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## A B S T R A C T.

The paper deals with the general effect of cations and particularly that of sodium ion (in the form of chloride) on paddy (unhusked rice) and its application in parboiling, and in the dewatering and preservation of high moisture paddy under adverse weather conditions. A significant effect, which is seen even at low concentrations, is that of keeping the husk in a closed condition, discouraging the entry of salt into the kernel and facilitating its quick drying. This effect is complementary to that of ex-osmosis which is seen only at high concentrations, leads to the reduction in the moisture content of the kernel and helps in the preservation of the grain from heating, discolouration, sprouting and other spoilage changes. There is also the added advantage in that

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the effects are reversible and that the original properties of the grain, including germination, can be restored even after several months. Some of these findings have been demonstrably applied, with economic benefits, in 1) parboiling and quick drying of about 13,500 tonnes of paddy and producing marketable rice worth about a crore of rupees (equivalent to over 1.3 million U.S. Dollars) and 2) in the preservation and processing about 1000 tonnes of high moisture paddy at different centres. Other possible applications, not only in respect of paddy, but also other foodgrains, pulses, oilseeds, etc., have been indicated.

Other related observations are as follows:-

1) When paddy is soaked in cold salt solution at different concentrations, there is slow penetration of water, with equilibration at certain levels; but only minute quantities of salt enter the paddy even after prolonged soaking.

2) There is quick parboiling, with concurrent dewatering, when soaked paddy is boiled in salt solutions above a certain concentration so much so that the kernel moisture can be reduced from 27.5 to less than 13% in 30 minutes. At lower levels only the entry of water is retarded and this effect is seen even when paddy is merely rinsed with salt solution (sp. gravity 1100) and then parboiled with steam at a pressure of 50 - 75 lb per sq. inch (P.S.I.). The subsequent drying rate of the paddy is more than double that of untreated paddy. During these operations, a minute quantity of salt enters the paddy in the first few minutes because of the slight gap between the two folds of the husk, but this gets subsequently closed, preventing further entry.

3) When dry salt is mixed with high moisture paddy, there is steady withdrawal of water from the kernel, which eventually attains a safe moisture level of 12 - 14%. The water emerging from the kernel dissolves some of the salt to form a

nearly saturated solution (sp. gr. 1180) in which form it drains out. All spoilage changes are arrested by the salt and its solution without entering the kernel.

4) Careful opening and subsequent analysis of the different fractions of salt treated raw or parboiled paddy, after drying, would show that the residual salt is chiefly present on the husk, while a minute quantity is present on the surface of brown rice. After polishing, no more than a trace (less than 0.05%) is generally left on the surface of polished rice.

5) When drained free from the adhering solution, dry salt treated paddy keeps well even without further drying. Even after several months of storage, the germinating capacity of the paddy is restored after the adhering salt is removed by mere washing with water.

6) While the chemical mechanism is still not clear, the physical effect of the cation is seen through the changes in the properties of the husk which gets closed and becomes nearly impervious to the entry of salt. It is this effect, combined with ex-osmosis, which renders it possible to apply the treatment in preservation and processing. As the effects are reversible on washing with water, the associated changes should be regarded as being of a labile nature.

7) Pre-soaking of the paddy permits of the transmission of heat without the cracking of the grain. By conditioning at temperatures upto 70°C, it is possible to retain most of the original properties of the raw rice with distinct improvement in milling performance through over 20% increase in the yield of head rice and reduction in breakage. At higher temperatures, there is further hardening of the kernel with a tendency for the cooked product to remain integrally separate and stiffen on cooling. At temperatures above 100°C, there is further hardening, but there is also tendency for the kernel to become discoloured through non-enzymatic browning.

8) There is pronounced increase in the oil content of the polishings as the result of parboiling; but there is yet no evidence to show that it is influenced by the salt treatment. The oil content of the polishings is somewhat variable (22 - 28%), but the total quantity thus removed would represent only less than 50% of the total oil present in the aleurone layer.

9) The kernel in the salt treated and parboiled paddy is somewhat bigger in size and more uniform in shape than that from untreated parboiled paddy. The cooking qualities, in both the cases, are almost the same.

10) Mild steel tanks generally used in India for parboiling by hot soaking and steaming require general protection against rusting and scale formation, especially when they are not in continued use. Heat resistant, protective paints (eg. of the epoxy-resin type) confer the necessary protection and these have also been found to be adequate in conjunction with salt treatment. Acid and salt resistant cements are now available for application to floors and walls. Jute bags are already in use for storage of salt in India and salt treated raw or parboiled paddy have stood well in such bags.

11) Details of the procedure followed for the large-scale parboiling of paddy in conjunction with salt treatment have been given. Particular attention may be drawn to the non-absorption of water by the kernel during steaming and the quick rate of drying which is more than double that of untreated paddy. The cost of processing has been worked out and the economic benefits through saving in time, reduction in cost of drying and the increased turn-over have been indicated.

12) The procedures followed for dry salt treatment of wet season (high moisture) paddy, on a fairly large scale, at four different rural centres and also in conjunction with silo storage at Tiruvarur, have been outlined. In all cases, the

paddy had been stored for some months without any further drying; and then soaked and parboiled, after mere washing in the tank, to remove the adhering salt. The rice obtained on milling was of good, marketable quality and the yield was about 2% more than from untreated paddy which had been similarly stored after drying. The cost of salt treatment has been worked out and shown to be about a third of that incurred for mechanical drying.

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Though different mineral salts are being used as additives for the improvement of taste, fortification and preservation of different classes of foods, there is not much scientific literature on their direct effects on whole food grains. In the case of some pulses (particularly, Cajanus Cajang - Tur dhal), the action of some divalent ions, especially calcium and magnesium, as present in water, on the cooking quality; and also the beneficial effect of softners like the carbonate or the bicarbonate of sodium are well known. Sanjiva Rao and associates[1] used Calcium Chloride, for the soaking of paddy, so as to increase the calcium content of the kernel; but found the actual penetration to be very small. There have been reports about the use of common salt to prevent the spoilage of soaked paddy in bad weather; and also of the admixture of dry salt, along with a small percentage of vegetable oil (generally, mustard oil) in the preservation of milled rice. In some areas, dry salt alone is added to improve the keeping quality of parboiled rice. Such uses are, however, rather restricted and are not extensively known or practised.

The present paper relates, generally, to the effect of cations and, particularly, to the rather unique effect of sodium ion on paddy husk, with the attendant closure of the grain, the arrested inward movement of water and salt, while

there is outward movement of water through ex-osmosis, thus facilitating the dewatering of the rice kernel and the rapid drying of the grain, without any appreciable entry of salt into the kernel.

In the course of a study on the mechanism of the increase in the oil content of the rice bran as the result of parboiling, soaked paddy, with a kernel moisture content of about 25%, was dropped into boiling concentrated salt solution so as to attain temperatures above 100°C. It was then observed that the paddy parboiled in 2 - 3 minutes without the opening of any of the grains. Following this, there was visible reduction in volume of the grain and the hardening of the kernel at a very fast rate. As the latter suggested the withdrawal of water from the kernel through ex-osmosis, the studies were repeated with different salts and at various concentrations. The following results with concentrated Sodium and Calcium Chloride solutions and also with Sodium Chloride at lower concentrations will illustrate the trend.

## EXPERIMENTAL.

Paddy (variety, IR-8) which was hot soaked at 65°C for 4½ hours was used for all the experiments. In all the cases, the paddy was introduced into the boiling solutions and the heating continued, with frequent stiring to maintain the temperature. At selected intervals, samples of paddy were taken out, gently wiped between folds of dry cloth to remove adhering liquid and the moisture contents determined in both the whole paddy and in the kernel after quick shelling. The drying was done at 100 - 105°C for 4½ hours in each case.

## T A B L E - I.

Initial moisture content of paddy, 28.0%; that of kernel, 27.5%

Variety, I.R - 8.

| PARTICULARS | Time in Minutes | PERCENTAGE MOISTURE CONTENT | | REMARKS |
|---|---|---|---|---|
| | | Whole Paddy | Kernel* | |
| I. With concentrated Sodium Chloride solution of sp.gr. 1200 - Salt concentration 26.0% B.P. 108°C | 5 | 22.0 | 21.9 | Simultaneous parboiling and dewatering Parboiling completed in 2 - 3 minutes; but dewatering continued. |
| | 10 | 19.9 | 18.8 | |
| | 15 | 19.1 | 16.8 | |
| | 20 | 18.0 | 15.0 | |
| | 25 | 17.5 | 13.8 | |
| | 30 | 17.4 | 12.6 | |
| II. With concentrated calcium chloride solution of sp.gr. 1220 - Salt concentration 25.0% B.P. 120°C | 5 | 22.2 | 21.7 | Simultaneous Parboiling and dewatering. Parboiling completed in 2 - 3 minutes; but dewatering continued. |
| | 10 | 19.4 | 18.5 | |
| | 15 | 18.8 | 17.3 | |
| | 20 | 17.9 | 15.2 | |
| | 25 | 17.3 | 13.5 | |
| | 30 | 16.9 | 12.9 | |

* The moisture content of the kernel was determined at each stage by quick separation of the kernel with the Laboratory sheller and then determining loss of moisture by oven drying. The usual types of moisture meters based on changes in electrical conductivity are not useful in such cases.

| PARTICULARS | Time in Minutes | PERCENTAGE MOISTURE CONTENT | | REMARKS |
|---|---|---|---|---|
| | | Whole Paddy | Kernel | |
| III. | | | | |
| With sodium chloride solution of sp. gr. 1150 - Salt Conc$^{n}$ 20.0% B.P. 105°C | 5 | 23.7 | 23.0 | Parboiling completed in 2 - 3 minutes; dewatering more slowly than in I. |
| | 10 | 22.3 | 20.5 | |
| | 15 | 20.4 | 18.5 | |
| | 20 | 18.4 | 16.6 | |
| | 25 | 17.6 | 15.5 | |
| | 30 | 16.0 | 14.3 | |
| IV. | | | | |
| With sodium chloride solution of Sp.Gr.1100 - Salt Conc$^{n}$ 14.0% B.P. 103°C | 5 | 23.9 | 24.4 | Parboiling completed in 2 - 3 minutes; dewatering proceeds more slowly than at higher concentrations. |
| | 10 | 22.3 | 22.1 | |
| | 15 | 21.6 | 20.8 | |
| | 20 | 20.8 | 19.2 | |
| | 25 | 20.8 | 18.9 | |
| | 30 | 20.4 | 17.4 | |
| V. | | | | |
| With Sodium Chloride solution of Sp. Gr. 1050 - Salt Conc$^{n}$ 8,0% B.P. 102°C | 5 | 25.8 | 26.1 | Parboiling completed in 2 - 3 minutes. Very slow dewatering. |
| | 10 | 25.0 | 24.4 | |
| | 15 | 23.5 | 23.6 | |
| | 20 | 23.2 | 23.0 | |
| | 25 | 23.0 | 22.7 | |
| | 30 | 22.7 | 22.1 | |
| VI. | | | | |
| With Sodium Chloride solution of Sp. Gr. 1020 - Salt Conc$^{n}$ 4.0% B.P. 101°C | 5 | 27.2 | 27.9 | Parboiling completed in 2 - 3 minutes. Practically no dewatering. |
| | 10 | 26.9 | 27.9 | |
| | 15 | 27.3 | 27.9 | |
| | 20 | 26.4 | 27.3 | |
| | 25 | 26.4 | 27.3 | |
| | 30 | 26.4 | 27.0 | |
| VII. | | | | |
| With tap water (CONTROL) B.P. 100°C | 5 | 29.0 | 29.5 | Parboiling completed in 2 - 3 minutes with entry of water into paddy. |
| | 10 | 30.0 | 31.5 | Splitting of the grain started. |
| | 15 | 32.7 | 33.8 | -- -- |
| | 20 | 35.5 | 36.9 | Grain starts opening. |
| | 25 | 37.9 | 39.4 | -- -- |
| | 30 | 40.5 | 42.1 | Grain bursts completely. |

There was quick parboiling in all the cases, but the rate of drop in the moisture of the kernel was proportional to the concentration of salt. The results with other varieties of paddy - hard, soft or glutinous - also followed the same pattern; so, they have not been cited. Similar observations were also made with other metallic salts, but as their usage was expensive and also, in many cases, not permissible, further studies were mostly concentrated on sodium chloride. When the moisture content of the kernel was at about 15%, there was need to remove extra moisture only from the husk and this proceeded very fast even at the ambient temperature of 32 - 35°C. On milling the dried paddy, it was observed that the presence of salt could be detected only at the surface of the brown rice; but, there was only about 0.05% on the surface of rice polished to 4 - 6%.

## EXTENT OF PENETRATION OF SALT INTO PADDY DURING PARBOILING IN SALINE MEDIA.

In view of the very low penetration of salt even in a boiling medium, systematic studies were carried out to determine the actual extent to which salt solution enters the paddy from the time of immersion of the soaked material into the boiling brine (Sp. Gr. 1180). The procedure followed was to take out samples at intervals, remove the liquid adhering to surface, drying in the oven, opening each grain carefully with a scalpel, extraction of kernel with distilled water and estimating salt content volumetrically by the AOAC method. This procedure was adopted so as to eliminate the contact of salt present on the husk with the brown rice. The quicker aqueous extraction was adopted because it was found that the results were the same whether by this method or after ashing and extraction with dilute nitric acid.

T A B L E - II.

Variety, G.E.B - 24

| Time in Minutes. | Percentage of Nacl on Brown rice (On dry weight basis) |
|---|---|
| 1 | 0.32 |
| 5 | 0.48 |
| 10 | 0.49 |
| 15 | 0.49 |
| 20 | 0.49 |

Only a very small amount of salt had entered the paddy in the early stages; but, after that, there was no perceptible entry, though the heating in the same medium was continued.

Similar results were also obtained on prolonged cold soaking of paddy in salt solutions of different concentrations. There was only a slight increase in the salt content of brown rice even when the concentration was raised from 3 to 25%.

T A B L E - III.

