STUDIES ON PRESSURE PARBOILING OF PADDY

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled "**STUDIES ON PRESSURE PARBOILING OF PADDY** " is a bonafide record of project work done by us and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title, or any other University or Society.

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CERTIFICATE

Certified that this project report, entitled, "**STUDIES ON PRESSURE PARBOILING OF PADDY**" is a record of project work done jointly by simi V.P and Sudeep P.S under my guidance and supervision and that it has not previously formed on the basis for th3 award 3f any d3gree, d3ploma, 3ssociat3ship or3fellows3ip to them.

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Dedicated To

The Profession of

Agricultural

Engineering

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SYMBOLS AND ABBREVIATION

CFTRI	Central Food Technological Research Institute
cm	Centimetre (s)
et al.	And others
EMC	Equilibrium moisture content
GI	Galvanised Iron
GT	gelatinization temperature
g	gram(s)
hr	hour (s)
i.e	That is
Kg	Kilogram
Kg/cm^2	kilogram per centimetre square
min.	minute (s)
m	metre (s)
mm	millimetre (s)
ml	millilitre
mg	milligram
MC	moisture content
No.	Number
N/mm^2	Newton per millimetre square
Psi	pounds per square inch
RPEC	Rice Process Engineering Centre
Sp.gr	Specific gravity
s	second (s)
viz.	namely
wb	wet basis
%	per cent
°C	degree celsius

INTRODUCTION

1. INTRODUCTION

Rice has been used as a staple food since ancient times. Even today, more than half of the world's population eats rice as the main calorie source. Rice is consumed whole after milling and cooking. During milling, a considerable amount of breakage occurs. To withstand the pressure exerted during dehusking and whitening, the kernal may be hardened by some conditioning techniques, commonly known as parboiling. About a quarter of the world's paddy production is parboiled. Parboiling is practised in many Asian and some western countries.

Parboiling is one of the premilling treatments of paddy, to improve its milling, nutritional, cooking and keeping qualities. This is a hydrothermal treatment given to paddy, which changes the physiochemical and organoleptic properties of the rice kernal. Because of the gelatinisation of starch, a significant increase in the hardness of rice kernal occurs during parboiling and subsequent drying. Parboiling of paddy results in higher milling recovery, translucent kernal, greater nutrient status, easy hulling, less susceptibility to insect attack during storage, higher oil in bran with better stability, less cooking loss, more swelling when cooked to desired softness and easy digestibility with high protein efficiency ratio.

Parboiling process consists of giving a hydrothermal treatment to the threshed paddy, followed by drying, to bring the moisture level back to an optimum level for milling and storing. Therefore this is a partial cooking process with the husk intact, and after drying, the paddy acquires the required hardness.

Parboiled rice is produced in India by both traditional and modern parboiling processes. The traditional process consists of soaking of paddy in cold water at atmospheric temperature and pressure, for 24 to 72 hours, followed by steaming of paddy in iron kettles. The soaked paddy is then sun dried.

In general, modern parboiling method popular in India consists of soaking of paddy in hot water, followed by steaming and then sun or mechanical drying. In order to improve hygiene, reduce the soaking time and eliminate the foul smell, the method evolved by the Central Food Technological Research Institute (CFTRI), Mysore, is usually practised. In this method paddy is soaked in hot water for 3.5 to 4 hr at 70 ^{0}C to 75 ^{0} C and then open steamed and dried. But the CFTRI method has some drawbacks;

1. Soaked paddy is steamed in the same soaking tank, which results in dark colour of the parboiled rice.

.

2. The energy requirement per tonne of paddy parboiled is high.

In order to eliminate these drawbacks, pressure parboiling of paddy could be resorted to. Pressure parboiling of paddy involves washing the paddy using potable water in a pressure vessel and hot soaking paddy, followed by steaming of paddy at high pressure to effect full gelatinization of starch. This technique facilitates deeper penetration of vitamins into the grain and results in good quality, light coloured and soft cooking parboiled rice without the typical parboiled paddy smell. Pressure parboiling also reduces the energy requirement per tonne of paddy parboiled. Therefore a project was undertaken at Kelappaji Colllege of Agricultural Engineering and Technology, Tavanur, on pressure parboiling of paddy with following objectives

1. To design and develop a laboratory model pressure parboiling system for paddy.

2. To study the process of pressure parboiling at different steaming pressures, different soaking temperatures and soaking time.

