinated polymers and as a plasticizer in certain alkyd resin formulations.

Key words: Natural rubber; Rubber derivatives; Rubber seed oil; Alkyd resin; Paint; Sri Lanka

303 **Use of rubber oil for anti-malarial purposes**
Malaria Advisory Board

*The Planter*, 20: 1939. 277.
(RRIM Bibliography No.10. Bibliography on Rubber seed oil)

Key words: Rubber seed oil; Antimalaria

304 **The use of rubber seed as feed supplement for grazing sheep**
Sanchez, M D

*Proceedings of the 5th AAAP Animal Science Congress*, May 27- June 1, 1990, Taipei, Taiwan, V 3, pp.144.
(AGRICOLA. 1984-12/91)

Key words: Rubber seed; Feed supplement; Sheep feed; Taiwan

305 **The use of rubber (*Hevea brasiliensis*) seed meal in poultry. Pt 1. The effect of varying levels of rubber seed meal in broiler diets**
Yeong, S W and Syed Ali, A B

*MARDI Research Bulletin*, 7(2): 1979. 127-134.
(Cited by Yeong, S W, *et al.*,1981)

Key words: Rubber seed; Seed meal; Poultry diet; Malaya

306 **The use of rubber seed meal in poultry. II. The effect of rubber seed meal in layer diets**
Yeong, S W; Syed Ali, A B and Yosof, N

*MARDI Research Bulletin*, 9(1): 1981. 92-96.

The effect of feeding rubber seed meal (RSM) at 10, 20, 30, 40 and 50% to replace part of the maize and soybean meal was studied on laying performance.The results showed

that over a 50 week trial period there were no significant differences ($P<0.05$) in egg number, per cent hen-day egg production, total egg mass and feed efficiency (feed/gain in egg mass) among the maize-soybean control group and those groups with RSM levels upto 30% in the diets. Significantly poorer results were observed with 40 and 50% dietary RSM. Egg quality (Haugh Unit) was significantly superior ($P<0.01$) with high levels of RSM. It is suggested that this effect could be caused by the supplementary *DL*-methionine. The chickens tended to gain less body weight ($P<0.05$) when RSM levels increased. No difference in mortality and no toxic symptoms were observed. It was suggested that RSM could be included in layer diets upto 30% without causing adverse effect on laying performance provided the diet was balanced with sufficient lysine and methionine.

Key words: Rubber seed meal; Poultry; Layer diets: Malaya

## 307 Use of sago palm meal, palm kernel cake and rubber seed meal as basal feed for muscovy

Sawakon-Rojanastid, Noppawan-Chaiyanukulkitti and Anan-Pusittigul

*Thurakit-Ahan-Sat (Thailand)*, 7(25): 1990. 28-39.

(AGRIS. 1993-1994)

One hundred and twenty native muscovy ducks, aged of four weeks were fed with four diets: diet 1) concentrate + broken rice+ rice bran; diet 2) concentrate + sago palm meal + rice bran; diet 3) concentrate + sago palm meal + palm kernel cake and diet 4) concentrate + sago palm meal + rubber seed meal, until 19 weeks old. The performances of the muscovy on the four diets were as follows: average daily gain 18.74, 17.32, 17.39 and 16.97 grams: feed conversion ratio 6.58, 7.57, 8.27 and 7.94; and feed cost per kilogram weight gain 38.45, 43.44, 45.51 and 37.33 baht, respectively. The ducks fed diet one had a significantly ($p<0.05$) better feed conversion ratio than other groups. However, the average daily gain among groups were not statistically significant different. And the diets had no effect on carcass percentage and quality of ducks meat.

Key words: Rubber seed meal; Oil seed cakes; Animal feed; Muscovy duck; Thailand

## 308 The use of thin layer chromatography for analysing fatty acids in rubber seed oil

Hardjosuwito, B and Hoesnan, A

*Menara Perkebunan*, 44(5): 1976. 261-267.

(BPPM Abstract bibliography of *Hevea* rubber 1975-76. 482)

Rubber seed oil contains saturated and unsaturated fatty acids. For the investigation of rubber seed oil it is necessary to know the composition of the fatty acids in it. Some methods of analysis of fatty acids are: 1) Based on light absorption after crystallization at low temperature and alkaline isomerization, 2) Distillation of the ester, 3) Determination of thiocyanogen value, iodine value and percentages of saturated fatty acids and of unsaponifiable matter. Thin layer chromatography (TLC) has also been tried. It has proved

can be used as a partial substitute for costly synthetic polyvinyl acetate latex in emulsion paints. The authors also describe use of chlorinated rubber and cyclised rubber, prepared from low protein natural rubber, for the production of quick drying chemical resistant paints. Alkyd resins prepared from rubber seed oil is reported to be in use by the paint industry in Sri Lanka. Rubber seed oil after reacting with maleic anhydride is used in printing inks. Epoxidised rubber seed oil could be used as a plasticizer/stabilizer for chlorinated polymers and as a plasticizer in certain alkyd resin formulations.