Variety, I.R - 8

| Medium in which paddy soaked. | Percentage salt in the kernel (after 72 hrs of cold soaking on dry weight basis) |
|---|---|
| Distilled water (Control) | 0.005 |
| Salt solution Percent | |
| 3.0 | 0.019 |
| 9.0 | 0.024 |
| 15.0 | 0.027 |
| 21.0 | 0.035 |
| 25.0 | 0.038 |

Manner of entry of minute quantities of salt in the early stages.

On microscopic examination of dry or water soaked paddy (moisture content, 30%), it was observed that consequent on the absorption of water, there is a small but, perceptible gap between the two halves of the paddy husk. Through this gap, a minute quantity of salt solution enters the paddy and remains lodged in the groove. This can be seen even with the naked eye. The subsequent observations would suggest that the paddy then seals up and that there is no further entry of salt solution. The sealing of the paddy is observed even at lower concentrations of salt when there is neither much withdrawal nor shrinkage of paddy.

Extent of penetration of other sodium salts under similar conditions.

Similar experiments with other neutral salts of sodium (sulphate, and nitrate) yielded results which followed the same pattern as in Table - II. Sodium hydroxide, however, has a direct chemical action and tended to dissolve some of the constituents of the husk, besides imparting a colour.

Effect of different concentrations of salt on the penetration of water into paddy at different levels of moisture.

These studies were started with the object of determining the effect of salt solutions at ordinary temperatures on the penetration of water into paddy. Trials with paddy at different initial levels of moisture have been carried out; but in the following tables the results at only two levels have been cited.

## T A B L E - IV A.

Variety, I.R - 8

| Medium in which paddy soaked percentage Salt solution. | INITIAL MOISTURE CONTENT OF WHOLE PADDY - 9.5% KERNEL - 10.7% - PERCENTAGE MOISTURE CONTENT AFTER THE FOLLOWING HOURS - | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.0 | | 12.0 | | 24.0 | | 36.0 | | 48.0 | | 72.0 | |
| | A | B | A | B | A | B | A | B | A | B | A | B |
| Distilled water (Control) | 20.6 | 18.5 | 24.5 | 22.8 | 28.2 | 25.9 | 28.3 | 26.2 | 29.7 | 26.5 | 31.3 | 28.9 |
| 3.0 | 19.7 | 17.0 | 22.4 | 20.2 | 24.8 | 22.2 | 24.9 | 22.4 | 26.6 | 23.7 | 28.4 | 25.8 |
| 9.0 | 18.2 | 16.5 | 19.4 | 17.8 | 21.9 | 19.2 | 21.5 | 19.2 | 22.6 | 20.5 | 24.1 | 21.4 |
| 15.0 | 16.8 | 14.6 | 18.4 | 16.5 | 19.2 | 16.8 | 19.2 | 16.8 | 20.5 | 18.1 | 21.4 | 19.0 |
| 21.0 | 14.5 | 14.0 | 17.5 | 15.5 | 17.5 | 15.5 | 17.5 | 15.5 | 18.9 | 16.7 | 20.2 | 17.8 |
| 25.0 | 13.7 | 12.9 | 16.5 | 14.5 | 16.5 | 14.5 | 16.5 | 14.5 | 18.0 | 15.6 | 19.4 | 17.0 |

A :- WHOLE PADDY B :- KERNEL.

## T A B L E - IV B.

Variety, I.R - 8

| Medium in which paddy soaked, percentage salt solution. | INITIAL PERCENTAGE MOISTURE CONTENT OF WHOLE PADDY - 25.0 KERNEL - 23.0 - PERCENTAGE MOISTURE CONTENT AFTER THE FOLLOWING HOURS - | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4.0 | | 12.0 | | 24.0 | | 36.0 | | 48.0 | | 72.0 | |
| | A | B | A | B | A | B | A | B | A | B | A | B |
| Distilled water (Control) | 26.7 | 24.0 | 28.1 | 26.6 | 29.0 | 27.6 | 29.7 | 27.8 | 29.7 | 27.9 | 29.7 | 28.0 |
| 3.0 | 25.2 | 23.7 | 26.7 | 25.1 | 27.0 | 25.0 | 27.5 | 25.0 | 27.7 | 25.3 | 27.5 | 25.3 |
| 9.0 | 24.0 | 21.8 | 24.5 | 21.8 | 24.5 | 21.1 | 24.2 | 21.1 | 24.7 | 21.5 | 25.0 | 21.5 |
| 15.0 | 23.5 | 20.8 | 23.6 | 20.8 | 23.5 | 20.3 | 23.0 | 19.8 | 23.0 | 19.8 | 22.5 | 18.9 |
| 21.0 | 21.8 | 19.3 | 23.0 | 18.7 | 23.0 | 18.5 | 23.2 | 18.3 | 23.2 | 18.3 | 21.6 | 17.5 |
| 25.0 | 21.0 | 18.9 | 22.9 | 18.7 | 22.9 | 18.5 | 22.8 | 18.3 | 22.8 | 18.3 | 21.6 | 17.5 |

A :- WHOLE PADDY. B :- KERNEL.

It may be noted that, irrespective of the initial moisture content of the paddy, prolonged contact with salt solution results in the kernel gradually attaining a certain level of moisture, depending on the concentration of the salt. This would offer scope for application even in cold soaking of paddy for parboiling provided there is 1) no development of off flavour 2) arrangement for periodical sedimentation of soil and other foreign matter by addition of alum or other clarifying agent. As the paddy continues to remain closed and does not permit of the entry of more than traces of salt, there would be scope to parboil such paddy by steaming while still maintaining a low level of moisture in the kernel. This would deserve to be followed up because, apart from quick drying, there may be scope to produce odourless parboiled rice even under village conditions.

Effect of rinsing soaked paddy with salt solution on the penetration of water during steaming.

Though parboiling and dewatering of paddy can proceed side by side in saline media, it was considered desirable to determine the effect of mere rinsing of soaked paddy with salt solution on its subsequent response to parboiling by steaming as is generally practised. This was studied with different concentrations of salt solution; but in the following table only a few results have been cited. Both open steaming and closed steaming (15 P.S.I) were tried. Steam was applied for 15 minutes in each case. When untreated paddy is used, there is continued absorption of moisture, whereas, after salt treatment, the absorption is retarded. In the latter case, the paddy remains completely closed. In the control, the paddy opens and that facilitate larger entry of water. The salt solution can act with greater efficiency at higher concentrations and lead to reduction of moisture content of the kernel to even 17 - 18%, but if the steaming is not applied immediately, there is some risk of quick dewatering before parboiling

in which case there will be a high incidence of white abdomen (belly) and heavy breakage during milling.

T A B L E - V.

Variety :- I.R - 8.

| INITIAL MOISTURE CONTENT WHOLE PADDY - 27.0% KERNEL - 26.5% | | | | |
|---|---|---|---|---|
| Temperature of soaking - 65°C | | | | |
| CONCENTRATION OF SALT USED FOR RINSING. Sp. Gr. | PRESSURE 5 to 8 p.s.i. (Open steaming) | | PRESSURE 15 p.s.i. (Closed steaming) | |
| | PERCENTAGE MOISTURE CONTENT | | | |
| | A | B | A | B |
| - NIL - (CONTROL) | 31.1 | 34.0 | 29.2 | 33.0 |
| 1100 | 26.2 | 25.8 | 25.4 | 25.7 |

A :- WHOLE PADDY B :- KERNEL

RATE OF DRYING OF PARBOILED PADDY WITH AND WITHOUT SALT TREATMENT.

This of considerable practical significance as mechanical drying is a major item of expenditure for modern rice mills in conjunction with parboiling. Even in plinth drying, it is of importance, especially under humid conditions when the drying is very slow.

In the following experiment, the drying was done with the same quantities and under identical conditions, with maintenance of circulating air at constant temperature in a Kilburn dryer.

## T A B L E - VI.

Variety - Co-25

| TIME IN MINUTES | Soaked and steamed (Control) | | Parboiled in boiling salt solution of Sp. Gr. 1180 | | Steamed after rinsing with salt solution of Sp.Gr.1100 | |
|---|---|---|---|---|---|---|
| | - TREATMENT GIVEN - | | | | | |
| | PERCENTAGE MOISTURE CONTENT | | | | | |
| | A | B | A | B | A | B |
| TEMPERATURE OF DRYING - 50°C | | | | | | |
| (INITIAL) | | | | | | |
| 0 | 27.8 | 29.7 | 23.8 | 16.9 | 25.3 | 24.0 |
| 30 | 25.2 | 27.8 | 20.6 | 16.7 | 21.6 | 22.3 |
| 60 | 22.8 | 23.5 | 18.3 | 16.4 | 21.2 | 20.3 |
| 90 | 19.6 | 19.8 | 16.6 | 14.8 | 17.2 | 17.8 |
| 120 | 17.7 | 19.0 | 13.5 | 13.0 | 14.0 | 15.5 |
| 150 | 15.3 | 18.0 | 12.5 | 12.6 | 12.7 | 14.5 |
| TEMPERATURE OF DRYING - 70°C | | | | | | |
| INITIAL | | | | | | |
| 0 | 30.6 | 41.0 | 26.2 | 16.5 | 27.2 | 32.0 |
| 20 | 23.8 | 26.8 | 21.3 | 16.3 | 20.9 | 22.0 |
| 40 | 21.7 | 24.0 | 17.6 | 15.0 | 18.1 | 20.0 |
| 60 | 16.7 | 20.5 | 13.0 | 13.5 | 13.7 | 15.5 |
| 80 | 14.4 | 16.5 | 9.8 | 11.0 | 10.2 | 12.8 |

A :- WHOLE PADDY B :- KERNEL.

The rate of drying of paddy parboiled in brine is extremely fast; that of paddy rinsed with salt solution is also much faster than that of untreated paddy. During steaming of salt rinsed paddy, there is condensation of water, which, though it does not enter the paddy, has to be fully drained out or otherwise mechanically separated before drying.

The rate of drying increases with the temperature. Repeated large-scale trials have shown that parboiled paddy can be dried, at a fast rate, by hot air at 120°C or more provided a vigorous blast of air is maintained. As long as the moisture of the paddy is above 13 - 14%, the evaporation of water maintains the temperature of the paddy at less than 60°C. Under such conditions, the rate of drying of the salt rinsed paddy is more than double that of the untreated paddy; while paddy parboiled in concentrated brine dries at more than four times the rate of untreated (steam parboiled) paddy.

Action of dry Salt on high moisture paddy.

Dewatering by concentrated salt solution results in the release of water into the medium with attendant dilution and reduction in subsequent rate of dewatering. In the case of freshly harvested wet season paddy, quick, dewatering and the removal of the drained fluid is essential for preventing the various undesirable effects such as heating, discolouration of kernel,[4,7] loss of dry weight and sprouting. It was considered desirable, therefore, to try the effect of uniform admixture of dry salt with such paddy and to study the rate of drop in kernel moisture. For preliminary assessment of the effect, paddy with initial moisture content of over 22% was intimately admixed in small lots of two kg each with dry, powdered salt at different levels and allowed to stand in metal containers with hopper bottoms and adequate drainage facilities.

T A B L E - VII.

RATE OF DROP IN THE MOISTURE CONTENT OF RICE KERNEL AS THE RESULT OF DRY SALT TREATMENT OF HIGH MOISTURE PADDY.

| Variety of Paddy | Percentage Initial kernel Moisture Content. | Percentage of Dry salt added. | PERCENTAGE OF KERNEL MOISTURE AT INTERVALS IN HOURS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 3.0 | 6.0 | 9.0 | 24.0 | 36.0 | 48.0 | 72.0 |
| ADT - 27 | 22.0 | 5.0 | 18.7 | 16.4 | 15.3 | 14.0 | 12.8 | 12.8 | 12.5 |
| Co - 25 | 24.5 | 5.0 | 19.5 | 16.7 | 16.6 | 15.0 | 15.0 | 15.0 | 13.8 |
| I.R - 8 | 22.8 | 5.0 | 17.9 | 16.6 | 16.0 | 16.0 | 14.2 | 14.2 | 14.1 |

Other experiments carried out by addition of salt at proportions higher, as well as lower, than 5% to the weight of paddy showed that the rate of dewatering generally increased with the concentration of salt. Bigger sized grains dewatered at a lower rate than smaller ones; but the preservative action of salt with the arresting of the heating and, discolouration, besides sprouting, was about the same in all cases. The water coming out of the paddy dissolved a part of the added salt to form nearly a saturated solution (Sp. Gr. 1180) in which form it drained out as a clear liquid. The drainage was rapid from the top, but the liquid being thick, there was a tendency for some quantity to stick to the bottom layers. On being discharged and placed in a sloping basin, the drainage proceeded faster. The paddy thus dewatered could then be stored in jute bags without any of the undesirable features already referred to. The same paddy could also be washed and then soaked for parboiling or dried at any convenient time and milled in the raw condition. In India, the wet season paddy is generally used for parboiling; so the dewatered and preserved paddy can be used as such for the purpose.

Mode of action of salt on paddy under different conditions.

The foregoing and other related observations would show that salt, either in solution or in a dry state, has an inhibiting action on the penetration of water and that this effect becomes quite pronounced with the increase in concentration. There is also the associated, visible effect on husk which, even after a short period of contact, gets completely closed. Paddy in that condition discourages further entry of water or salt even when there is strong heating in solution or on steaming. This does not however prevent the movement of water in the reverse direction from the kernel into the outer medium, so that dewatering by ex-osmosis is facilitated. Drying of the paddy is also facilitated by this treatment. The effect is also seen in the case of other neutral sodium salts, so that the common factor seems to be the cation. Similar effects, though with varying degrees of efficiency, are also produced by different potassium, ammonium, calcium, magnesium, iron, aluminium and other salts and these would require further study.

