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EFFECT OF PROCESSING CONDITIONS ON THE PROTEIN CONTENT OF CONCENTRATED LATEX

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INTRODUCTION

Natural rubber latex is a complex colloidal dispersion of rubber particles in an aqueous medium, the colloidal system being stabilised by some non rubber materials. The major non rubber constituents are proteins, lipids, phospholipids, carbohydrates, amino acids and inorganic ions. The total non rubber materials in Hevea Latex is about 3-5% by weight, of which about 1% is proteins(1,2). About half of the proteins is dissolved in the aqueous phase, one quarter is adsorbed on the surface of the rubber particles and the remaining associated with larger particle bodies, such as Lutoids(1,3).

The importance of proteins in determining the colloidal stability of natural rubber field latex was understood much early. Kemp and Teoiss making use of the assumption that the resultant surface charge density of a composite colloidal particle depends on the surface charge densities of the surface active substances adsorbed at the particle surface, demonstrated that above a total solids content of 12%, the rubber particles are completely covered with a layer of proteins(4). Proteins in latex behave as amphoteric polyelectrolytis. The behaviour of any given protein is determined not so much by any free carboxyl and amine groups which may be situated at the ends of the molecules, but by the presence of free acidic and basic functional groups in the main chain substituents(5). The zwitter-ion effect indeed by the presence of free amino and carboxyl groups in the latex proteins is of fundamental importance in determining the colloidal characteristics of latex(6).

Proteins in Hevea Latex

Attempts to characterise the latex proteins were reported from 1930s onwards. Bondy and Freundlich(7) have separated two proteins from the centrifugally separated serum of ammonia preserved NR latex, which they called protein A and B. The proteins were distinguished by their electrokinetic behaviour and their solubilities in aqueous solutions and in alcohol. Proteins A and B had isoelectric points of 4.55 and 3.9 respectively. The former was insoluble in water and alcohol, while the latter was soluble in water and 70% alcohol.

Kemp and Straitiff(6) isolated 3 proteins from ammoniated latex serum by ammonium sulphate precipitation method - Protein A, Protein B and Protein C. However Protein C was found to be a heat-denatured product of protein B.

Archer and Sekhar(3) have studied the aqueous serum of unpreserved NR latex, obtained by high speed centrifuging and by freezing at -25°C. In both the types of serum, seven electrophoritically distinct protein components have been detected. However in the serum of ammonia preserved field latex, only two of the above seven proteins were readily resolvable electrophoritically. From the freeze dried serum solids, Archer and Cockbain(8) separated α-globulin by an isoelectric ammonium sulphate precipitation method. It has an isoelectric point of 4.8 and molecular weight of the order of 2×10^5. The similarity in the electro phoritic and colloidal behaviour between dissolved α-globulin and the particles of Hevea Latex suggest that this protein is an important component of the protein layer which is adsorbed on the rubber particles. The nature of α-globulin corresponds to 'Protein A' reported earlier(6,7).

Hevein, the second principal protein, which is dissolved in latex serum was isolated by ammonium sulphate fractionation of cold aqueous extract of the freeze-dried solids derived from the so called 'bottom fraction'(9). It was a low molecular weight of about 10000 and isoelectric point of 4.5. Hevein is water soluble at all pHs and does not contribute much to the colloidal behaviour of NR latex.

Paper electrophoritic studies(10) ion exchange chromatographic and starch gel electrophoric studies(11) of 'Bottom Fraction', Starch Gel Electrophoric studies of C serum proteins(12) have detected several protein components. Recently it is shown that proteolipids are associated with the rubber particles in latex(13).

Even though a lot of studies have been carried out on proteins in natural rubber field latex, the volume of work on proteins in concentrated latex is much less despite the fact that concentrated latex is the main raw material for almost all latex products. Recently some work has been done on the proteins in high ammonia (HA) preserved NR latex concentrate(14). Such studies are very relevant in the present circumstances because some proteins in NR latex gloves have been identified as source of some allergic problems in sensitive human beings.