3. To analyse the milling and cooking quality of rice obtained from pressure parboiled paddy.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2:1 Structure of Rice Kernal

Paddy grains are 5 to10 mm long and 4.2 to 4.6 mm in equivalent diameter (Sahay and Singh, 1994). Rice grain is tightly enclosed by palea and lemma. The grain is firmly covered by an easily removable protective hull. Inside the hull is the rice kernal. The aleurone layer is present in different layers. The outer most layer of the kernal is the pericarp, consisting of the epicarp, mesocarp and cross layer, the tegmen (seed coat). Aleurone layer is rich in protein, vitamins and fats (Juliano, 1972). These layers together with germ constitute what is known as bran. The germ is present in a depression at the lower ventral end of the kernal. Structure of rice kernal is shown in Figure.1

2:2 Chemical Composition

The chemical composition of rice and its milling by-products is shown in Table .1 The percentage of protein, fat, vitamins and minerals is maximum in the outer layers of rice kernal and reduces inwards (Jagannada Rao, 1991). The Table.1 also shows that 80 % of the total endosperm is starch. A significant change occurs in the structure of starch granules during the parboiling process.

Table.1 Chemical composition of rice grain and its milling by-products

Sl no	Constituents	Hulled rice	Raw milled rice	Parboiled rice	Bran
1	Water, %	12.00	12.00	10.30	9.70
2	Carbohydrate, %				
	Total	77.40	80.40	81.30	50.80
	Fibre	0.90	0.30	0.20	11.50
3	Protein, %	7.50	6.70	7.40	13.30
4	Fat, %	1.90	0.40	0.30	15.80
5	Vitamins, %				
	Thiamine	0.34	0.07	0.44	2.26
	Riboflavin	0.05	0.03	-	0.25
	Niacin	4.70	1.60	3.50	29.80
6	Minerals, (mg/100g)				
	Calcium	32.00	24.00	60.00	76.00
	Phosphorous	221.00	94.00	200.00	1385.00
	Iron	1.60	0.80	2.90	19.40
	Sodium	9.00	5.00	9.00	Trace
	Potassium	214.0	92.00	150.00	1495.0

(Source : Jagannada Rao, 1991. Pneumatic parboiling of paddy)

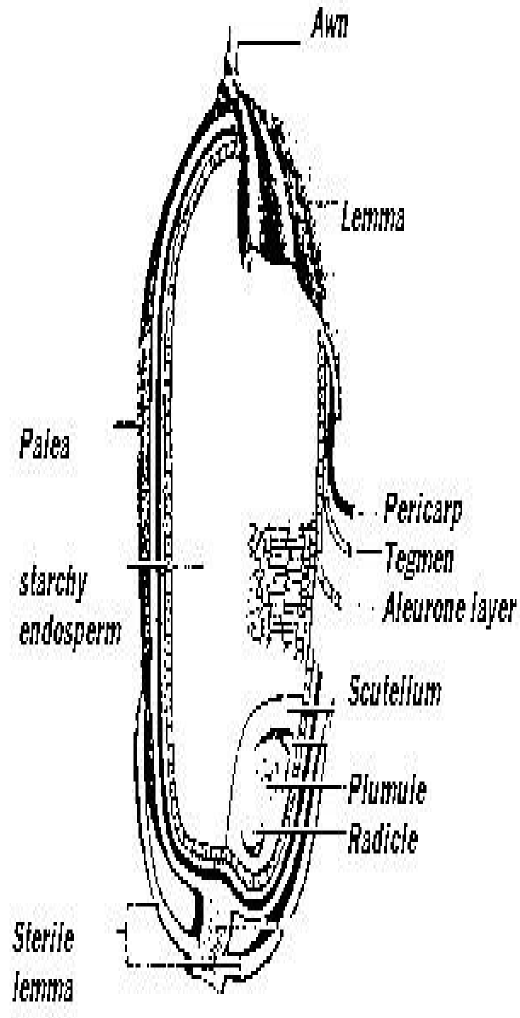

Figure.1 Structure of rice grain

(Source : Juliano, 1972. Rice caryopsis and its composition)