In the case of fruits, vegetables and such other food products, the withdrawal of water by the osmotic effect of salt is generally accompanied by the subsequent penetration of salt solution into the food product so that, eventually, a stage of equilibrium is attained. In the case of paddy, there is essentially an one-way movement, so that the paddy gets dewatered while no more than a minute quantity of salt enters the paddy. It is this feature which offers scope for practical application. Added to this, the closing of the paddy under such conditions, combined with the presence of salt on the exterior of the husk, may be expected to confer some protection against the entry and action of the commoner spoilage organisms and also many forms of insect fauna.

## Mechanism of action of salt on paddy and scope for extended application.

While the physical effect of the cation on the husk is visible and significant, the related chemical changes will require systematic investigation. That the effect is reversible can be inferred from the fact that the paddy soaks and otherwise behaves in the same way as untreated paddy after it is washed with water. A similar property is shown by soil clay which is rendered impervious to water through formation of sodium clay by the action of salt; and which is also reversed on thorough washing. This is attributed to the effect on soil humus which is largely derived from lignin. Paddy husk does contain some lignin, but another important component is silica which exists in combination to the extent of over 30% of the dry weight. A systematic chemical study in relation to the different components not only of the husk, but also of the aleurone layer will yield fruitful results.

A better understanding of the mechanism will further help to improve on the applications which have been dealt with in later sections of the present paper. There may also be scope to extend the application to other seeds in general and particularly in the preserving and processing of other cereals, as also pulses, oilseeds etc. All these present serious post - harvest problems when there is unexpectedly heavy rainfall and prolonged high humidity in the atmosphere. In addition to the general effects on quality, milling or oil extraction, as the case may be, there may also be serious hazards to public health through growth of microorganisms and the attendant formation of toxins.

Distribution of salt between different milling fractions under varying conditions.

Attention has already been drawn to the fact that there is a short interval between the introduction of the paddy (dry, moist or presoaked) into the saline medium and the closing of the paddy husk; that, as the result of it, a minute quantity of salt solution enters between the folds of the paddy husk. There is also another factor which contributes to a small extent to the deposition or smearing of the salt on the surface of brown rice. During shelling, either in the laboratory or in the mill, there is the contact of both unshelled paddy and the husk, though for a very short period, with brown rice. During polishing, the bulk of this adhering salt is removed with the bran, the quantities adhering to the polished rice diminishing as the rice moves from one cone to another. When sheller cum hullers or only hullers are used, there is also similar removal of the adhering salt along with the mixture of husk and bran. Whatever is left over on the final polished rice is removed during the usual washing of the rice before cooking. It was nevertheless considered desirable to make a quantitative assessment of the possible ranges in each case.

The results presented in column 2 have been subsequently confirmed in the case of nearly 1000 tonnes of ADT-27; those in column 3, with nearly 13,500 tonnes of different varieties of paddy.

Because of its direct contact with the salt or its solution, the highest concentration is naturally present on the husk. The bulk of the salt left on the surface of the brown rice is removed with the bran, so that the polished rice contains no more than traces of salt. As the latter are present on the surface, even that gets removed during the washing off the rice prior to cooking.

## T A B L E - VIII.

### DISTRIBUTION OF RESIDUAL SALT IN DIFFERENT MILL FRACTIONS.

| Experiment No. | Variety of paddy with Initial Moisture Content (Percentage) | TREATMENT GIVEN | RANGE OF SALT CONTENT (AS Nacl) ON MILLED PRODUCT (PERCENTAGE) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Paddy | Husk | Brown rice. | Bran (as 5 - 6% polish on brown rice) | Polished rice |
| 1. | ADT-27 (20-25) | Dry salt treated Dewatered and then dried to 14 - 16% Moisture - Milled raw. | 0.365 | 0.610 | 0.211 | 0.590 | 0.190 |
| 2. | ADT-27 (20-25) | Dry salt treated, dewatered, then washed, cold soaked, parboiled and dried to 13 - 14% Moisture. | 0.074 | 0.110 | 0.067 | 0.062 | 0.061 |
| 3. | Co-25 (13-16) | Hot soaked, rinsed with salt, parboiled and mechanically dried and milled in modern mill. | 0.076 | 0.253 | 0.013 | 0.087 | 0.009 |
| 4. | Co-25 (13-16) | Same as (3) but milled in a huller mill | 0.076 | 0.220 | -- | 0.150 | 0.014 |

Effect of dry salt treatment on germination of paddy.

As the dry salt treatment of high moisture paddy arrests the germination, it was of interest to determine whether such treatment affected the viability of the seed. Different varieties of paddy, as produced for seed purposes, were treated with dry salt at 5% for removal of excess moisture from the kernel, then dried, stored for six months at the then prevailing temperature (25 - 33°C), then washed with water, soaked for four days and the percentage of germination determined. The results were compared with those for the same varieties of seed paddy which were mechanically dried at a low temperature of about 50°C, treated for protection against insect infestation, and then stored.

T A B L E - IX.

EFFECT OF SALT TREATMENT ON THE SUBSEQUENT GERMINATING CAPACITY OF SEED PADDY.

| TREATMENT | VARIETY AND PERCENTAGE OF GERMINATION | | | | | |
|---|---|---|---|---|---|---|
| | ADT - 27 | ADT -8 | IR-8 | Co-25 | Co-32 | IR-5 |
| - CONTROL - Mechanically dried at low temperatures. (45 - 50°C) | 99.0 | 97.0 | 98.0 | 96.0 | 95.0 | 99.0 |
| Salt treated, dried at ordinary temperature and stored. | 98.0 | 92.0 | 93.0 | 91.0 | 90.0 | 98.0 |

It may be seen, from the above, that though it arrests the germination, the salt treatment does not have any serious

adverse effect on the viability of the seed. As the salt on the surface of the husk acts as a general protection against the growth of microorganisms, the treatment would offer a simple method for the dewatering and preservation of seed paddy from the stage of harvest. Further work in this line may prove fruitful.

Processing of paddy, at different temperatures, in conjunction with salt treatment, for improvement of milling performance and production of different qualities of rice.

Though parboiling has been recognized as a means of improving the milling quality of, particularly; the soft varieties of rice, its use has been largely confined to India and also countries where Indians have settled. There is a limited demand for such quality of rice in U.S.A. and also in some of the countries of Europe. Most of the rice-eating countries, especially in the Far East, do however prefer raw rice, especially of the soft and glutinous type which have generally poor milling quality. In such regions, it would be desirable to improve the milling quality without much change in the cooking quality. This may be particularly necessary in the case of a high yielding variety like IR-8. With this in view, the paddy was soaked at 65°C for 4½ hours and cured at different temperatures in water and finally dried at 45°C. About 2% salt was added to avoid the opening of the paddy grain when treated at higher temperature than 80°C.

## T A B L E - X.

EFFECT OF CONDITIONING OF PADDY (IR-8) AT DIFFERENT TEMPERATURES.

| Temperature and time of treatment C for twenty minutes | PERCENTAGE YIELD ON WEIGHT OF PADDY DEGREE OF POLISHING 5.0% | | | APPEARANCE OF MILLED RICE (Opaque, Translucency, hardness, color etc.) | Time of cooking in minutes | QUALITY OF COOKED RICE |
|---|---|---|---|---|---|---|
| | Head rice | Small and Medium Brokens ($\frac{1}{4}$ and $\frac{1}{2}$) | FINE BROKENS ($< \frac{1}{4}$) | | | |
| No treatment (Control) | 44.2 | 28.0 | 1.5 | Completely opaque white abdomen. | 16.0 | Soft, white in colour, grains stick to each other. |
| 50 | 53.3 | 20.2 | 1.3 | Opaque and more abdomen grains. | 16.0 | Soft, white in colour, grains stick to each other. |
| 60 | 54.1 | 18.5 | 1.3 | Opaque and diminishing white abdomen grains. | 21.0 | Soft, white in colour, grains stick to each other |
| 70 | 67.9 | 6.0 | 0.8 | Translucent and very few white abdomen grains. | 23.0 | Slightly soft, white in color, less sticking of the grains. |
| 80 | 73.0 | 1.0 | 0.8 | More translucent light yellow and no white abdomen grains | 38.0 | Slightly stiffer and light brown in colour. |
| 90 | 73.0 | 1.0 | 0.08 | Completely translucent faint yellowish and hard grains. | 39.0 | Stiffer and very light brown in colour. |
| 100 | 73.4 | 0.4 | .. | Completely translucent; faint yellowish and very hard grains. | 42.0 | More stiff light yellow in colour. |

The results show that upto 70°C, there is no major change in the cooking quality of rice; but there is a distinct improvement in the milling quality. Soft and glutinous varieties are most liked in many of the countries of the Far - East; but the milling of such varieties generally involves heavy breakage, especially in hullers which are extensively used in those countries. By simple processing such as the above, it should be possible to improve the milling quality without changing the cooking quality. The improvement in milling quality coincides with the gradual disappearance of the white abdomen. Displacement of the minute quantities of entrapped air can be achieved in many ways, such as dry heating, steaming[5,6] and evacuation. In the above experiment, the pre-soaking of the paddy served as a means of transmission of heat. By increasing the time combined with evacuation, the processing conditions can be further modified.

Parboiling, as adopted in India, would only represent a more advanced stage of the same procedure in which there is also a partial gelatinization of starch. By increasing the temperature of processing, the grain can be further hardened with still better milling quality; but this also increases the cooking time and changes the property of the cooked rice. In the latter case, there is very little gruel loss, and the grains become integrally separate. In many parts of India, parboiled rice is liked, not only for its better milling quality, but also for the properties of the cooked rice. By changing the temperature of processing, it is possible to produce different qualities of parboiled rice. Increase in temperature beyond 100°C makes the grain more and more hard; but it also catalyses non-enzymatic browning. The cooked grain also acquires a scalded flavour which is liked by consumers in some areas.

Effect of Salt treatment on the oil content of the bran.

Though the present study started with that object, repeated trials with different varieties have shown that the action of salt relates chiefly to the movement of water and does not affect that of oil. The oil in the bran layer is only partially released by water and moved towards the surface during parboiling. The variety of paddy and the temperature of parboiling are important; but with the methods which are now being followed, it is not possible to get more than 40-50% of the total oil present in the aleurone layer through the polishings. In the case of treatment of paddy with a high concentration of calcium salt, it was observed that the oil could not be fully extracted from the parboiling. The subject will be dealt with, in greater detail, in another communication.

Effect of salt treatment on the shape, size, cooking quality and taste of rice.

As the result of the salt treatment, the kernel remains completely encased within the husk during all the operations and also during subsequent storage up-to the stage of milling. By this means, the kernel is well protected and has no contact with dust, dirt or other foreign matter.

There is however expansion in volume to the extent of about 15% during soaking and parboiling. Whether the parboiling is done in concentrated brine or whether the paddy is only salt rinsed and steamed, the size of the rice kernel continues to remain bigger; but the husk continues to remain as an elastic belt around it and thus maintains the original shape of the rice. Steaming of soaked paddy, without salt treatment, leads to the kernel, not only absorbing excessive amount of water but also emerging out of the husk. When such paddy is dried either in the open or in a mechanical dryer, there is only incomplete closure of the husk and part of the

kernel remains exposed. Even rinsing of the soaked paddy with salt solution - prior to steaming - keeps it closed and preserves the shape of the kernel upto the milling stage.

In the early stages, there was some apprehension in the minds of even fellow scientists about the possible entry of salt into the kernel and thus affecting the acceptability of the milled product; but, that fear has now been completely eliminated, not only by scientific data but also the ready acceptance of such rice by the consumers.

For comparative evaluation of cooking quality and taste, samples from the same batches of paddy were soaked and parboiled under identical conditions excepting that, in one set, the soaked paddy was steamed as such while in another, it was rinsed with salt solution of Sp. Gravity 1100 before steaming. They were then dried and milled under identical conditions. The cooking performance, as also evaluation of the quality of the cooked product, were studied by a testing panel.

It was observed that the cooking time was practically the same in both the cases and ranged from 40 - 45 minutes. The difference in flavour and taste was not noticeable; so, it may be regarded as being practically the same. There was some slight difference in swelling number and the figures are given in the following table.

T A B L E - XI.

SWELLING NUMBER OF PARBOILED RICE WITH AND WITHOUT SALT TREATMENT.

| V A R I E T Y O F P A D D Y | | | | | |
|---|---|---|---|---|---|
| IR - 8 | | Co - 25 | | ADT - 27 | |
| S.T. | U | S.T. | U | S.T. | U |
| 4.4 | 4.1 | 4.1 | 4.0 | 4.1 | 4.4 |

S.T. :- Salt Treated. U :- Untreated.

For practical purposes, the consumer acceptability of parboiled rice as produced with and without salt treatment may be regarded as being the same.

Effect of salt treatment on the keeping quality of parboiled paddy.

Storage studies have been conducted with paddy parboiled in brine (Sp.Gr.1150 - 1180) and also with steam parboiled paddy treated with dry salt (5%) during the wet season. Both of these classes of products have kept very well in jute bags after merely draining out the adhering salt solution. There was no fungus growth or insect damage for about 6 months. Parboiled paddy, as produced after rinsing with salt before steaming, and then mechanically dried had stored well in silos for about 3 months. There is however need for more systematic study comparing it with untreated, steamed paddy after both mechanical and plinth drying to the same level of moisture.

Effect of salt treatment on floors, walls, containers and equipment - Application of simple, protective treatments.

At the present time, paddy is being stored, mostly, in jute bags and to a limited extent in concrete silos. Cold soaking for traditional parboiling is done in concrete tanks, while hot soaking is generally done in mild steel tanks. The conveying and other equipment, including dryers, are also made of the same type of metal. Flooring in most places is of cement or brick or tile with cement pointing. It was anticipated that, in all such cases, contact with salt or salt treated products will have some effect and protective measures should be adopted in the same way as in chemical industries which have to handle salt and related chemicals.

