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POSSIBILITIES OF BACTERIAL COAGULATION IN RAW RUBBER MANUFACTURE

BY

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INTRODUCTION

In conventional raw rubber manufacture, every effort is made to keep bacterial contamination at a minimum; as such contamination : (1) results in spoilage of the latex, and (2) causes defects such as bubbles in smoked sheet.

This paper on the contrary discusses the possibilities of the deliberate use of bacteria, in raw rubber manufacture, as a coagulating agent.

The most costly item in natural rubber production is harvesting the crop, that is tapping and collection. This may be as high as 50 % of the total cost of production (Baptiste, 1962). An important objective of natural rubber research is the reduction in the cost of production. The advent of new process rubbers has eliminated the need to bring rubber to the factory as liquid latex. Rubber collected in solid form can be made into new process rubbers conforming to high technical standards. Because of this development, it is appropriate to rethink about collection methods. Another factor which makes it necessary for us to rethink about collection methods is a result of our using high-yielding clones for replanting. These clones have longer flow times. Consequently a high proportion of the crop will be left in the cup as late drip, if routine collection in cups is carried out three to four hours after tapping. This late drip autocoagulates in the cup and is collected as cup lump on the next tapping day. With a view to catering for high-yielding clones, Southorn (1969) has suggested harvesting the crop as coagulum in one top quality form by collecting the latex in disposable polythene bags. To reduce costs, the bags are left on the trees for several tappings. The latex autocoagulates in the bag and is collected as coagulum for new process rubber manufacture.

The necessity to leave the polybags on the trees for more than a day arises not only from cost considerations but also from the fact that autocoagulation takes more than 24 hours for completion and hence the latex requires adequate protection from contamination. Leaving polybags in the field for prolonged periods creates the problem of theft. This will be a major problem, where the majority of the estates are small and surrounded by villages as is the case in Ceylon.

In addition, polybag collection has the following three disadvantages (Southorn, 1969) : (*a*) labour costs of fixing new bags after each collection, (*b*) cost of bags and the special hangers which over a period exceeds that of semi-permanent cups, (*c*) cost of stripping the polythene from the rubber during processing.

However, the advantages in favour of polybag collection are : (*a*) increased effectiveness of the tapper, (*b*) collection can be done by unskilled labour, (*c*) elimination of coagulation in the factory, and (*d*) no need for latex collecting centres.

Many of these advantages of collecting latex as coagulum could be retained and the disadvantages eliminated if coagulation of latex in the field can be speeded up and collection of coagulum made possible on the day of tapping. Satchuthananthavale & Satchuthananthavale (1970) have demonstrated that controlled coagulation of field latex could be effected by seeding field latex with suitable strains of bacteria. This may be called bacterial coagulation of latex.

This paper examines the possibilities of this method of coagulation as applied in the field and also its applicability for latex skim coagulation.

MATERIALS AND METHODS

Field trial

A small scale field trial was carried out, using 40 trees of clone PB 86 in the 1961 clearing, Dartonfield. The trees were tapped on the half spiral, alternate-day system. Coagulation of the latex was done in coconut shell cups. Of the 40 trees, 20 trees were taken for treatment and the other 20 for control. Observations were made over a period of two months beginning from June. Tapping was done as usual between 6·45 and 7·15 a.m. on normal tapping days and 11·00 and 11.30 a.m. on late tapping days. For the 20 trees taken for treatment, a four-day old bacterial culture was added, 10 ml per cup, and stirred into the latex, about one hour after tapping. Nothing was added to the cups of the control trees.

The latex from these 40 trees was not collected but left in the respective cups on the trees. Observations were then made at frequent intervals. The treated latex began to gel, about three hours after adding the culture and on normal tapping days had coagulated by 3.30 p.m., except in a few cases where the cups had a large quantity of latex. This difficulty was overcome by increasing the quantity of culture added to 15 or 20 ml per cup in later trials. The untreated latex remained uncoagulated even by 6.00 p.m. of the same day. When left overnight in the field, the latex coagulated, but incompletely. When both treated and untreated latex in cups were left overnight in the field, the coagulum of the untreated was discoloured while that of the treated showed much less discolouration. Further, autocoagulated-rubber gives a bad smell which is not given by bacteria-coagulated rubber.