Proteins of HA latex concentrate are distributed between two main fractions - the serum fraction and the rubber fraction.

The serum contains mainly six proteins and probably these are the ones that can be leached out of latex products. The rubber particles are associated with one main protein of molecular weight 14000, along with small quantities of another one of molecular weight 24000. A small fraction of the rubber

particle proteins can be extracted with ammonia solution. The rest is tightly bound to rubber particles and are retained even after leaching(14).

Several attempts have been made to control the level of extractable protein(15) like wet gel leaching, dry film washing, steam treatment, chlorination etc. Recently some reports have come on the production and technological evaluation of a low protein latex(16).

Protein Removal during Latex Concentration

As reported elsewhere, the non rubber content of field latex is about 3-5%, whereas that of concentrated latex and skim latex are about 1.2-1.6% and 5-10% respectively. The particle size distribution in NR latex has a profound influence on the above non rubber percentages.

The particle size distribution of NR latex covers a wide range - a typical order being 0.2 to 20 microns(17). About 4% of particles have diameters above 4 microns. However this small fraction accounts for some 85% by mass of the total dispersed rubber.

When field latex is centrifugally concentrated, the association of high levels of non-rubber materials in skim latex can be ascribed to

(a) high serum to rubber ratio means that a large proportion of soluble proteins and other non rubber materials are carried into skim.

(b) skim latex consists of particles of very small diameters, and high specific surface area, so that the quantity of adsorbed non rubber materals per unit mass of rubber is higher.

During centrifuging if a latex particle is initially at distance of Ro from the axis of rotation, and if R is the limiting position, such that the particle be carried to the cream after centrifuging for a time t, then the limiting radius of the largest skim latex particle is given by

$$x_L = \left[\frac{9\eta}{2w^2(p'-p)t} \ln\left(\frac{Ro}{R}\right) \right]^{\frac{1}{2}} \qquad (1)$$

where η is the viscosity the aqueous medium w the argular velocity of the particle, p' and p are the densities of serum and rubber partice respectively.

The above equation can be rearranged as

$$x_L^2 t = \frac{9\eta}{2w^2(p'-p)} \ln\left(\frac{Ro}{R}\right) \qquad (2)$$

Under a given set of operating conditions the right hand side of equation (2) is a constant, so that $x_L^2 t$ = a constant.

$$\text{or } x_L \propto \frac{1}{\sqrt{t}}$$

ie. as the time t a particle is subjected to centrifugal force, is increased, the limiting radius x_L decreases. During centrifugal concentration of latex, t can be varied by changing the skim screw - the longer the screw, the higher will be the t value.

It seems that the protein distribution in latex as soluble protein, interfacial protein, and those associated with lutoid particles is at an equilibrium. If the field latex is

diluted, then it is likely that this equilibrium is disturbed and the soluble protein content increases so that protein removal in skim latex should be higher. Further ammonia solution can extract some rubber particle protein.

Hence it was decided to study

(1) effect of skim screw length on the non-rubber content, and thereby the protein content of cenex.

(2) the effect of dilution of field latex on protein removal

EXPERIMENTAL

Effect of Skim Screw Length

Preserved field latex was centrifuged in an Alpha Laval LRB 510 model latex separator using 10.5 mm feed tube 6 inch float valve level and skim screws of different lengths. The trial was conducted using HA and LATZ preserved field latex. The field latex used and cenex obtained in each case was subjected to the following tests:

1. Total Solids
2. Dry rubber content
3. N Content in TS
4. N content in dried coagulum.

The above estimations were made by following the relevant Indian Standards. Non rubber content was estimated as a difference between TS and DRC.

The properties of the field latices used are given in Table 1. The characteristics of the cenex obtained are given in Tables 2 and 3.