Jute bags are already being used for storage and transport of salt. This is known to reduce the life of the

jute bag to some extent; but it has been found that if direct contact with salt is minimised, this effect may not be pronounced. Acid resistant cement formulations are now available and they can be safely used for protecting any surface or wall with which salt may come into contact. Protection of metal - particularly iron - against the action of salt has been the subject of extensive research, with particular reference to ships, bridges, dykes etc. which have to remain in continued contact with sea water. In chemical industries, quite high concentrations of salt are generally being handled with perfect safety. With this background, a number of studies were carried out with advice and assistance from the Central Electrochemical Research Institute, Karaikudi. Enquiries in respect of metal cladding and direct metal coating with stainless steel of aluminium showed that such protection would be much too expensive for the rice milling industry. Expendable anodes such as aluminium or aluminium-magnesium alloys were found to be useful; but, they had comparatively limited scope. Brushable epoxy - resin paints were found to be both easy to apply and also effective and, among those, heat and salt resistant formulations based on bitumen or zinc were found to be useful. The type of paints used for painting boiler tubes (eg. Apexior paints) were also found to be useful and conferred protection for a few months at a time.

The dissolution of iron in salt solution is comparatively negligible, being of the order of a few parts per million. Iron is normally prone to rusting, especially in contact with moisture and air and this accelerated by heating. This takes place even without contact with any salt as soon from the experience of even rice mills which are not using any salt treatment. At Tiruvarur, Apexior No.3 was first used, but another formulation has since been found to be more effective. A brushable epoxy-resin black paint marketed by a leading manufacturing firm has also been found to confer good

protection Aluminium paints can also be used, but they may require periodical repainting.

Experience has shown that tanks and equipment require protection particularly when they are in continued use and there are prolonged periods of exposure to air. With almost continued use and with periodical application of protective paints, the parboiling tanks and other equipment at Tiruvarur have continued to remain in good condition. Actual measurements have shown that tanks which were first installed in 1965 and which have been in continued use with salt treatment since 1969 have suffered practically no damage; that the actual loss in the thickness of the metal sheets (which were originaly 6 mm thick) is less than 0.2 mm. Even this was found to be mostly due to the rusting of the metal during the first four years when the tanks remained mostly unused. With the application of protective paints, the tanks are now in a better condition than before; so much so that the capacity of the tanks has been increased by 50% so as to parboil larger quantities than have, so far, been possible.

As may be seen from the details of the procedure, as given in a later section, the actual period of contact of soaked paddy, with salt solution in each tank, is only about 15 minutes, after which the salt is withdrawn. For the rest of the period, the paddy is in contact with either water or steam. After each parboiling operation, the tanks are completely washed with water before a fresh batch of paddy is introduced for hot soaking.

Parboiling is now emerging from the stage of being an empirical rural industry, based chiefly on human labour, to a scientifically controlled modern industry in which metallic equipment, with tanks, conveyers, elevators and dryers have some to be increasingly used. Such equipment require

protection and preventive maintenance and the significance of this is now being increasingly realized.

## APPLICATIONS.

As the laboratory studies had shown that soaked paddy can be both parboiled and dewatered in a few minutes by being dropped into boiling brine of Sp. Gravity 1180, the feasibility of the reverse procedure of pumping boiling brine into paddy previously soaked at 65°C was first tried, so as to make the best use of the available equipment. This proved, however, to be unsatisfactory because there was an initial drop in temperature; so much so that some percentage of the grains got dewatered and developed white abdomen (belly) before the parboiling could take place.

Further advance in the application of boiling brine can however be made by design of suitable equipment for continuous feeding of soaked paddy into boiling brine; subsequent removal of adhering brine by centrifuging or other quick means and then drying the husk by superheated steam (as practised in sugar manufacture) or with a current of hot air.

Another procedure which was tried was the pumping of a calculated quantity of cold, concentrated brine into soaked paddy, without removing the soak water, and then raising the temperature to boil. The object of this was to have a minimum concentration of brine (4%) in the medium so as to prevent the opening of the paddy and excessive absorption of water during parboiling. This method also offered some practical difficulties, as there was not sufficient dewatering and the parboiling was not uniform. Moreover, the salt solution became so dilute at the end of each operation that it could not be recovered for re-use.

The procedure which was then adopted and successfully applied on a large scale may be described as follows :-

HOT SOAKING OF PADDY.

Water is first heated to about 90°C in a large tank and about 5,500 litres are drawn into the soaking tank which has a total capacity of 10,250 litres. Paddy, which is drawn from the silo and kept in an overhead tank is then discharged in a steady stream till about 5½ tonnes are drawn into the tank. The water in the tank is then circulated so as to ensure uniformity of wetting and distribution of heat. During circulation, part of the heat is absorbed by the paddy and the temperature becomes steady at 65 - 68°C. At this point, the circulation is stopped and the mass of chaff, immature grains and other light-fractions which could not be removed by the enscalper and which tend to float are removed. During the soaking period, which follows, there is not much drop in temperature below 63 - 64°C even after some hours. At the end of 3½ - 4 hours (depending on variety), a small sample of paddy is taken from the tank and tested for completion of soaking.

The interval between the starting of the soaking and the testing can be used for starting the soaking in 2 or 3 more tanks at hourly intervals.

SOAKING TEST.

About 60 ml of salt solution of Sp. Gravity 1180 is introduced into a metallic vessel and heated to boiling. The heating can be done with gas or a small kerosene stove. While the boiling is continuing, the paddy (30 - 40 gms), drained free from adhering water, is dropped into the boiling brine and the heating continued so as to maintain the boiling for five (5) minutes. The paddy is then drained free from adhering salt solution, wiped between folds of cloth and then shelled either in a mechanical sheller or between two wooden discs one of which is provided with grooves. The sample of

kernel which is thus separated is examined to see whether there is any visible white abdomen (belly). If the latter is present, the soaking in the main tank is continued and a further sample taken after about 30 minutes for further testing. When the white abdomen is completely absent, the paddy in the tank may be regarded as having soaked to the desired extent.

The above test, which is comparatively simple, is considered to be necessary because the unsoaked portion in the centre of the grain may not be easily visible to the naked eye. Moreover, it has been found that all grains, even in the same batch, do not soak at an uniform rate. The test helps to bring the white abdomen in the kernel into prominence, so that we can detect it even if a small percentage of grains remains under soaked.

Experience with about a dozen varieties of paddy has shown that the soaking time is variable, depending on 1) the variety of paddy, 2) the initial moisture content 3) the temperature that is maintained in the tank and 4) the extent to which dissolved salts and other impurities are present in the water. If most of the conditions are identical, the soaking time is practically the same for the same batch of paddy; but, even then, the soaking test is considered to be a measure of safety because the subsequent operations and the milling performance are largely dependent on the efficiency of soaking.

When the soaking is complete, the total moisture content of the paddy is about 30% and that of the kernel about 25%.

BRINE TREATMENT.

After completion of the soaking test, the soak water is generally discharged into the drain as it is somewhat muddy and coloured. If, however, heat economy is important, the

soak water can be re-used two or three times after raising the temperature to about 90°C on each occasion.

After the soak water is mostly drained out, salt solution of Sp.Gravity 1080 - 1100 which is kept ready at the ordinary temperature, (25 - 30°C) is pumped from another tank, using a chemical pump for the purpose. It takes less than 5 minutes to pump sufficient brine to cover the soaked paddy. The brine is then circulated for 8 - 10 minutes so as to make certain that all the grains get wetted with the brine. The brine is then withdrawn into another tank so as to make up the concentration for re-use.

There is always some dilution of the salt solution during the above operation chiefly because of the water which is adhering to the paddy. Most of the salt used for the treatment is recovered, but as the volume goes on increasing, there is need to preferably concentrate it before re-use. Addition of a further quantity of dry salt helps to make up the concentration, but it also further increases the volume. When large quantities (60 - 70 tonnes of paddy per day) have to be parboiled, the concentration and subsequent reuse of the salt assumes some economic importance.

STEAMING.

With the present type of parboiling tanks and the large masses of paddy to be handled in each batch, it has been found necessary to send steam from the bottom at 50 - 75 pounds per square inch (p.s.i) so as to ensure quick and uniform heating of the entire mass. This takes about 15 minutes but an extra period of 3 - 5 minutes is generally allowed.

During parboiling, the paddy attains a temperature of 105 - 110°C. This heat is more than sufficient to drive out all the dissolved air (as shown by the complete transluscency of the kernel) and also to bring about the necessary gelatini-

sation of starch. The steaming operation is consistently so efficient that no special test is considered necessary at this stage.

When the steaming is in progress, the drain taps at the bottom are kept fully open so as to drain off as much water as possible. Even after completion of parboiling, the drainage may be continued so as to minimise the amount of adhering water to be evaporated during the drying of the paddy.

If the salt treatment is not applied, the water is absorbed by the kernel, the moisture content of which rises to 32 - 35%. As the result of the salt treatment however the paddy remains completely closed and no water is absorbed by the kernel. The condensed water, which could not enter the paddy remains, however, in the interspace; but, could not be fully drained out. For efficient removal it will be advantageous to centrifuge or to incorporate a shaking device; but the feasibility of introducing these in conjunction with the existing equipment will have to be studied.

It has been noted that there are pockets of steam within the mass of paddy. Preliminary trials have shown that these can be displaced by sending compressed air from the bottom. This also helps to bring about a slight reduction in moisture while, at the same time, reducing the temperature to about 85°C. This would deserve to be followed up because quick lowering of the temperature of the steamed paddy will help to improve the colour of parboiled rice.

DRYING.

At Tiruvarur, drying is done with both the L.S.U. Dryer using furnace oil as fuel and the S.F. Dryer with steam heating through an exchanger for transfer of heat. The dryers are designed for holding about 7 tonnes of raw paddy; but they hold only about 5½ tonnes of parboiled paddy because of the larger volume of the latter.

In the early stages, the drying was done at 85-90°C; but it was found latter that a higher temperature can be safely used because the temperature of the paddy does not rise above 75°C during drying upto 13 - 14% moisture. At the present time, large-scale drying is being done with the inlet air blowing at about 125°C. The drying is being carried out as a single, continuous operation.

Some systematic studies were recently carried out comparing the rates of drying almost the same quantities of paddy in the L.S.U. Dryer, with and without salt treatment. The results are given in the following table.

T A B L E - XII.

RATES OF DRYING PARBOILED PADDY IN THE L.S.U. DRYER.

Variety - Co-25.

| Temperature and rate of blowing of air-capacity of the dryer. | Without Salt treatment (Control) 125°C - 12,000 cfm 5.5 Tonnes | | With Salt treatment 125°C - 12,000 cfm 5.5 Tonnes | |
|---|---|---|---|---|
| TIME IN MINUTES | PERCENTAGE MOISTURE DETERMINED BY OVEN DRYING. | | | |
| | A | B | A | B |
| 0 (INITIAL) | 35.0 | 38.3 | 25.3 | 23.0 |
| 30 | 33.4 | 35.5 | 21.7 | 20.6 |
| 60 | 28.6 | 33.0 | 15.5 | 17.7 |
| 90 | 27.0 | 30.2 | 13.0 | 14.0 |
| 120 | 23.0 | 26.0 | | |
| 150 | 19.3 | 21.6 | | |
| 180 | 17.3 | 19.4 | | |
| 210 | 14.0 | 16.3 | | |
| 240 | 10.6 | 12.6 | | |

A :- WHOLE PADDY. B :- KERNEL.

It has been the experience at Tiruvarur that the Modern Rice Mill with its accessories - especially the paddy separator - functions most efficiently when the moisture content of the whole paddy and the kernel are nearly at the same level of about 14%. It may be seen from the above that with salt treatment, drying to the desired extent is complete in about 90 minutes. When the untreated product is dried, it takes more than 210 minutes to dry to the same extent. This would mean that as the result of the salt treatment, there is substantial saving in the cost of fuel and the turn-over for the same dryer is also considerably increased.

It was observed however that in spite of the facility for drainage, there was still some quantity of condensed water adhering to the surface of the salt treated paddy; whereas there was nonein the case of the untreated grain. In spite of that, the total drying time was only about half of that required for the untreated paddy. With more efficient drainage, the time required for the drying of the treated paddy can be further reduced.

Tempering - before and after milling.

It has invariably been the experience that the milling performance is improved if the parboiled paddy is allowed to stand for 12 - 24 hours before milling. The breakage is generally more if the paddy is milled immediately after drying. In the huller the parboiled paddy can be milled satisfactorily at a moisture level of 18 - 19%; but, in the modern mill, drying to a lower moisture level is found necessary.

After milling, the parboiled rice, irrespective of the method of preparation, has properties similar to those of plastic products. At this stage any prolonged application of high pressure can either change the shape of the grains or make them stick to each other. Though the moisture content is low, the product requires to be allowed to stand for some

time so as to harden. The polished grain continues to give off some moisture and this has to be eliminated by proper aeration, as, otherwise, this may encourage fungus growth especially in humid weather.

TOTAL PRODUCTION OF PARBOILED PADDY BY THE METHOD OF SALT TREATMENT.

Though the production at Tiruvarur was started during the Autumn of 1969, there was need to make changes and to standardise the working conditions. Bulk production was taken up only during May - June 1970, and till about June 1971, the total weight of paddy parboiled and milled was about 13,500 Tonnes - allowing for the number of stoppages, breakdowns, power shutdowns etc. The rice produced from this quantity of paddy may be value at about a crore of rupees (equivalent to over 1.3 million U.S. Dollars). The present rate of production is of dried parboiled paddy 60 - 65 tonnes per day, with only a single L.S.U. Dryer in operation. With cleaned paddy, the yield of marketable rice was 70 - 72% on the weight of paddy. As most of the parboiling and drying were done as batch operations, and with several varieties, including mixed ones and, some times, even mixtures of raw and parboiled paddy, there was necessarily some variation in performance. With the evaluation being done with the same variety, and with the necessary technical control, the breakage loss has been of the order of 1 - 2% and some times even as low as 0.2 - 0.3%. The degree of polishing has varied from 5 - 6% on the weight of brown rice. The oil content of the clean bran varied from 22 - 28%.

COST OF PRODUCTION OF PARBOILED RICE - WITH AND WITHOUT SALT TREATMENT.