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to be suitable for the qualitative analysis of fatty acids in rubber seed oil, while quantitative analysis has still to be investigated.

Key words: Rubber seed oil; Fatty acid; Thin-layer chromatography; Indonesia

## 309 Use of vegetable oils as fuels for diesel engines with specific reference to rubber seed oil

Perera, E D I H and Dunn, P D

*Journal of the Rubber Research Institute of Sri Lanka*, 70: 1990. 11-25.

Rubber seed oil and methyl ester of rubber seed oil have been evaluated as fuel for diesel engines. Engine performance tests, spray characteristics measurements and fuel property evaluations were performed using the above materials. The study indicated that rubber seed oil has fuel properties very similar to other vegetable oils. Compared with diesel oil, rubber seed oil meets the ASTM limits for cetan number, flash point, and total and active sulphur, water and sediment contents. But it failed to meet the ASTM limits for viscosity, ash content, carbon residue, cloud and pour points. Higher viscosity was found to affect the characteristics of the fuel spray. Fuel properties of methyl ester of rubber seed oil were more close to those of diesel oil. Engine performance tests indicated that rubber seed oil, methyl ester of rubber seed oil and blends of these with diesel oil were very much similar to diesel oil in terms of power productivity, thermal efficiency and specific fuel consumption.

Key words: Rubber seed oil; Diesel; Fuel; Vegetable oil; Sri Lanka

## 310 Uses of indigenous rubber seed oil in the Nigerian leather industry

Bangaruswamy, S and Obonukut, E T

*In: Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood: Proceedings of National Conference*. (Ed .Ephraim E. Enabor). Rubber Research Institute of Nigeria, Benin City, 1986, pp.39-42.

Rubber seed oil available within Nigeria was used in the production of fatliquor for the leather industry. The sulphated rubber seed oil was employed in the fatliquoring operation as a fatilquor and was used as a plasticizer in the finishing process in the manufacture of leathers from both goat skins and cow hides. The leathers obtained with the sulphated rubber seed oil were found to possess physical and chemical characteristics that compare favourably well with those obtained with imported fatliquor. Commercial production of rubber seed oil and fatliquor based on the same for utilisation in the Nigeria leather industry can help substitute the imported material and thus conserve foreign exchange for the country.

Key words: Rubber seed oil; Leather industry; Fatliquor; Nigeria

311 The uses of rubber seed
Vimal, O P

*Planters' Chronicle*, 76(7): 1981. 333-336.

India now ranks fifth among the natural rubber (*Hevea brasiliensis*) producing countries, the crop covering an area of some 230 000 ha. This article points out that rubber seed holds great potential of generating an ancillary industry in rubber plantations. Its oil is used mostly for soap manufacture but recently work has been initiated on a number of new uses. Factice is recognised as a valuable processing aid by rubber technologists, and rubber seed oil can be used instead of other vegetable oils for factice preparation.

Key words: Rubber seed; Oil extraction; Rubber seed cake; India

312 Utilisation of maleinized rubber seed oil and its alkyd resin as binders in water-borne coatings
Aigbodion, A I; Okieimen, F E; Obazee, E O and Bakare, I O

*Progress in Organic Coatings*, 46: 2003. 28-31.

Rubber seed oil- RSO (a renewable resource) was used in the production of alkyd emulsion. Samples of the oil were initially treated with different amounts of 2% (A), 5%(B), 10%(C),15%(D) and 20%(E) of maleic anhydride. The resultant maleinized rubber seed oil (MRSO) samples (A-E) were used to formulate water-soluble alkyd samples (I-V), respectively. The MRSO samples and their corresponding alkyds were evaluated for their physico-chemical properties and compared to the pure RSO. Acid, saponification and iodine values were affected by maleinization. Samples of the MRSO and their alkyd derivatives were evaluated as binders in water-borne coatings. The MRSO samples were of relatively lower volatile organic compound (VOC) (between 1 and 1.5%) compared to their corresponding alkyd derivatives (about 10%). While the MRSO samples exhibited poor chemical resistance, the alkyds exhibited excellent resistance to acid, brine and water, and fair resistance to alkali.