Effect of Dilution

Field latex was diluted with water to different extents and diluted latex allowed to equilibrate for 24 hrs. In the case of HA latex, dilution was done by 1% ammonia water. For LA latex 0.3% ammonia water containing 0.025% ZnO and TMTD was used. The cenex obtained in each case was tested and the results are given in Tables 4 and 5.

Results and Discussions

The variations of NRS given in Tables 2 and 3 show almost a linear relation with the skim screw length both in the case of LA and HA latex. Similarly the approximate protein content in the dry cenex coagulum varies linearly with the skim screw length. The increase in NRS and protein content is due to the inclusion of more of smaller rubber particles into cenex, rather than their going in skim. Also some more water soluble components are introduced into the cenex. (Figs. 1, 2)

The results obtained on diluting the latex prior to centrifuging are given in Tables 4 and 5 and in figures 3 and 4. Effect of dilution is more marked in the range 0-20% in reducing the NRS and protein content in cenex. This is due to the preferential loss of the water soluble fractions into skim, which may reside with cenex in a normal centrifuging. Some contribution is made by the ammonical medium in solubilising some more of adsorbed proteins. As dilution increases beyond

20% the contribution from soluble materials decreases. It is likely that protein solubilisation may increase, but its rate decreases, as it becomes more and more difficult to remove the very strongly adsorbed proteins.

Conclusions

1. The increase in skim screw length, with a view to enhance the processing efficiency, results in a simultaneous increase in non rubber solids and protein content in cenex.

2. Diluting the field latex reduces the NRS and protein content in cenex. The rate of reduction decreases as the dilution increases.

3. Dilution by 10-20% is found to be the optimum.

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Table 1

Properties of Field Latex

Sl.No.	characteristics	Preservation System	
		LATZ	HA
1	Total Solids %	35.4863	30.9436
2	Dry Rubber Content %	32.7146	28.1451
3	Non rubber solids %	2.7717	2.7985
4	N on TS %	0.649	0.694
5	N on dry coagulum %	0.413	0.424
6	Approximate Protein content in dry coagulam %	2.58	2.65

Table 2

Effect of skim Screw Length on NRS and Protein Content of LA Latex Concentrate

Sl.No.	Characteristics of Cenex	Skim Screw length (mm)			
		10.5	11.0	11.5	12.0
1.	Total Solids %	63.7243	62.9573	63.2880	63.1142
2.	Dry Rubber Condent %	62.4368	61.5689	61.9202	61.5354
3.	Non rubber solids %	1.2875	1.3884	1.4678	1.6788
4.	N on TS %	0.2593	0.2933	0.3021	0.3271
5.	N on dry coagulum %	0.2172	0.2453	0.2534	0.2754
6.	Approximate Protein Content in dry coagulum %	1.36	1.53	1.58	1.72

Table 3

Effect of Skim Screw Length on NRS and Protein content of HA Latex Concentrate

Sl.No.	Characteristics of Cenex	Skim Screw Length (mm)			
		9.5	10.5	11.0	12.0
1	Total Solids %	64.1730	62.5728	62.4586	61.8266
2	Dry Rubber Condent %	63.2077	61.2488	61.0577	60.1051
3	Non rubber solids %	0.9653	1.3240	1.4009	1.7215
4	N on TS %	0.3338	0.4004	0.4086	0.3756
5	N on dry Coagulum %	0.2687	0.2784	0.2911	0.3366
6	Approximate Protein Content in dry coagulum %	1.68	1.74	1.82	2.10

Table 4

Effect of Dilution of LA field latex on NRS and Protein content in Cenex

Sl No	Characteristics of Cenex	Dilution as % of field latex				
		0	10	20	30	40
1.	Total Solids %	65.5513	64.2618	65.02135	64.2469	64.3715
2.	Dry Rubber Content %	64.0183	62.9913	64.0630	63.3325	63.5302
3.	Non rubber solids %	1.5332	1.2705	0.9584	0.9144	0.8413
4.	N on TS %	0.2837	0.2549	0.2273	0.2226	0.2178
5.	N on dry coagulam %	0.2627	0.2445	0.2034	0.1821	0.1767
6.	Approximate Protein content in dry coagulum %	1.64	1.53	1.27	1.14	1.10