RESULTS AND DISCUSSION

Properties of the rubber

In order to make comparison easy, the cup coagula of both treated and untreated samples were collected in the morning of the day following tapping. The different samples were washed, combined separately and made into blanket crepe. The raw rubber properties and technological properties of these samples are given in Table 1.

TABLE 1

PROPERTIES OF RUBBERS OBTAINED BY CUP COAGULATION
CLONE PB 86

	No. of samples tested	Untreated (autocoagulation)		Treated (bacteria – R6)	
		Mean	Range	Mean	Range
Dirt %	15	0·034	0·028 – 0·042	0·021	0·017 – 0·024
Ash %	15	0·38	0·34 – 0·44	0·36	0·32 – 0·42
Volatile matter %	15	0·38	0·36 – 0·42	0·38	0·37 – 0·41
Acetone extract %	15	2·69	2·45 – 3·11	2·63	2·10 – 3·31
Nitrogen %	15	0·41	0·39 – 0·44	0·41	0·39 – 0·44
Manganese ppm	15	1·14	0·85 – 1·32	1·30	1·00 – 1·85
Copper ppm	15	1·20	1·00 – 1·80	1·26	0·92 – 1·56
PRI	5	81·0	70·3 –97·0	82·2	81·6 –87·8
* Strain (TC)	10	51·3	50·0 –52·0	55·4	53·5 –58·0
* Resilience (Lupke pendulum)	10	77·6	76·5 –79·5	77·8	76·5 –80·0

* ACS 1 mix cured for 40 min at 140°C

Relative freedom from dirt is a prime market requirement. As shown in Table 1, the dirt content of bacteria-treated samples is lower than that of untreated and autocoagulated samples. This is probably because, any extraneous matter that falls on the coagulum after it has set, is washed off during cleaning. The dirt content could be expected to be still reduced in the new process block rubber manufacture during the washing stage after crumbling or granulation. Collection of the coagulum has to be carried out in clean bags or baskets. The PRI of bacteria-treated samples is also better than that of untreated and autocoagulated samples.

Increasing the dosage of bacterial culture to hasten coagulation had no ill-effects on the rubber produced. This is illustrated in the results of a laboratory experiment given in Table 2.

TABLE 2

EFFECT OF INCREASING RATIO OF BACTERIAL CULTURE (R6) TO LATEX ON PROPERTIES OF RUBBER

Ratio culture : latex	Nitrogen %	PRI	Strain (TC)	Resilience (Lupke pendulum)	Wallace hardness (BS)	Raw Mooney (V/C) at 212°F
1 : 20	0·42	82·5	75·5	75·0	37·5	64·0
1 : 10	0·39	85·7	74·0	75·0	37·5	65·0
2 : 10	0·42	81·4	71·0	76·5	38·0	66·0
3· : 10	0·42	79·0	70·5	75·5	37·5	61·5
Autocoagulation	0·39	81·8	73·5	76·0	38·0	63·0

ACS 1 mix cured for 40 min at 140°C

Rain interference

If the latex was allowed to remain in collecting cups in the field throughout the day, there might be a loss of crop due to rain after tapping. However, once gelling of latex begins, the loss of crop by washout will decrease. During the field trials it was observed that on a day when there was sudden rain at about 9.30 a.m., which was before the tapper could finish tapping his task, the entire crop in the tapped trees was lost by washout, except in cases where the cultures had been added at the time of tapping. It was possible in these cases to recover as coagulum the latex that had gelled by the time it rained (Fig. 1).

The gelling in this case, about two hours after the addition of culture, was probably due to the acidity of the culture medium itself.

The fixing of expanded polystyrene rainguards to trees as described by Southorn (1969), helped to recover the entire crop as coagula in light or moderate rain (Fig. 2).