Key words: Rubber seed oil; Maleinized rubber; Volatile organic compound; Alkyd derivatives

313 Utilisation of para rubber seed
*Bulletin of the Imperial Institute*, 7:1909. 95-96.

Key words: Para rubber seed; Seed utilization

314 Utilisation of para rubber seed
*Bulletin of the Imperial Institute*, 9: 1911. 35-38.

Key words: Para rubber seed; Seed utilization

315 The utilisation of para rubber seed. II.

*Bulletin of the Imperial Institute*, 11: 1913. 551-559.

Key words: Para rubber seed; Rubber seed cake

316 The utilisation of rubber oil as an anti-malaria oil

Althuisius, F

*Chronica Naturae*,104: 1948. 68-71.
(Horticultural Abstracts, 18: 1948. 3087)

Key words: Para rubber seed; Rubber seed oil

317 Utilisation of rubber seeds in India

Haridasan, V

*ANRPC: Third seminar on Progress and Development of Rubber Smallholders*, 24-30 Nov. 1977, Cochin, India

This paper examines to what extent the rubber seed is being commercially exploited. It is pointed out that though Kerala is being the major source of rubber seed since majority of area under rubber cultivation is here the entire seed collected is being sent and processed at Virudhunagar in Tamil Nadu due to its specific locational advantages. After decortication and drying the kernel it is crushed by adding molasses to extract oil. For crushing, rotaries and expellers are used. Though expellers are cost effective the processors prefer rotaries as the cakes processed in rotaries fetch high value addition. The rubber seed oil is used for the manufacture of soaps, paints, alkyd resin etc. and the cake is used as manure and cattle/poultry feed. The major marketing centres of oil are Madurai, Coimbatore, Tirupur and northern district of Tamil Nadu while southern districts are centres of cake. The paper concludes that rubber seed oil and cake have high market potential as their industrial uses are coming up as they are proved to be substitutes of many edible/non edible oils and cake. Rubber seed cake was recommended for use in livestock and poultry feed.

Key words: Rubber seed; Seed utilization; India

318 Utilization of oil and fat resource in Southeast Asia (Thailand)

Wimonsri-Tewaphalin; Phaichit-Chantharawong and Kato, A

Research Report, Dept of Agriculture, Bangkok, Thailand, 1977-78, pp. 21-26.
(AGRIS. 1981-1985)

The results of the study indicates that Thai rubber seed oil containing lower linolenic acid than the standard value of about 5-6% can be used as an effective ingredient of painting. Rambutan seed contain 35% oil, the fatty acid composition has 7-8% Eicosenoic (c 20:1) and 46.7% of saturated fatty acid, which show that rambutan oil is suitable for

margarine and shortening industries. New fatty acid, Monoenoic (C 19:1) was found in Thai longan seed oil which will be the subject of a future study.

Key words: Rubber seed oil; Fat; Seed utilization; Oil producing trees; Thailand

## 319 Utilization of para rubber seed

Lewton-Brain, L

*Agricultural Bulletin of the Straits Settlements and Federated Malay States*, 10: 1911. 352-356.

Key words: Para rubber seed; Seed utilization

## 320 Utilization of rubber (*Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg.) seed as feed for goat

Rattananupong, T

Ph.D. Thesis, Philippines University, Laguna, Philippines, 1996, 106 p.
(AGRIS. 1/97-2/98)

In the first experiment, RSK (rubber seed kernel) contained greater amounts of crude protein, ether extract and gross energy, and lesser nitrogen-free extract, neutral detergent fiber, acid detergent fiber, hemicellulose, cellulose and lignin than RSC (Rubber Seed Cake with shell). RSK and RSC were similar in ash, Ca, P, HCN and tannin content, but the free gossypol was higher in RSC than RSK. In the second experiment, the digestibilities of dry matter, organic matter, cell wall constituents and gross energy were higher ($p<0.05$) in RSK than those in RSC, while that of crude protein was similar. The N retention in terms of retained N per N intake or retained N per digested N were similar in both ruzy hay + RSK and ruzy hay + RSC. In the third experiment, the animals fed with ruzy hay alone lost weight. When the ruzy hay was supplemented with concentrate, both body weight gain and feed efficiency increased ($p<0.01$). However, concentrate intake was inversely related to RSK in concentrate. Increasing level of RSK in concentrate mixture was associated with linear decline in concentrate intake, total feed intake and simultaneous lineal decrease in body weight gain and feed efficiency. The goats fed with all ruzy hay diet had greater ($p<0.05$)white blood cells, hematocrit and haemoglobin than those fed with ruzy hay supplemented with concentrate ration. Also, red blood cells, hematocrit and haemoglobin linearly decreased when the level of RSK in concentrate increased. The protein deficiency symptoms were observed in goats fed with ruzy hay as a sole diet. In the fourth experiment, the animals fed with ruzy hay alone gained weight. Supplementation of concentrate significantly increased feed intake, body weight gain and feed efficiency but did not affect total cost of feed per kg weight gain. Increasing level of RSC in concentrate caused linear decline in body weight gain and feed efficiency. The total plasma protein linearly increased as the level of RSC in concentrate increased.