Table 5

Effect of Dilution of HA field latex on NRS and Protein Content in Cenex

Sl No	Characteristics of Cenex	Dilution as % of field latex			
		0	10	20	40
1	Total Solids %	62.4553	65.1730	63.8258	64.4504
2	Dry Rubber content %	61.1851	64.2077	62.9962	63.6880
3	Non rubber solids %	1.2702	0.9653	0.8296	0.7624
4	N on TS%	0.3459	0.3338	0.3131	0.3012
5	N on dry coagulum%	0.3267	0.2898	0.2898	0.2606
6	Approximate Protein Content in dry coagulum %	2.04	1.81	1.81	1.63

Fig.1 Effect of Variation of Skim Screw length on NRS in Cenex

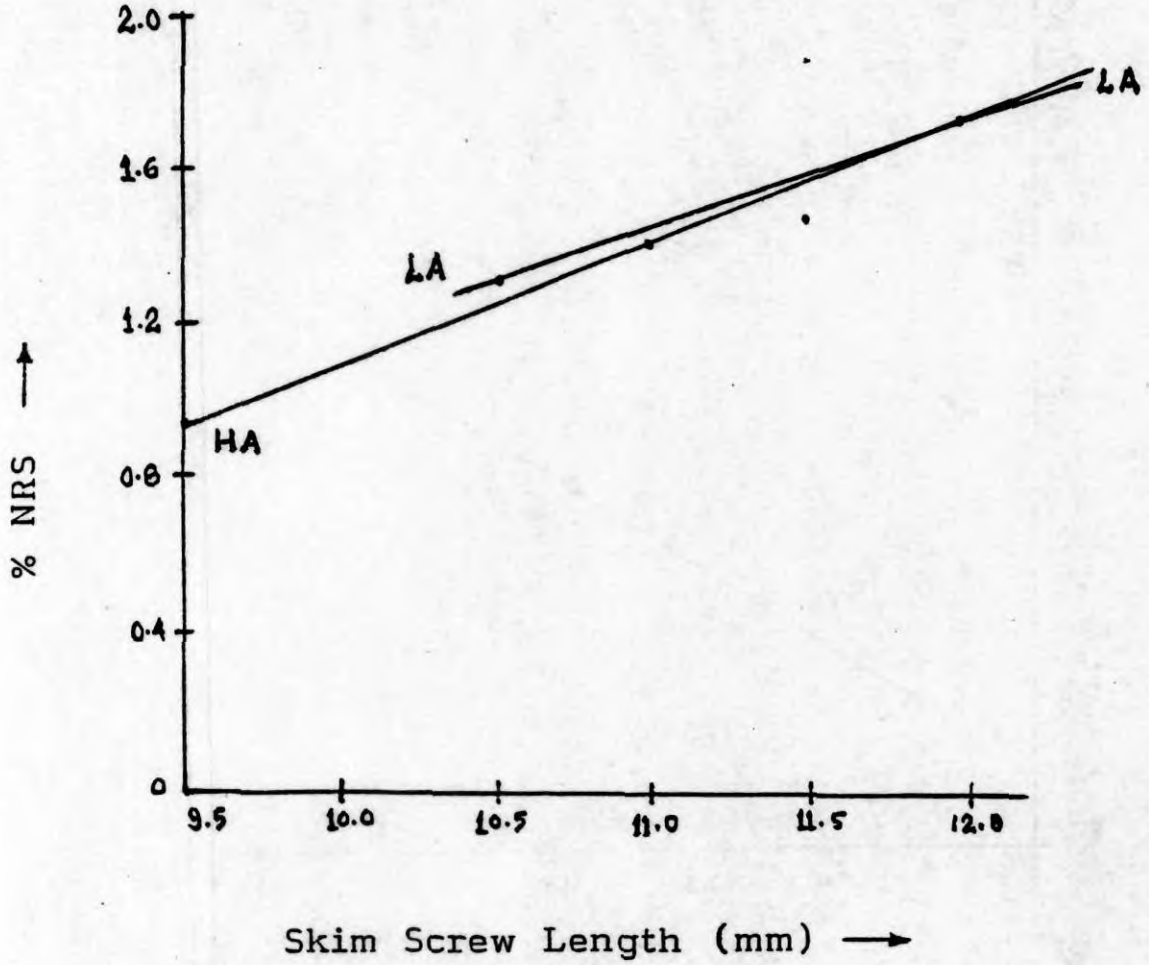