The technique of hot soaking and steaming was introduced in India by Subrahmanyan, Desikachar and Bhatia[3] during the fifties. Practical application of the method, combined

with mechanical drying and modern milling, was taken up, however, only during the late sixties. Though the method is clean and hygienic, the cost of production is still high, as compared with the traditional method of cold soaking, steaming, plinth drying and huller milling. A major item contributing to the cost of the former is that of mechanical drying. The object of the salt treatment is primarily to reduce this cost and also to increase the turnover, which, in turn, will bring additional earning to the miller. For practical purposes, the salt treatment may be looked upon as only a modification of the earlier method.

A fair and workable method of evaluating the benefit from such a modification will be to carry out a comparative evaluation with the same plant and keep all the other conditions identical and then to work out the comparative costs.

At Tiruvarur, three types of dryers were used and two of them involved steam heating. At present the major part of the drying is being done however, with the L.S.U. Dryer, using furnace oil as fuel. As the latter is also most extensively used in India, it was considered desirable to base all calculations, on actual performance, with that type of dryer.

In the evaluation of benefits, not only saving in cost of production, but also anticipated additional earning, through increased production, should be taken into account. The latter will depend, to a large extent, on the difference between the cost of procurement of paddy and the sale price of rice and by-products. Though both of these are variable, it may be reasonably anticipated that there will be a minimum additional earning of Rs.30/- (equivalent to 4.0 U.S. Dollars) through processing each extra tonne of paddy.

## COMPARATIVE COSTS AND ECONOMIC BENEFITS FROM THE PARBOILING OF PADDY WITH AND WITHOUT SALT TREATMENT.

The calculations are based on the experience at Tiruvarur. In doing so, it was noted that the capital outlay and overheads were heavier than at other centres. Steam is being generated from both paddy husk and oil-fired boilers. Similarly drying is being done with oil-fired and steam heated dryers. In order to arrive at reasonable average figures comparable with those in other parts of the country, it was assumed that the required quantity of steam can be generated by burning only paddy husk. The actual figures for only the L.S.U. Dryer have been taken into account.

| PARTICULARS | PARBOILING AND MECHANICAL DRYING | |
|---|---|---|
| All data based on processing 1,000 T and 1,500 T of paddy per month of 25 working days by following 'A' & 'B' methods respectively. * | Without Salt Treatment. 'A' | With Salt Treatment 'B' |
| | Rupees (Dollars) COMMON FOR BOTH THE METHODS | |
| | Rs. | ($) |
| a) Block capital required:- | | |
| 1) Land and building (Boiler house, cold water cement tank etc.) | 31,026.50 | (10,803.50) |
| 2) Machinery:- Parboiling unit. | 3,31,618.00 | (44,215.70) |
| Schule boiler (1.4 T/Hr) | 50,000.00 | (6,666.70) |
| Two L.S.U. Dryers. | 68,410.00 | (9,121.30) |
| Furnace oil tank. | 7,886.00 | (1,051.50) |
| Total Block capital required. | 5,38,940.50 | (71,858.70) |
| b) Recurring Expenditure :- | PER ANNUM | |
| 1) Supervisory Staff :- Engineering, mechanics, operators, helpers, boiler attenders, labourers, Administrative overheads etc., | 77,562.00 | (10,341.60) |
| 2. P.F. and Bonus (8 + 4)% | 9,307.20 | (1,241.00) |
| 3. Mechanical stores, spares, repairs, stationary etc., | 15,000.00 | (2,000.00) |
| 4. Insurance for the machinery and Licence for the boiler. | 3,600.00 | (480.00) |
| Total recurring Expenditure. | 1,05,469.20 | (14,062.60) |

* Experience has shown that daily production is increased by at least 50% as the result of the salt treatment.

| - : PARTICULARS : - | 'A' RUPEES | (DOLLARS) | 'B' PER MONTH | |
|---|---|---|---|---|
| | Rs. | ($) | Rs. | ($) |
| c) Expenditure on process:- | | | | |
| 1. Electrical charges: | | | | |
| i) Parboiling-loading the tanks with raw paddy, pumping and recirculation of hot water - pumping, recirculating and discharging of brine solution. | 90.00 | (12.00) | 325.00 | (43.32) |
| ii) Mechanical drying-conveying, bucket elevators, buffalo blowers, spreaders, pumping of furnace oil and water from the bore well. | 1,500.00 | (200.00) | 1,433.70 | (191.16) |
| Total Electrical charges. | 1,590.00 | (212.00) | 1,758.70 | (234.49) |
| 2. Consumables :- | | | | |
| i) Furnace oil consumption in L.S.U Dryers. | 10,500.00 | (1400.00) | 7,834.00 | (1,044.53) |
| ii) Common salt required 96 T/month. | -- | -- | 2,880.00+ | (384.00) |
| | (COMMON FOR BOTH THE METHODS) | | | |
| 3. Depreciation on | | | | |
| i) Building @ 5% | 337.60 | | (45.01) | |
| ii) Machinery @ 10% | 4,491.20 | | (598.83) | |
| 4. Interest on block capital for Rs.50,000.00 ($ 6,666.70) only @ 5% | 208.40 | | (27.80) | |
| 5. Total recurring Expenditure. | 8,789.10 | | (1,171.88) | |
| Total Expenditure | 25,916.30 $ (3,455.50) | | 26,299.00 $ (3,506.50) | |
| Quantity of paddy parboiled: | 1,000 Tonnes | | 1,500 Tonnes. | |
| Cost of parboiling and mechanical drying per tonne. | 25.92 | (3.46) | 17.53 | (2.33) |

* The figures in brackets are the equivalent U.S. Dollars.

\+ The major part of the present loss of salt is through dilution. This can be concentrated and reused.

On the basis of the above, the extra earning, per month, would be 1) Rs.12,585 (equivalent to 1,695 U.S. Dollars) through application of salt treatment on a minimum total production of 1,500 Tonnes of parboiled paddy;
2) Rs.15,000 (equivalent to 2,000 U.S. Dollars) through extra earning from processing of larger tonnage of paddy within the same period. Thus making a total of Rs.27,585 ($ 3,695) per month which may be considered to be reasonable for a parboiling plant.

## APPLICATION OF SALT TREATMENT FOR THE DEWATERING, AND PRESERVATION OF WET SEASON PADDY.

Sudden and, some times, very heavy damage to food-grains through typhoons, unseasonal rains and such other adverse conditions have been known to occur in all parts of the world. In India, this has been experienced in respect of most of the crops and even as late as the Summer of 1971, there was very heavy damage to wheat crop (in some states as high as 20 - 25%) over most parts of North India. In the case of rice, there is the added problem of one of the major crops coming to harvest right in the midst of the N.E. Monsoon. Under such conditions, the paddy, which could not be easily dried by the producer, continues to retain a kernel moisture content of 20 - 25% which leads to microbial damage through heating, discolouration, attendant loss of dry matter; and subsequent mould growth. There is also sprouting which causes further damage and loss of weight. In the Cauvery delta and, particularly in the Thanjavur District of Tamil Nadu, about half a million tonnes are affected to a greater or less extent by the N.E. Monsoon. Under such conditions, the major problem is the preservation of the kernel and, for this, the methods which are now available are 1) mechanical drying to reduce the moisture content to a safe limit of 14 - 15% and 2) use of permissible chemicals which can arrest

all spoilage changes till such time as the grain can be conveniently preserved. Experience has already shown that mechanical drying is expensive and can, at best, help to dry only a small fraction of the total production. Moreover, the discolouration changes which generally start during storage in the farm, generally get aggravated by the drying and also parboiling. Chemical preservation, like that with propionic acid, functions best in a closed system and in presence of carbondioxide. Moreover it is rather expensive and there is not much experience of its use in countries like India. Preliminary studies carried out at Tiruvarur have shown that at low concentrations (0.15 to 0.2%) chemicals like propionate, acetate, bleaching powder etc. have only a slight retarding effect on the spoilage changes or sprouting and that the producers would like to adopt much simpler and safer methods, if they are available.

The concept of dewatering the kernel and, at the same time, keeping the paddy fully closed and preserved against microbial spoilage and sprouting, was a logical sequel to the observations reported in the earlier section of the present paper. The procedure has an advantage over the propionate treatment in that the kernel moisture is reduced quickly, and there is no scope for any discolouration; that the paddy remains completely closed and the husk retains a protective concentration of salt to discourage any fresh infection. Such paddy can be packed without any further treatment, though it would be preferable to eliminate the wetting of the bag or other container. As most of such paddy is used for parboiling, it has to only to be given a water wash before soaking. It is only when the paddy is required for milling in the raw state that it has to be washed and then dried at any convenient time. As the object is primarily to abstract water from the kernel, it was considered desirable

to use dry salt (preferably powdered) for such a purpose. The following results, as attained with some varieties, which are normally raised during the wet season, will illustrate the action of dry salt. The moist paddy (60 kg) was intimately mixed with 5% dry salt (by weight) and allowed to stand over a perforated base in a vessel with hopper bottom.

T A B L E - XIII.

RATE OF REDUCTION IN THE MOISTURE CONTENT OF THE RICE KERNEL AS THE RESULT OF DRY SALT TREATMENT.

| TIME IN HOURS. | PERCENTAGE MOISTURE CONTENT OF KERNEL | |
|---|---|---|
| | ADT - 27 | IR - 8 |
| 0 (INITIAL) | 25.0 | 27.0 |
| 12 | 20.9 | 16.2 |
| 24 | 19.7 | 16.6 |
| 36 | 19.3 | 16.0 |
| 48 | 18.5 | 16.6 |
| 60 | 17.8 | 15.0 |
| 72 | 16.9 | 15.0 |
| 84 | 15.5 | 14.5 |
| 96 | 13.6 | 13.2 |

It was noted that the moisture withdrawn from the kernel dissolved a part of the adhering salt and drained out as a nearly saturated solution (Sp. Gravity 1180). The drainage was slow and as there was also some evaporation, the actual weights of the water drained from the kernel could not be calculated from the volume of the liquid that was collected. When the drainage was nearly completed, the liquid adhering to the bottom could be largely removed by shaking on a perforated

sieve.

TRIALS WITH DIFFERENT PERCENTAGES OF DRY SALT.

Though it may not be possible to adjust it in practice, the actual requirement of dry salt for preserving any batch of paddy will depend on its moisture content and this in turn, should be only a little more than what is required to withdraw enough water to maintain the moisture content of the kernel at 14 - 15%. As this water will dissolve the surrounding salt, any quantity in excess of what is required to make a saturated solution will continue to remain undissolved. If calculated on this basis, the requirement of dry salt will be only 2 - 3% of the weight of paddy if the moisture content is 18 - 20%. When the treatment is applied in this manner, it has been found that there is no free flow of solution though the kernel moisture diminished to a safe level.

Removal of adhering salt solution.

This may not be of much practical significance to one who may apply the treatment only for preservation of the paddy only until such time as it could be used for parboiling. There is however an aesthetic aspect especially when large quantities have to be dewatered and stored. It is also important for those who may wish to sell the paddy and also those who may wish to buy it in the same way as dry paddy. With a view to determining whether this could be achieved by some simple and inexpensive methods, attempts were first made to treat the dewatered paddy with some easily available substances like paddy husk, (as such and after powdering) deoiled huller bran, limestone powder, paddy husk ash, sand, and dry soil, with and without addition of burnt lime etc. These had varying amounts of efficiency in absorbing the brine adhering to the surface of the paddy husk. Some also affected the appearance

of the final product. Among these, powdered paddy husk gave the best results. Even on mere shaking with the dewatered paddy, the adhering salt solution was mostly removed. On longer contact - say for 12 - 24 hours - it was still more effective in drying and largely restoring the original appearance of the paddy. The added paddy husk does not stick to the paddy and can be easily removed by shaking on a sieve. Even if a little of the husk is left behind, it can be easily removed during milling. In view of its practical significance, this aspect deserves further investigation, with pilot plant studies leading to early application.

Pilot studies on dewatering of paddy, parboiling and milling.

These were carried out, in the premises of four traditional mills, situated in the rural area of Thanjavur District, during October 1969 when the N.E. Monsoon was fairly severe. The paddy (variety ADT-27), which was received in the mills, had a moisture content of 26% and was already rising in temperature. A portion was already starting to sprout. 3400 bags (57 kg each) of such paddy were treated with sea salt (cheap, industrial quality) at 5% on the weight in the following manner. In each batch the paddy was first spread out in a thin layer and a portion of the salt sprinkled uniformly on it. A further lot of paddy was them spread on the first layer and salt again sprinkled on it. In this manner, it was continued till sizeable heaps were built up. The paddy was then turned over with shovels till there was a fairly uniform admixture of paddy and salt. After this, the mixed material was transferred to corrugated G.I. sheets which had been so placed as to provide a slight inclination. The entire quantity was thus treated at all the four centres.

The above procedure was followed so as to make use of such facilities as may be expected in rural areas. It was hoped, however, that, on the basis of this experience,

the operations can be subsequently mechanised by using continuous mixers and then transferring to appropriate containers provided with adequate drainage facilities.

It was observed that the dewatering started within an hour after placing of the paddy on the G.I. sheets; but the actual discharge of the liquid became pronounced only after 24 hours. Though it was then raining heavily, the treated paddy which had been placed on covered verandhas, (with side shelter to prevent the direct splashing of the rain) began losing moisture at a speedy rate. The heating and sprouting stopped immediately after the addition of the salt. Because of the high humidity, it took one week for the kernel moisture to come down to 16%. At this stage, a part of the paddy was left as such on the G.I. Sheets while the rest was bagged and used, as and when required, for washing, cold soaking and parboiling.

It was observed that, during storage in either of the above conditions, the paddy continued to remain in good condition. The total moisture came down to 13.5% after storage for a month, but there was no subsequent drop. The soaking and parboiling proceeded in the normal way and the parboiled rice, as obtained after milling in the huller, yielded 2% more of parboiled rice than a similar batch of paddy (control) which was soaked and parboiled after any treatment.