An important practical aspect is that the serum from bacteria-coagulated latex can be used as a satisfactory coagulant for four or five tappings, to give coagula with good physical characteristics. The serum from autocoagulated coagulum, on the other hand, gave coagula with a bad odour and colour confirming the findings of John (1966). The use of serum from bacteria-coagulated latex for coagulation will be an added advantage, cost-wise, to the smallholders who are known to tap their trees daily. The serum from bacteria-coagulated latex from the first day's tapping, can be squeezed into the cup at the time of tapping on the second day. Tapping and collection can then be carried out at the same time.

The use of plastic-coated coconut shells will be advantageous in keeping contamination by undesirable bacteria to a minimum. The removal of coagulum is also found to be quite easy when such cups are used.

Use of bacterial coagulation in new process rubber manufacture

Whilst rubber cultivation is economically viable when done on a small scale, it is necessary (1) in order to obtain maximum returns, and (2) to obtain a uniform product that the raw rubber manufacture be done on a large scale, more so as it is prepared for export. During the last five years, the methods of raw rubber manufacture have undergone changes and new processes are now available. New process rubber manufacture has to be done on a large scale — the minimum economic unit being 10 tons/day. New process rubbers can be manufactured from (*a*) latex, (*b*) coagulum, or (*c*) scrap. The use of latex would be feasible in the drier rubber growing areas of Ceylon and the RRIC has recommended to the Government to set up a prototype central factory to cater for smallholders' latex (Veerabangsa & Nadarajah, 1970). The transportation of smallholders' latex to the central factory may not be feasible in the wetter rubber growing areas in Ceylon and in these areas coagulum prepared either in the cup or in divisions has to be transported to the central factory.

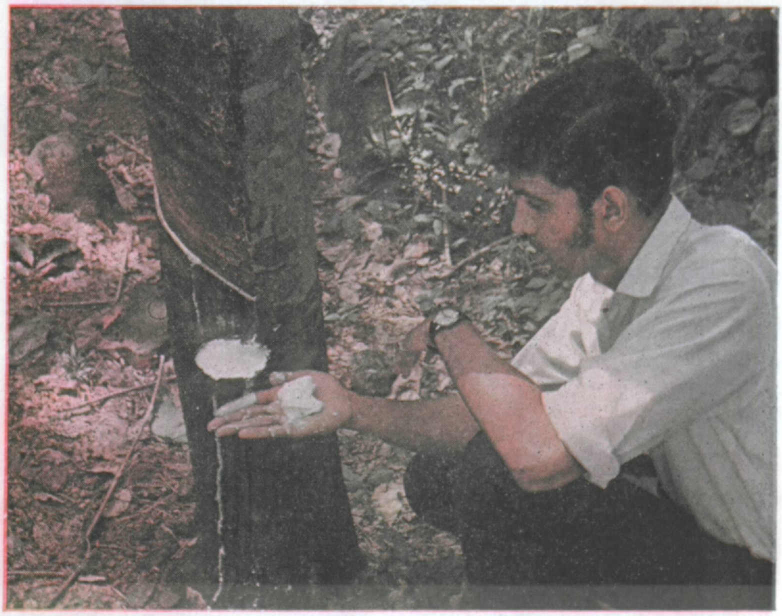

Fig. 1. Washout by rain minimised by adding bacterial cultures to tapping cups at the time of tapping. See coagulum obtained, when rain occurred two hours after tapping.