Fig. 2 - Effect of variation of skim screw length on Protein Content in Cenex

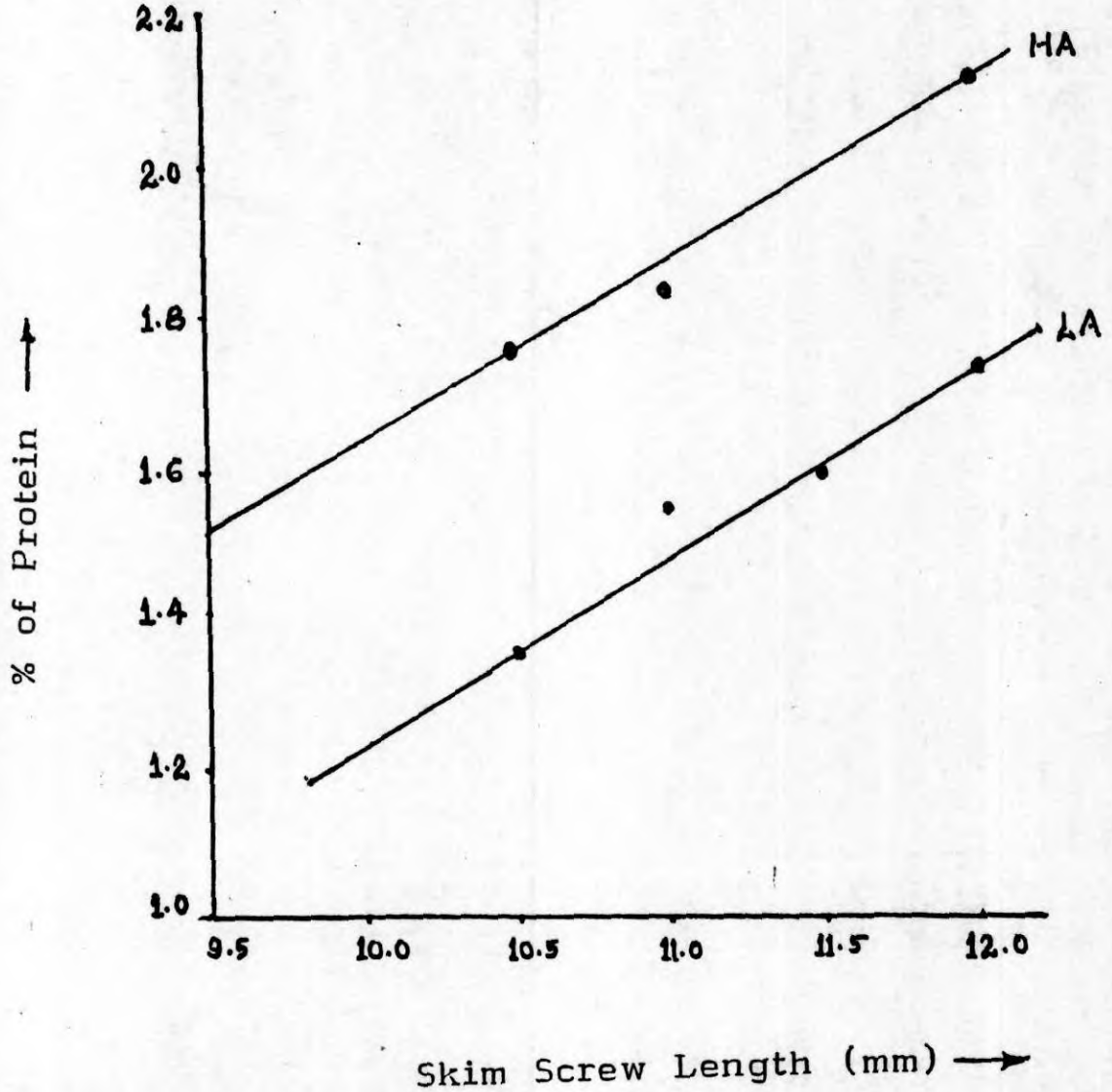

Fig.3 - Effect of Dilution on the NRS in Cenex

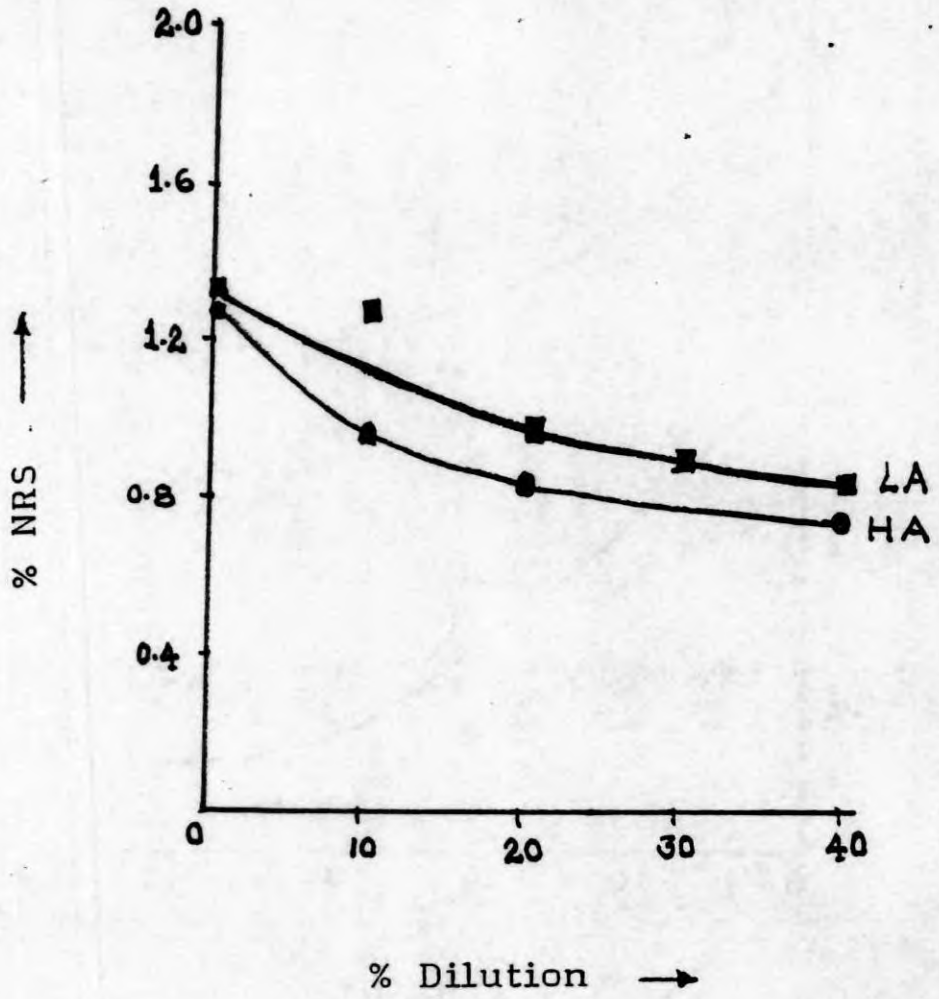

Fig.4 - Effect of Dilution on the Protein Content in Cenex