Independent batches of the same treated paddy, stored for more than three months, remained in the same condition. Another lot (2 tonnes) treated with salt and stored in a perforated bamboo basket (basket silo) remained unaffected for over 18 months. Because the basket was open to entry of insects from all directions there was some infestation after over a year, but the damage was confined only to immature and

damaged grains, while the mature grains continued to remain unaffected. One large lot of 60 tonnes was treated at Tiruvarur by doing with dry salt when moving on the conveyer and left in concrete silo (ca. 200 tonnes) with outlets for drainage of the discharged liquid. This paddy got dewatered and drained in the same way as the paddy treated in the open heaps. The subsequent hot soaking (after washing), parboiling, mechanical drying and milling were done exactly in the same way as for untreated paddy. The resulting milled rice was of good quality without any discolouration.

The above would show that the salt treatment for dewatering and preservation of wet season paddy offers scope for application to production of parboiled rice under both village conditions in conjunction with traditional methods and also under factory conditions with mechanical drying. There is however need to standardise the procedure for routine use.

Based on the above experience the cost of preserving of wet season paddy with 1) mechanical drying 2) salt treatment for dewatering and subsequent storage without any drying, primarily with the object of usage for parboiling were prepared.

Comparative costs of preservation of wet season paddy by 1) MECHANICAL DRYING AND 2) SALT TREATMENT.

| PARTICULARS | Mechanical drying | Dry Common Salt treatment |
|---|---|---|
| All data based on preserving 1,500 T per month of 25 working days from moisture 25 down to 14% Treating with 5% dry common salt. | I<br>Rupees | II<br>*(Dollars) |
| a) Block capital required :- | Rs. | ($)* |
| 1) Land and Building. -- | 50,000.00<br>(6,666.70) | 50,000.00<br>(6,666.70) |
| 2. Machinery:- Two dryers with conveyer and elevator, furnace oil tank. -- | 1,20,640.00<br>(16,085.30) | -- |
| Weighing balances. -- | -- | 2,000.00<br>(266.70) |
| Total block capital required. | 1,70,640.00<br>(22,752.00) | 52,000.00<br>(6,933.40) |

| | - PER MONTH - I | II |
|---|---|---|
| b) Recurring Expenditure :- | | |
| 1) Supervisory staff:- | | |
| Engineering, Administrative overheads, etc., | 3,827.20<br>(510.20) | 225.00<br>(30.00) |
| Provident fund and bonus(8+4)% | 459.30<br>(61.24) | 27.00<br>(3.60) |
| 2. Mechanical stores, spares, repairs, stationery, licence, Insurance etc. | 600.00<br>(80.00) | 70.00<br>(9.30) |
| Total Recurring Expenditure. | 4,886.50<br>(651.54) | 323.00<br>(42.90) |
| c) Expenditure on process :- | | |
| 1) Electrical or labour charges. | 1,684.50<br>(224.60) | 2,631.60<br>(350.88) |
| 2) Consumables :- Furnace oil. | 6,750.00<br>(900.00) | -- |
| Common salt. | -- | 2,250.00<br>(300.00) |
| Total Expenditure on Process. | 8,434.50<br>(1,124.60) | 4,881.60<br>(650.88) |
| I. Depreciation on i) Building @ 5% | 208.30<br>(27.78) | 208.30<br>(27.78) |
| ii) Machinery @ 10% | 1,005.40<br>(134.05) | 16.70<br>(2.24) |
| II. Interest on Total block capital @ 8% | 1,137.60<br>(151.66) | 346.70<br>(46.23) |
| III. Total recurring expenditure. | 4,886.50<br>(651.55) | 322.00<br>(42.90) |
| IV. Total expenditure on Process. | 8,434.50<br>(1,124.60) | 4,881.60<br>(650.89) |
| Total expenditure per month. | 15,672.30<br>(2,089.64) | 5,775.30<br>(770.04) |
| Quantity of paddy preserved per month:- | 1,500 Tonnes | 1,500 Tonnes. |
| Cost of mechanical drying or dry common salt treatment to preserve freshly harvested moist paddy per tonne. | 10.75<br>(1.44) | 3.85<br>(0.51) |

* The figures in brackets are the equivalent U.S.Dollars.

High moisture paddy can be used, as such, for hot soaking and parboiling, and, in fact, the time of soaking is reduced if the paddy has already a fairly high level of moisture. If all the individual grains are have a moisture content of 25% and above, it should be possible to parboil without any soaking; but in actual practice, the moisture content varies from one grain to another and then is always some percentage with lower levels of moisture than the others - hence the necessity to apply the soaking in all the cases so as to ensure uniformity in parboiling and to minimise the incidence of white abdomen.

During the rainy season, the producer likes to sell the harvested paddy as quickly as possible and large purchasing organizations have had to collect and to preserve thousand tonnes of more per day. As all this quantity cannot be parboiled on the same day, there is naturally necessity to preserve the paddy till such time as it can be taken up for parboiling. Mechanical drying followed by parboiling actually involves double drying and partly as the result of this and the general heating of the grain even before it is purchased, there is a tendency for the resulting parboiled rice to get discoloured to varying extents. This can be largely avoided and the cost reduced through preservation by salt treatment, which, in the present state of our knowledge, is the simplest and the cheapest method available under Indian conditions.

## DISCUSSION.

The use of salt in food preservation has long been known and applied in various ways. The preservative action is assisted by ex-osmosis, especially in the case of perishable materials with high water content. Under such conditions, water is withdrawn towards the surface and unless there is some type of drying, the dissolved salt tends to penetrate and to get redistributed. This would naturally result in the preserved product acquiring a saltish taste and that, in turn, will restrict the quantity that can be consumed. Good examples of these are the several types of pickles and sauces which can be consumed, only in small quantities, generally in combination with other foods. Such a property will not be acceptable in the case of staple foods like rice; and any process or treatment which will result in the penetration of salt into the rice kernel, in more than traces, will not find any application.

It should therefore be considered to be a remarkable feature that salt can act as a preservative, and a dewatering agent and also help in drying of paddy without entering the kernel. The most significant finding which has emerged from this research is this unique method of action which has opened out vast possibilities leading to practical application. While the mechanism action is still not clear, the most striking effect is on paddy husk which 1) permits of withdrawal of excess water from the kernel which at the same time acts as a barrier to the entry of salt in more than traces 2) keeps the husk closed and discourages the entry of water

into the kernel either directly or through condensation of steam, 3) preserves the shape of the kernel in spite of the expansion in volume 4) protects the kernel from contact with foreign matter during parboiling and drying and also extends the storage life of dry parboiled paddy 5) dewaters and protects high moisture paddy from heating, sprouting and spoilage organisms and 6) has a reversible action, so that all the life processes, including germination, can be restored by mere washing of the paddy with water. More of systematic scientific research will be required to explain the mechanism action; but there is already some evidence to show that it is essentially the action of cation which is naturally shared by other sodium salts and, to greater or less extent, by other cations.

More research is also needed to study the possible application of similar or other modified forms of treatment in the case of other classes of products which are also endowed with seed-coats. Though parboiling or such other treatment may not be required in the case several other classes of food products, protection against the effects of excessive amounts of moisture is needed by a variety of food grains, pulses, oilseeds etc. will always be required both for preservating them in a condition suitable for human consumption and for discouraging the growth of undesirable organisms, some of which also produce toxins. The scope for extending this line of study can hardly be exaggerated.

In respect of rice, the wetting of the grain by unseasonal rains or other causes has long been a problem of many countries; and this has led to heavy losses besides

reducing the supply of an essential foodgrain required for human consumption. Parboiling of paddy, as now practised in India, may not find ready acceptance in many of the rice producing countries; but all have recognized the need for some type of treatment or conditioning of rice which would improve the milling performance without affecting the taste habits of the people. The findings reported in this paper which will be of practical significance in respect of the above aspects may be of interest and value to other rice growing countries.

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# A CENTRE FOR
# POST-HARVEST TECHNOLOGY OF RICE BASED CROPS
# AND
# RURAL DEVELOPMENT

A practical approach for preservation and better utilisation of the produce and application of available knowledge for improving the earning capacity, nutrition and general welfare of the people.

## A B S T R A C T

In spite of the several advances in agricultural and industrial production, the conditions in most of the rural areas have not appreciably improved during the past six decades. Many of the causes are already known and there are reasons to apprehend that if there are no quick remedial measures, the conditions will even worsen during the next decade. Some of the worst hit areas will be those based on rice-based crops where there is a rapid increase in population.

The situation becomes both poignant and challenging when considering that there is a large potential for advancement in an area like Thanjavur Dt. where the per capita income is hardly one-eighth of that of a similar area (Ludhiana Dt.) in the Punjab. The object of the present programme is to make a comprehensive, multi-disciplined approach for improving the earning capacity of the people in the very lines on which they are now engaged and then to develop new ones which will add to their productivity and income; to improve the nutrition of the vulnerable groups through their own produce; to apply the present knowledge for the better preservation and utilisation of the produce and to direct scientific research for the solution of urgent practical problems.

Thanjavur is the largest rice producing district in the whole country with an annual production of about two million tonnes of paddy, besides a variety of associated crops of economic importance. The annual turn-over may be worth over Rs.200 crores; but the benefits are not reaching most of the rural population. Even with the existing resources of materials and man-power, there is scope for practically doubling the per capita income; but the immediate target is increase by 25 paise per day which would bring considerable relief to the people. It is aimed to achieve this modest end through several approaches for which we already have the background of the different agricultural disciplines; high concentration of rice milling and allied lines of processing; very large, but poorly nourished, cattle, goat and poultry

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population, extensive scope for marine as well as inland fishing; vast, but poorly cared or organised coconut, mango, tamarind and a variety of marketngarden crops, pulses, sugarcane, millets, oilseeds, tuber crops etc. - all waiting to be better developed and utilised for the benefit of the people. There are also vast resources of untapped underground water (especially in West Thanjavur); hundreds of Kilometers of canals, tanks etc. which can be better utilised even in dry seasons. These, combined with an artistic and cultural background high level of general education unique measure of mutual respect and collaboration between votaries of all religions, intelligence and potential capacity of people fo gainful employment - all offer a fertile medium for quick advance.

## RETROSPECT

Looking back over a fairly long span of about seventy years, it may be stated that the noticeable advances have been mostly in industrialised urban areas, whereas the conditions in the rural areas - with a few exceptions here and there - have remained almost the same. An intensely agricultural district like Thanjavur may now be earning over Rs.200 crores per annum from its produce; and out of that at least Rs.15-20 crores may be the net earning. The latter is largely migrating to urban areas and also to other regions, whereas the area which produces the wealth continues to remain in almost the same poor condition, as it was in the past. Many of the old houses are still there, almost in the same condition. We only see more huts with mud walls and thatched roofs.

## Conditions of the past

Though there are earlier records to show that even areas like Thanjavur Dt. have had occasional periods of drought and famine, the majority of people have always had some rice to eat and some water to drink, though it may not be protected. Even in the early days, several lakhs of acres were under rice cultivation; but the land was mostly owned by a small section of the population. This inevitably led to the establishment of a feudal system, with a hierarchy, which with exceptions, led to an easy life, which was not a good example to others. The rest of the population, which were largely engaged on farm or domestic employment, were mostly low paid, with very little of cash for their various needs. There was very little business excepting that of setting up grocery, cloth and pan shops. Tea and Coffee stalls and rice milling with hullers came up during the twenties and thirties. A small section

prospered through rice milling and export of surplus rice to Sri Lanka, Malaysia and elsewhere; but even this practically disappeared during the forties. Those who were enterprising were glad to proceed to other countries as indentured labour and in other capacities. For the majority, who stayed on, life continued to be poor and dull. There was no thought of family planning and a part of the pleasure of life was in producing and rearing children in the hope that they would support the parents in later years. Educational facilities were poor. There was however a lot of talent which expressed itself largely through music, poetry and other arts, which did not bring much earning. A fair section of the educated groups moved over to urban areas where they shone and prospered as Government servants lawyers, engineers medical practioners and such other professions. They acquired properties in rural areas; but remained largely absentee landlords.

Living conditions have not improved over some decades

During the past 6-7 decades, the area under cultivation has increased by more than 50%. The paddy yields which, even under the best conditions, were no more than about half a tonne per acre have now become more than doubled and even tripled in many areas. Side by side with this, the population has also nearly tripled. In the whole country, it rose from about 200 millions in the first decade of the century to nearly 600 millions in the seventies. The rate of increase in Tamil Nadu has also followed the same pattern, though not perhaps so fast as in some of the States in the Gangetic valley.

Table - I

Population and food situation - Past and Present

| Item | About 1910 | 1977 |
|---|---|---|
| Population | About 200 millions - Slow increase - Epidemics and high infant mortality | Nearing 600 millions - Rapid increase in rural areas |
| Production of foodgrains | About 40 million tonnes - Surplus of all grains exported - Low internal prices | 110-115 million tonnes - Imports recently stopped - No exports |
| Oilseeds and oils | Export of over a million tonnes | Growing shortage and rising prices - Further shortage inevitable without more production&new sources |
| Milk, eggs, meat etc. | Low production but easily available in rural areas | Inadequate - Larger movement to urban areas |
| Vegetables | Adequate and cheap | Inadequate and very costly |

Table - II

Earning capacity and amenities in rural areas
(with special reference to Tamilnadu)

| Item | About 1910 | 1977 |
|---|---|---|
| Employment | Largely on farms and domestic service | Full time work for a very small section - Mostly under-employed or unemployed |
| Earning | Mostly as grains - Cash about Rs.60 per annum | As grains and cash - Rs.600 per annum |
| Stability & purchasing power | Stable low prices - High purchasing power of rupee | Increasing prices- Purchasing power very low |
| Movement of wealth and population | To towns for education and employment - Migration to other countries | Movement to urban & industrial areas - very low investment in rural areas |
| Housing | Mud and brick houses - Mud & thatched huts | Almost unchanged - increase in thatched huts |
| Clothing | Very poor | Still very poor - Largely under-clothed |
| Health and Medical care | Cheap indigenous systems - Heavy mortality from epidemics | Mostly allopathic - Reduced epidemics - More malnutrition |

The production of paddy in Tamil Nadu, in relation to requirements, has been mostly marginal, with surplus during some years and deficit during others. 1974-75 was a year of deficit, while 1975-76 was a year of surplus for not only Tamil Nadu, but also the whole country. The estimated production for 1976-77 would be about a million tonne less than for the previous year.