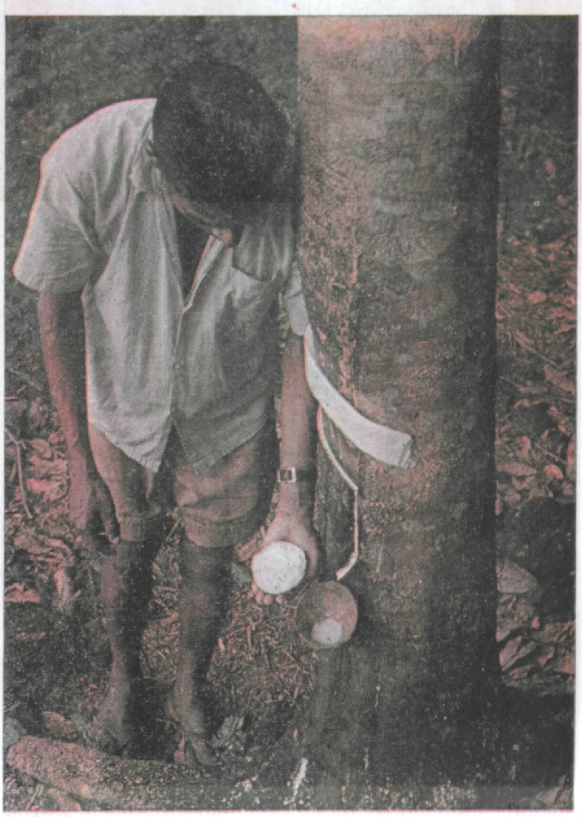

Fig. 2. Use of rainguards enables maximum crops to be obtained after bacterial coagulation during light or moderate rain.

Fig. 3. Skim coagula obtained by autocoagulation (left half) and by bacterial coagulation (right half).

Bacterial coagulation in the cup provides the key to decentralized coagulation which may be regarded as a major contribution to potential cost reductions. Most of our natural rubber is used in the tyre manufacturing industry and hence we should aim at producing an economically-processed compound suited to this industry which today uses low grade RSS and scrap crepe, rather than converting our total latex grades into SCR 5L.

A problem in purchasing latex for the central factory from smallholders is their inherent suspicion of a loss in dry rubber due to the possibility of the under-estimation of the dry rubber content in their latex. This would not arise in the purchase of cup coagulum.

Experiences in Malaysia regarding transportation as reported by Bayne & de Jong (1968) indicate that a single vehicle is capable of hauling three times the tonnage of coagulum as opposed to latex. Furthermore, transportation of the crop as latex to the processing plant will require the use of anticoagulants and if the quantity of anticoagulants used is to be kept at a minimum, then transportation has to be accomplished within a very limited time. In the case of coagulum, the use of anticoagulants and time limitation for haulage are eliminated. This would be advantageous especially for smallholders, as the proper use of anticoagulants would be an added problem to them. Also, coagulum can be delivered to the central factories to meet demands of daily production schedules which will result in greater factory utilization efficiency and lower capital costs. These are important economic factors in reducing the cost of production.

Use of bacterial coagulation in skim rubber manufacture

In the preparation of skim rubber from centrifuged skim latex, large amounts of coagulants are needed (about $1\frac{1}{2}$ pints of 2% sulphuric acid per gallon of skim latex), mainly because of the small size of the latex particles. Sheet or crepe rubber produced from latex skim by ordinary methods of coagulation with acids is heavily loaded with non-rubber substances such as protein and fatty material which impart undesirable properties to the rubber. The estate sample of skim rubber contains 8·15% acetone extract (*i.e.* fatty material) and about 6% of protein material compared with about 3% fatty material and about 2% protein for RSS (Table 3).

Skim fractions are normally held for periods of 36 — 48 hours prior to acid coagulation. During this period, incipient bacterial degradation of the skim takes place, thus requiring only minimal quantities of acids for coagulation and reducing the amount of non-rubber substances in the coagulated rubber. If the skim latex is left long enough, no acid will be necessary as it autocoagulates by bacterial action, which results in the production of obnoxious gases. This creates a nuisance to the workers in the factory and to the community resident in the neighbourhood. Coagulation takes five to six days to complete and the resulting coagulum is dark brown in colour (Fig. 3). The obnoxious gases produced are mainly due to contamination by aerobic bacteria.