Key words: Rubber seed; Rubber seed kernel; Rubber seed cake; Goat diet, Philippines

321 **Utilization of rubber seed cake supplemented with napier grass for goats**
Sitorus, S S

*Proceedings, the 5th AAAP Animal Science Congress*, May 27-1 June, 1990, Taipei, Taiwan, V 3, pp.146.
(AGRICOLA. 1984-12/91)

Key words: Rubber seed cake; Feed supplement; Goat diet

322 **Utilization of rubber seed meal in diary cows ration**
Suthisak-Kiewkamjan

Thesis. MSc Agriculture, Bangkok, Thailand, 1992, 86 p.
(AGRIS. 1997-1998)

Key words: Rubber seed meal; Milk production; Nutritive value; Feed meals; Cattle feed; Thailand

323 **Utilization of rubber seed oil and karinnotta oil for the preparation of air drying oil modified alkyd resins**
Muralidharan Nair, N; Unnikrishnan, K G; Unnikrishnan, M and Nair, C S B

*Paint India*, 31(5): 1981. 5-9.

Alkyd resins were prepared from rubber seed oil and karinnotta oil and from the blends of these oils with linseed oil and dehydrated castor oil, by the conventional alcoholysis method, using lithrage as catalyst. Drying test, water, acid and alkali resistance tests were performed to evaluate the resins for use in paints. The results indicated that rubber seed oil is superior to karinnotta oil in long oil alkyd formulations. The study also indicated that rubber seed oil and karinnotta oil could completely substitute linseed oil and dehydrated castor oil in the preparation of medium oil alkyds with satisfactory air drying performance. In the case of long oil alkyds, rubber seed oil could substitute linseed oil and dehydrated castor oil to the extent of 80%. Karinnotta oil could substitute linseed oil upto 65% and dehydrated castor oil upto 50%.

Key words: Rubber seed oil; Drying; Karinnota oil; Alkyd resin; Paint; India

324 **Variations in the composition of some linolenic-rich seed oils**
Hilditch, T P; Achaya, K T and Seavell, A J

*Journal of the Science of Food and Agriculture*, 2: 1951. 543-547.
(RRIM Bibliography No. 10. Bibliography on Rubber seed oil)

Key words: Rubber seed oil; Linolenic acid; Fatty acid; Oil seed plant

325 **Vegetable oils produced in the tropics. VII. Oil of rubber seeds**
Nobori, H and Takehara, M
*Journal of the Society of Chemical Industry of Japan*,49:1946.159-160.
(RRIM Bibliography No.10. Bibiliography on Rubber seed oil)
Key words: Rubber seed oil; Vegetable oil

326 **Viability of rubber seeds from green pods**
Premakumari, D
*Rubber Board Bulletin*, 12(1):1975. 24-25.
Key words: Rubber seed; Seed viability; Green pods; India

327 **Viability test on *Hevea* seeds by the tetrazolium method**
Husin, Sakhibun Bin Mohamad; Chin, H F and Hor, Y L
*Journal of the Rubber Research Institute of Malaysia*, 29(1): 1981. 44-51.
Key words: *Hevea brasiliensis*; Rubber seed; Seed viability; Tetrazolium method

328 **What to do with the seeds**
Wright, H
*In: Para rubber or Hevea brasiliensis: Its botany, cultivation, chemistry and diseases.* (Herbert Wright). Biotech book, Delhi, 1998, pp. 155-159.
Key words: Para rubber seed; Rubber seed oil; Rubber seed meal; Rubber seed cake; Linseed cake; Seed packing

329 **Wood finish from rubber seed oil alkyd resin**
Njoku, O U; Ononogbu, I C and Moneke, S M
*Indian Journal of Natural Rubber Research*, 9(2): 1996. 137.
Key words: Rubber seed oil; Alkyd resin; Wood finish; Nigeria

# KEY WORD INDEX