While there is marked fluctuation in the production of the most important foodgrain of the State, there has been steady increase in population.

Table - III

Trends in the production of paddy in Tamil Nadu
(in '000)

| Year | 1969-70 | 70-71 | 71-72 | 72-73 | 73-74 | 74-75 | 75-76 |
|---|---|---|---|---|---|---|---|
| Area in hectares | 2518 | 2636 | 2690 | 2851 | 2704 | 2246* | |
| Production in Tonnes (in terms of paddy-Rough rice) | 5988 | 7473 | 7913 | 8312 | 8342 | 6218* | 8757* |

* Final forecast estimate, SOURCE: Tamil Nadu - An Economic Appraisal, 1976.

Table - IV

Trends in population increase in Tamil Nadu (in '000)

| Year | 1971 | 1973 | 1975 | 1977 | 1979* | 1981* |
|---|---|---|---|---|---|---|
| Population | 41,036 | 42,661 | 44,309 | 45,761 | 47,006 | 48,182 |

* Projected

SOURCE : Tamil Nadu - An Economic Appraisal, 1976.

There has lately been marked increase in rural population, especially in the lower income groups like Thanjavur District. The reasons for this are well known. Barring a miracle through some agricultural or industrial revolution, the economic conditions in rural areas will soon become more difficult. In a year of low rainfall or other adverse weather conditions, even a normally surplus area like Thanjavur District (with an annual production of 1.8-2.0 million tonnes of paddy) will not have much grain to export to deficit areas. Grain from other States will help to make up; but the people who need it most do not have the money to pay for it.

During the past few decades, there have undoubtedly been several advances through more agricultural production, better roads, improved transport facilities, rural electrification, more of free educational facilities, radios, cinemas etc. The per capita income in rupees has become almost tenfold in sixty years. All these benefits have been largely neutralized by the increase in population and the greatly reduced purchasing power of the currency.

Consequences of exclusive dependance on agriculture

It has to be admitted that even within India, there are 'developed' and 'developing' States. An economic survey carried out, some years ago, by Messrs. Hindustan Lever showed that the per capita income in the district of Ludhiana in the Punjab is over six times that of Thanjavur Dt., where the conditions for agricultural production are equal, if not more favourable. The gap is steadily widening and at the present time it is even more (about 8 times). The Punjabis produce and earn more, live under better conditions, eat more nutritious food and keep much better health. They have a variety of industries, big and small, which keeps not only men and but also women engaged in their homes. This also serves as a good example for the children who also help in the work. In Thanjavur Dt., on the other hand, there is work for a good section of the people - and even from neighbouring districts - only during certain seasons. They live mostly on what

they earn during that period and remain largely idle during the remaining part of the year. They borrow money when they are short by pledging whatever they have and even what they hope to get from the next crop. In spite of all the curbs that have been introduced, heavy rural indebtedness has long been the traidition and continues to be so even at the present time. Such a condition, combined with general poverty, and numerous social and religious functions - and particularly marriages - led to corrupt practices and various attendant evils which have long been in existence.

Table - V

Comparative conditions in Ludhiana and Thanjavur

| Item | Ludhiana | Thanjavur |
|---|---|---|
| Per Capita income | Over Rs.4,000/- | About Rs.600/- |
| Investments | Largely in the district | Mostly outside |
| Land and Water utilisation | Maximum - Diversified cropping & mixed farming | Inadequate - Underground water and Canal beds poorly utilised |
| Industries | Chiefly engineering - Self employment | Chiefly rice milling - Limited employment during planting and harvesting seasons |
| Milk and feeding of animals | 10-15 litres per animal - Adequate concentrates-Big healthy | 2-3 litres - Small sized & sickly Mostly straw - Very little of & green fodder, concentrates |
| Sheep & goats | Well nourished -Good production of wool & meat | Goats mostly - Allowed to feed themselves |
| Poultry | Big healthy - Good egg layers - Concentrates and grain | Low production of small eggs - Allowed to feed themselves |
| People | Well fed - Sturdy, hard-working Several modern amenities | Malnourished and enforced idleness Indebted & lacking most amenities |
| Children | Healthy, well clothed and ambitious | Sickly, scant clothing, frustrated |

## Reasons for low production of nutritious foods

People of rural areas are neither fully ignorant of nor apathetic to the nutritional needs of themselves or their children. They are aware of the need for milk, eggs, meat, fish and vegetables for their own homes; but even those who produce these cannot afford to keep much for themselves. They have to sell them as fast as they can to meet their debts and to buy their clothing and domestic needs. There is however a difference. Their methods of production are unsatisfactory and the returns are poor.

There is currently a large amount of interest in the recycling of wastes as a means of partially substituting the nutritional requirements of farm animals. The underlying theory is that the wastes can serve as the media for multiplying certain lower forms of life, which in turn, can serve as food for higher forms which can then utilise them. This seems to have been distorted in practice and extended a long time ago in our rural areas, where they let them loose without feeding them. Examples of these are the ways in which they rear pigs, goats and poultry. Repeated enquiries have shown that there is no tradition for feeding them in East Thanjavur. Cows and buffaloes are given some concentrates only during the milking period. Bullocks and horses fare a little better because they could not do any work unless they are fed. Such animals have to sruvive mostly on paddy straw which is largely a roughage. Even that becomes largely mouldy in wet and humid weather and carries a heavy load of mycotoxins.

The practice of trying to get some thing out of almost nothing is bringing a poor return. Thus, the yields of milk from even good breeds of animals get reduced to 2-3 litres or less per day and the hens lay tiny eggs once in about 2 days. These are sold mostly to pay instalments in the repayment of loans and also to purchase urgent requirements of oil, Kerosene etc. for the home. If the animals are better fed, they could yield at least 1-2 litres

more per day of milk and the egg production can be doubled. In the latter case, at least a small part of each can be used for the children and the home in general. At the present time, most of the children do not benefit by even a small part of what is produced in their own homes.

Even in areas where water is available, there is not much attempt to raise vegetables. Each area is well suited for raising certain types of vegetables for which there is also a demand, both locally and in other areas. If there are even small kitchen gardens, there will be some thing for the homes. As things stand, the vegetable markets now stock only hill grown vegetables the production and distribution of which are well organised. Such vegetables are however beyond the reach of a large section of the people.

In Thanjavur District - there are extensive canal systems which do not carry any water for about 4-5 months in the year. Most of them do however contain enough water underneath for raising a variety ofmarket garden crops. There is need for organised cooperative effort, with Government interest and support, to utilise these as much as possible. A beginning should be made with some model units in some selected areas.

Instances such as the above can be multiplied. A logical inference is that one of the first steps to be taken for improving the nutritional status of the people would be that they should be advised and assisted to produce more of what they are already doing, so that there will be a little left over for their own homes. There is need for intense drive in this direction.

Steps for increasing production of nutritious foods

Before exploring other areas for improving the nutritional status, we should first concentrate on self employment of people for more production and better earning. We should advise and assist people in respect of inputs in the form of materials rather than of money. For this programme we do not need highly paid graduates in agricultural sciences. It would be more useful to have practical minded persons who would live in the areas and work in a spirit of dedication to demonstrate the benefits to the people. Dedication is now a rare commodity; but it is not completely dead. The people in rural areas are still responsive to kindness and self-less effort. Even if we start with one small area, the example can soon spread to others.

Need for trials with new approaches

Several years ago, it was proposed by the late Dr. G. Sankaran, who was also, for some time, Chairman of the Nutrition Advisory Committee of the ICMR, that there is a case for exploring

the economics of grass farming in a few areas where rice is now being cultivated. Even recently I had made this suggestion to the Director of Agriculture. We may experimentally try at least a small area of a few acres with a few varieties of permanent grass. If planted intensely with adequate inputs of lime and fertilisers we can get at least ten harvests a year which can maintain several milch cattle and other animals. This may in the end earn much more money and provide better nutrition for the people than exclusive production of rice. A few progressive farmers, here and there, are doing very well through mixed farming. The Government should take interest in such a programme and explore the possibility through their own farms and then set up demonstration units in other areas. Experience will show whether it would be desirable to raise only one variety of grass or a mixture of a grass and a legume as in New Zealand. There are many areas where there is adequate irrigation potential and also reserve of sub-soil water to maintain permanent grass. In Queensland, where we have a tropical climate and also areas with low rainfall, it has been possible to maintain permanent grass on an annual rainfall of 75-80 cm.

Facilities for marine and inland fishing at any rate in many parts of the East Coast require to be greatly improved. Storage and transport arrangements can be better organised. This has affected the interests of the people in rural areas in two ways. Because of the low production their economic conditions remain poor. There is not also enough to sell to people over a wider area.

The position in respect of meat is worse. Only goats and chicken are available; but their availability is low and the prices are high. Though the majority of the people are non-vegetarians, they cannot afford to have meat except on a festive occasions.

There is scope to improve fishing by better organisation and assistance to the fisherman. The meat position can be made better only by changing the present outlook with more attention to the care and feeding of the animals and birds.

## Consumer preferences

Experience of the past few decades in the production and popularisation of different classes of processed foods has repeatedly shown that the nutritive value by itself has only a limited appeal to the consumers. In actual practice they are largely guided by the flavour, taste, convenience in preparation, - if any required - ease of digestibility and such other properties. In respect of these requirements, there is no difference between different economic groups. We do have plenty of people with

poor purses; but there is no such thing as a low income taste. Many of the past failures of food and nutrition scientists in this field are largely due to the non-recognition of this important fact. A consumer may accept certain classes of products, if offered free, in times of emergency or shortage; but unless he is satisfied about the acceptability of the product, he will not pay for it. He may even reject it or feed it to his animals if he does not like it. Sophistication, including attractive packing, will add to the cost; but even poor consumers will not mind the extra cost if they know that the products are good for their children or recommended by their doctors.

Experimenters should try products in their own homes

Prior to distribution of any product to the consumers food and nutrition scientists generally follow the correct procedure of carrying out evaluations first with experimental animals and then with human subjects who may be children or volunteers. During recent years, sensory evaluation is also being adopted. Very few people however try the same products in their own homes - on themselves or their children over some period of time to assess their acceptability and also attendant effects, if any, on continued use.

The consumer preference is always for a class of products with which he is already familiar. Baby foods based on mmk milk and products based on fruits and vegetables which are not too cheap or common have found quick acceptance because people know that they are derived from materials which they like and respect. On the other hand, we have had decades of difficulties in respect of foods for children of the pre-school age, because they do not have the same measure of consumer appeal. Fortification of familiar foods have a fair chance of success provided they do not affect the taste or digestibility. Fortification of wheat atta with calcium salts, though nutritionally sound, failed in practice because they effected the taste, interfered with digestion and caused constipation. Over two decades ago we started the fortification through salt as a medium because it gets distributed throughout the food. Iodised salts have already proved useful in the control of endemic goitre. Salt fortified with iron salts, which has been recently introduced, has also a fair chance of acceptance for relief of anaeminc of certain types. At the same time, there would be a case for the scientists themselves trying the continued use of iron fortified salts in their own homes. In fact, all of us should join and assist in such trials. We should also get the active interest and assistance of our medical colleagues in recommending such products to their patients on the basis of their experience.

We have had decades of experience with products based on oilseed meals and pulses. Such efforts have run into difficulties firstly because of their familiar flavour and taste which the consumers consider to be cheap and easily available to them. Some of them also cause digestive troubles on continued use. Protein isolates are nutritionally superior and they are more concentrated and easily assimilated. They should however be either freed from odour or masked in some way so as to improve their acceptability. We have to produce odourless and tasteless proteins if we are to use them for extension of products like. This has already been achieved, especially in the case of Casein, and we should achieve the same measure of success in the case of vegetable proteins.

## Need for association of medical practioners with nutrition programmes

Except for baby foods, which the consumers consider to be safer than the locally available milk, and also certain popular brands based on malted milk or cocoa with milk, it is our general experience that other processed foods, however nutritious, cannot find ready accpetance in rural areas unless they are 1) concentrated and cheap and 2) recommended by the local medical practioners. Educative effort and free distribution will not by themselves be sufficient. The people in rural areas wish to have specific advice from those in whom they have confidence. The medical practioners - irrespective of the system they follow - can help a great deal if they are associated with extension and development programmes.

## Shortage of vegetable oils

In many of the rural areas there is shortage of vegetable oils. Oilseeds and pulses are produced in the villages; but the products are largely purchased by oil mills and merchants who, in turn, process and sell them in urban areas and to consuming industries. At the present time almost every material containing some oil is now being crushed and the oil used for some purpose or other.

## Production of edible rice oil

One of the few exceptions to the above is rice bran which has not yet found efficient use. This is one of the lines where a large amount of useful work has already been done in India but has not yet found adequate application. Many of the Far Eastern countries may not be much advanced in other lines; but they are certainly ahead of India in the production and utilisation of rice oil. The poor progress in India is largely due to lack of co-ordinated effort to make a success of the programme. In Tamil Nadu for instance we have the potential for producing at least half a

lakh of tonnes of edible rice oil. It is only with very great difficulty that we could now produce about 2,000 tonnes of industrial grade oil. The production of edible grade oil (with low free fatty acid content) may not be more than a few hundreds tonnes in a whole year.

## Need for more Government interest and for a new approach to extraction of oil

Scientists and technologists can go only upto a point in demonstrating the possibilities. Once the principles and procedures are known, there is need for active interest and support from the Government for further advance. There is need for a service oriented approach which is still rather weak in our country. If the Government is not in a position to develop a programme, it can at any rate organise production through the private industry and, where necessary exercise the necessary control.

The present procedures for production of oil-rich bran, its stabilisation, collection, extraction and further processing are more elaborate than in the case of the familar oilseeds. There is need for a much simpler technique which even small units can apply on their own.