Covering the tanks of skim latex would minimise contamination, but will prevent the escape of ammonia and hence will delay coagulation. We have observed that seeding the skim latex with suitable strains of bacteria, and covering the skim, overcomes these problems to a great extent. Complete coagulation is obtained in three days with no evolution of obnoxious gases. The properties of skim rubber obtained by autocoagulation and bacterial coagulation are given in Table 3. It will be seen that the covered samples have less dirt and less copper content than the uncovered samples.

TABLE 3
COMPARISON OF PROPERTIES OF SKIM RUBBER PREPARED BY AUTOCOAGULATION AND BACTERIAL COAGULATION

	Untreated (autocoagulation)		Treated (bacteria – R6)		Estate sample
	Covered	Uncovered	Covered	Uncovered	
Dirt %	0·029	0·035	0·028	0·046	0·077
Ash %	0·33	0·33	0·32	0·34	0·36
Volatile matter %	0·41	0·46	0·41	0·43	0·34
Acetone extract %	7·56	7·58	7·69	7·80	8·15
Nitrogen %	1·45	1·37	1·42	1·40	0·95
Manganese ppm	2·30	2·05	2·45	2·85	3·75
Copper ppm	6·46	11·60	5·50	10·50	8·20
PRI	21·7	19·1	22·7	11·6	—
Strain (TC)	31·0	28·0	30·0	30·0	50·0
Resilience (Lupke pendulum)	77·0	75·5	76·0	76·5	76·0

CONCLUSION

In conclusion it may be stated that the controlled bacterial coagulation is a useful process in enabling smallholders' latex to be converted into new process rubber by coagulation in the cup. It can also be used for coagulation in the factory. It is also of value in coagulation of skim latex to give a rubber with superior properties than acid coagulation with no attendant problems of odour nuisance.

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REFERENCES

BAPTISTE, E. D. C. (1962). Present possibilities of *Hevea* culture. *Rev. gen. Caout.* **39**, 1347 — 1374.

BAYNE, J. AND DE JONG, P. (1969). Current trends in processing of natural rubber. *Rubb. Bd. Bull.* **10**, 154 — 162.

JOHN, C. K. (1966). Biological coagulation of *Hevea* latex using waste carbohydrate substrates. *J. Rubb. Res. Inst. Malaya* **19**, 286 — 289.

SATCHUTHANANTHAVALE, R. AND SATCHUTHANANTHAVALE, V. (1970). Bacterial coagulation of latex. *Q. Jl. Rubb. Res. Inst. Ceylon* **48**, 182—191.

SOUTHORN, W. A. (1969). Latex collection in disposable plastic bags and the use of expanded plastic rainguards. *Plrs' Bull. Rubb. Res. Inst. Malaya* No. 104, 156 — 164.

VEERABANGSA, M. T. AND NADARAJAH, M. (1970). Suggested improvements in the manufacture of Ceylon natural rubber. *Q. Jl. Rubb. Res. Inst. Ceylon* **48**, 260—268.

QUESTIONS AND ANSWERS*

Question: Does bacterial coagulation produce a coagulum which is as porous as formic acid/molasses coagulated ? (Mr. M. Wijesinghe).

Answer : We would expect the coagulum to be more porous than that obtained by formic acid/molasses coagulation.

Question : Will the PRI be affected due to exposure to sunlight when bacterial coagulation is carried out in cups in the field ? (Mr. M. Wijesinghe).

Answer : We do not expect the PRI to be adversely affected due to exposure to sunlight in the field, because of the water present in the coagulum. The PRI would be adversely affected only if the coagulum is dry.

Question : Will there be no problems with regard to dirt content in the case of bacteria-coagulated rubber, if bacterial coagulation is to be carried out on the spot, without bringing the latex to the factory ? (Mr. A. Rasaratnam).

Answer : We agree that the dirt content may be more in bacteria-coagulated rubber than if the latex is brought to the factory and coagulated by the conventional method. However, as given in our paper the dirt content of bacteria-coagulated rubber is less than that of autocoagulated rubber.

* These questions and answers refer to the preceding paper as well. See pp. 182—192.