In addition to the Modern mills, the conventional rice mills are also now in a position to produce rice bran with 20% or more of oil. In Tamil Nadu alone there are about 15,000 units - big and small - which between them process over 80 lakh tonnes of paddy per annum. It is recognized that the procedure for extraction of edible grade oil from bran is more elaborate than in the case of oilseeds. The latter have only to be crushed for extraction of oil. In the case of bran, the product has to be stabilised and taken to an extraction plant which may at a considerable distance. The capital outlay on such a plant is high and the extraction costs between about Rs.150 and Rs.350 for each tonne of bran. In spite of that and the subsequent processing costs, the industry is still paying and besides the oil, the deoiled bran also fetches a good price.

There is a case for developing a new technology for the extraction of oil from bran without the use of a solvent. We should have a better understanding of the condition in which the oil is present in rice bran and to get into a free condition so that it can be expelled in the same way as any other oil. Some of the rice oil gets into a free condition as the result of the parboiling of the grain. There is scope for a fresh approach, which, if successful, will enable each rice mill to produce some quantity of edible oil.

## Separation and utilisation of rice germ

The germ is the most valuable part of any grain and it is particularly so in the case of rice. It contains over 35% oil and the decoiled product contains about 33% protein and about 7 mg. of thiamine (Vitamin $B_1$) in 100 gms, thus making the product many times as nutritious as rice. It is easily digested and does not require any cooking.

Hand-pounding has now been virtually abandoned because of the labour and cost involved and also greater breakage of the grain during the pounding. It had however one good feature. The second pounding operation - which was virtually a form of polishing - resulted in the separation of the germ. Though its nature was not then known, there was always competition among the children for this tasty product.

In the present day rice milling the germ which constitutes 1.0-4.0% of the weight of brown rice - depending on the variety - gets fully removed during polishing; but gets disintegrated and mixed with the bran or the bran and the husk so that it becomes unfit for human consumption. Methods are however now being evolved for the separation of the germ, directly from brown rice, before further polishing. The resulting product, with its high oil content, is very attractive; but keeps well only after the oil is removed. The big question is whether it will reach the people in rural areas. In any case, its production will help the rice milling industry and the protein-rich flour will reach some sections of the population.

## Tuber crops

Experience of the past few decades has shown that the tubers are mostly liked only in the fresh condition, because the flavour and taste are largely lost during dehydration or drying. Potato is the most popular and finds use in a variety of ways. There are some varieties which can be raised in the plains and there is already a large production in North India, even during warm weather. There is a case for trying out some of the varieties in the delta areas of South India. This would deserve to be tried out by the Agricultural Department and the methods demonstrated in rural areas where it would help to improve the earning of the people.

Tapioca is already being produced fairly intensely in Kerala and to a limited extent in other States. Even in rice eating areas like Thanjavur, there is demand for it for use in various ways. The main problem is one of keeping quality as it undergoes quick microbial spoilage and develops an off flavour.

Arising out of a programme started by the Food Department, it was found by us, some years ago, that the best way to preserve the tapioca in the fresh condition would be to keep it buried under moist soil. In this condition, the tuber remains viable for at least two months and is even capable of sprouting. This method is simple and deserves to be popularised in rural areas. The tuber can be taken out when desired, washed, deskinned and used. If there is a surplus, it can be used as an animal feed.

Sweet potato is produced only to a limited extent and it is not very popular as a vegetable, partly because of its taste, but to a larger extent because of the attendant digestive troubles. One way of overcoming this defect is to change over to the varieties which are now being raised in several Far Eastern countries. They are bigger in size, have an almost bland taste and less fibrous. Such varieties would be more acceptable, can be preserved in the same way as tapioca and any surplus can always be used for farm animals.

## Millets

In spite of all the researches conducted for introducing and popularising new varieties, they still continue to be the poor cousins of rice and wheat. In Tamil Nadu and also in Karnataka a good section of the erstwhile millet eaters - whether ragi or jowar - have been steadily changing over to rice because of the easy digestibility. Scientific methods have already been introduced for better processing and utilisation in various ways. Such advances may be of more benefit to urban than rural areas.

In many parts of the World and also in some parts of India, millets, as a whole, are looked upon as crops which can be shared between man and animals. When feeding to animals we should not always calculate in terms of the input of calories and proteins in relation to returns as measured by dry weights and estimation of nitrogen. We should also think of the quality in relation to taste, flavour, acceptability and assimilation by the human system - and also the ultimate value of the products derived from farm animals. Man can always consume millets which are more sustaining than a crop like rice; but when there is a surplus, it will not be a loss to share them with the farm animals and birds, which can well utilise them and also eventually bring a good return. This should be demonstrated and made better known to people in rural areas.

## Pulses

People in rural, as well as urban, areas are fairly well aware of the value of pulses for improving the taste and nutritive value of cereal diets. They are also conscious of the cost and

also the difficulty in digesting them excepting in small quantities. Many of the areas in South India are deficient in regard to pulses. Some like Cauvery delta produce green & black gram as short term crops after the harvesting of the dry season (Samba) crop of paddy. The yields are erratic and may range from 60 to 250 Kg or more per acre. There are practically no in-puts and most of the crop is sold for relatively low prices to merchants who export them to other areas. The people of rural areas require to be helped with advice and assistance for getting better yields of pulses and also for marketing them. If this could be done, the people will earn more and keep a larger proportion of their produce for their own use.

## Oilseeds - Coconut

The inevitability of oil shortage in countries like India was anticipated by International organisations even at a time when the country was exporting oils and handpicked kernels to other countries. Massive imports will only serve as a palliative for temporary relief. At the same time, it will hit the rural producers who are already getting poor returns for their crop. The prices announced in the papers do not always reflect those actually received by the small producers from the oil millers, who virtually control the regulated markets.

In addition to helping the rural producer to increase his yield, the Government should also see that the farmer gets a fair price for the crop. There should also be sustained advice and assistance that crop like groundnut are properly dried and protected against infection which spoils the crop and leads to health hazards.

There has been a controversy about the economic of producing soya-bean as an oil-bearing pulse in India. This has arisen because the emphasis has been largely on the oil content which has to be solvent extracted for an yield of about 18%. The real value of the pulse is in its non-oil fraction which makes an excellent feed for farm animals, which can digest and utilise it better than human subjects. The other countries have realized this value, whereas it has not yet been sufficiently brought home to our rural producers. The economic benefits should be shown to them so that they may produce soya-bean which can be used for the dual purpose as in other countries. In countries like U.S.A. the large production of soya oil is a surplus whereas the protein-rich deoiled meal is in great demand for farm animals.

A large amount of research has been done all over the World on the use of soya-bean in various ways as human food. In India, the

studies started with the use of the bean as a pulse. After some years of intensive study with both experimental animals and human subjects, it was concluded that inspite of its high protein content, the bean is inferior as a pulse to the other pulses which are already being produced and consumed in India. Only the extractives like the soya milk can be easily digested and be of benefit to our vulnerable groups. The first observation about the adverse effects of the mucilaginous residue on human subjects was first made in India. The harmful effects of the oligosaccharides as present in soya-bean and also other pulses have been studied by workers in other countries. The oligosaccharides along with the protein are however well utilised by different farm animals.

India is the third largest producer of Coconut in the World and most of the production is confined to South India and particularly the Kerala region. India is, at the same time, one of the few countries where coconut is used as an article of food, besides being also used as a source of oil. In spite of the large and almost insatiable potential demand, we are still not paying enough attention to the crop in many rural areas. Here again, there is a need for educative work with demonstration to show that coconut will respond and give a higher yield only if it is properly fertilised and protected against water-logging and pests. The earnings and also the availability of coconut for rural producers can be greatly improved if they get proper advice and assistance.

Some recent scientific work carried out both at Tiruvarur and under the CFTRI at Trivandrum have shown that it is technologically feasible to dry the coconut kernel without infection and then to extract the major part of the oil with acceptable white shreds which could be used for food preparations in the same way as fresh coconut.

Table - VI

Some lines of application of science & technology in the processing of paddy and by-products

| Subject | Lines of application |
|---|---|
| Rice Preservation, processing, milling & use of byproducts | 1) Reduction of pre-harvest losses. Preservation & better return from wet season crop<br>2) Dryers for moist grains - Other methods of preservation<br>3) Reduction of sun cracks - Storage of paddy and rice without deterioration of quality<br>4) Improved methods of parboiling - Elimination of smell with higher out-turn<br>5) Better milling with less breakage<br>6) Oil production of oil - rich bran - Bran stabilisation and production of edible oil<br>7) Deoiled Rice polish & germ as protein and vitamin rich foods<br>8) Better preservation of rice straw, utilisation of husk & jute bags<br>9) Advice & assistance to farmers and millers |

Pulses — The two major crops are black gram and green gram. The yield and quality can be greatly improved. Better marketing, drying and shelling have to be organised.

Coconut — The crop is valued; but the palm does not receive much attention. There is scope for practically doubling the yield by application of well known methods and pest control. Scientific methods can be applied for production of high class copra, edible oil and dried coconut shreds

Palmyra — This palm though fairly abundant does not at present bring a good return. Better uses will have to be found and the earnings increased.

Tamarind — The trees grow to large sizes. There is however profuse vegetative growth and the present yield of tamarind is very poor. The causes should be traced and corrected so that the district can be self sufficient in respect of this important food additive.

Mango — Some local varieties grow to big sizes; but give poor yields. There is a large potential for raising superior varieties. Their production and marketing should be organised.

Chilli — This comes out very well in some of the delta areas. There is a good market for both green and red chillies. The crop needs, especially in respect of essential minerals, should be studied and the production increased.

Millets — There is scope for more production of Jowar, maize, bajra and ragi as a part of the rotation in some areas. Excepting in some areas, the crops do not find use in human dietary. They can be processed and better used. They can also be profitably used for feeding poultry and Cattle.

Oilseeds — The district is deficit in regard to vegetable oils; but exclusive dependance on groundnut and sesame will not cover it. Rice bran is a large potential source and technology is available for production of edible oil. Mahua comes out very well in most of the areas but is now largely neglected. If properly cared, it can be a good source of oil which can be processed for use either as such or for production of Vanaspati. Soya-bean will be useful if it is used chiefly as a concentrate for animal feed and to a less extent as a source of oil and for other purposes, Rice and mahua oils would require more concentrated attention.

Sugar cane — This crop will be more paying if yields and quality of juice can be improved.

Tuber crops

Tapioca and sweet potato do well in many areas; but do not fetch a good return on the retail market. We have now improved methods of preservation and there should be a planned use of surplus for animal feeding. The varieties of sweet potato now produced in the Far East may find more acceptance in India. Colocacia and yams do well, but have to be improved in quality. There is scope for a good market for potato if some of the new varieties can be adapted to the soil & climatic conditions.

Market garden crops — This is a highly profitable line for which there is a large scope in the district. There are some vegetables like drum-stick, snake gourd and bitter gourd

which yield very well in some areas and for which there is a large demand in other districts. Their packing, storage and marketing without deterioration of quality would require careful attention. The district is now largely dependant on hill grown vegetables from other districts.

The extensive canal areas, tank beds and other areas can raise a variety of market garden crops for about 4 months in the year. If properly organised the produce will be used for both consumption in the same areas and also for sale in other districts.

Green fodder - Permanent grass

This line require careful study and evaluation for the benefit of the people. One of the important reasons for poor cattle development, and low yields of milk is the dependance on paddy straw which is a poor animal feed and which is also liable to heavy spoilage through mould growth in wet and humid weather. Some of the poorly drained areas may bring a better return in the form of permanent grass than through paddy. With proper choice of grasses suited to local conditions, it may be possible to double the milk production by even partial replacement of straw with grass, use of concentrates and provision of balanced mineral salt licks. A few progressive farmers have already succeeded with mixed farming; but demonstration of success in each area will lead to move extended application.

Animal husbandry

Being a predominantly rice growing district, this highly paying line has been much neglected. As stated in an earlier section, there is a large amount of ignorance & even wrong notions in respect of animal nutrition and health. The low milk yields, poorly developed bullocks, under-developed goats and the emaciated poultry and low yields of under-sized eggs are all largely due to neglect of the needs of animals. These have all got a direct bearing on the poor earning of the farmers and also the malnourished condition of their children. This pattern can be easily altered, with higher earning and better health of children by demonstration of improved methods.

Marine and Inland fisheries

In spite of all the natural advantages, this line has been poorly developed resulting in reduced income and poor nutritional status of the people. There should be facilities for collection storage, transport and marketing. With proper organisation, the Coastal areas, tanks, and canals can also be sources of earning and at the same time be of benefit to all age groups.

Planning and method of approach

If the objects of the proposed approach are generally approved by the authorities concerned, the first step would be to appoint a small multi-disciplined team of experts - as nominated by the ICAR and the State - to draw up the detailed plans on the basis of which further action can be taken. If there is a broad approval before the end of June 1977, detailed plans can be prepared before the end of October or, at any rate, by the middle of November, for further scrutiny of details prior to provision of funds before the end of the Calender year. Pending the construction of buildings and selection of staff, a beginning can be made with the knowledge and experience available in some of the lines at the Paddy Processing Research Centre, Tiruvarur, with the prior concurrence of the authorities concerned. Talent and facilities in other lines can be gradually built up. There is already a large volume of available knowledge and early start can be made in some of the most promising lines.

In areas where scientific research and experience have already shown the way, it will be largely a matter of demonstration of economic and other benefits to be followed by such assistance as may be needed in the early stages by the people. The choice of subjects and methods of approach should naturally have relevance to the needs and facilities available in an area and also scope for quick practical benefits. Success is autocatalytic and benefits derived in one area will lead to more confidence and quicker acceptance and application of others.

It is now reorganized that, while the scientific study of a problem may involve years of thinking and work, the practical application in rural areas should be through simple procedures which do not involve much expense. Even then, there may be reluctance to try any thing new unless the economic and other benefits are clearly demonstrated. When selecting the staff for extension of application, every effort will be made to secure persons who would identify themselves with the programme and work in a spirit of dedication.

AM/12/77.