2:1 Rice Starch

Starch granules of rice are the smallest commercially available starch. Their size vary from 3 to 8 microns. Their shape is polygonal and sometimes they are found honey combed in clusters. Rice starch like other starches consists of two components viz. amylose and amylopectin.

Amylose has a simple chain structure and is soluble in hot water. Rice starch from non-waxy varieties may contain up to 37% amylose by weight.

Amylopectin, the other component of starch, has branched chain structure. It is not soluble in water and tends to form a viscous suspension specially when heated. Rice starch in waxy varieties may contain up to 100 % amylopectin by weight (Jagannada Rao, 1991)

The cooking quality of milled rice is largely influenced by the amount of amylose present in it. Varieties having very little or no amylose content cook to pasty masses. While those with higher amylose content cook to separate grains. (Jagannada Rao, 1991).

2:2:1:1 Birefringence:

Jagannada Rao (1991) studied the crystalline structure of rice kernal. Orderly distribution of starch layers in the crystalline structure appears like a distorted spherocrystal (referred to as Maltese cross) when observed against plane polarized light under a microscope. This property is known as birefringence. Owing to the hydrothermal treatment during parboiling, rice starch loses birefringence as a result of change from crystalline to amorphous structure.

2:3 Swelling, gelatinization and retrogradation of starch

Araullo and Grahham (1976) suggested that the breakdown of the starch granule on heating in water takes place in three distinct phases as described below.

2:3:1 Swelling

Water is slowly and reversibly taken up and limited swelling occurs during the first phase. The viscosity of starch suspension does not increase considerably. The starch granules retain their characteristic appearance and birefringence upon cooling and drying, no appreciable change can be observed (Araullo and Grahham, 1976). This phenomenon governs the swelling of paddy during hydration in cold or warm water having temperature less than 65° C.

2:3:2 Gelatinization

The second phase of swelling starts during steeping in water having temperature higher than the gelatinization temperature, which is around 75° C. During this stage, the starch suddenly swells, expands many times in size and absorbs moisture several times its weight. Also, this phase of swelling is marked by rapid rise in viscosity of the starch suspension, upon cooling and drying the granule alter in appearance, losing their crystalline structure and consequently its birefringence. This phase of the change is irreversible and the phenomenon is referred to as gelatinization. The temperature at which it takes place is known as gelatinization temperature (GT). GT varies with varieties of paddy (Araullo and Grahham, 1976).

The increase in moisture content and the rise in viscosity are explained by the phenomena of breaking of hydrogen bonds between amylose and amylopectin components, giving more surface for water absorption by the starch granule and spilling of amylose that goes into solution and raises the viscosity.

2:3:3 Retrogradation

With an increase in temperature above 75° C, the starch granules become somewhat like formless sacs. The soluble part of the starch is leached out in the solution. Slow cooling and drying of such samples give hard gel type starch, resulting from a phenomenon known as retrogradation, which is due to close alignment of the simple chain amylose molecules (Araullo and Grahham,1976).

2:4 Parboiling

Parboiling is one of the pre-milling treatments of paddy to improve its milling, nutritional, cooking and keeping qualities. The term parboiling covers the operation to which the paddy is subjected before milling. The purpose of the process is to produce physical, chemical and organoleptic modifications in the cereal with economical, nutritional and practical advantages. A random market survey had suggested that parboiled rice was less contaminated with storage fungi (Jayaraman and Indira , 1994). Parboiling of paddy is hydrothermal process that may be defined as the gelatinization of starch with in the rice grain (Araullo and Grahham, 1976). The voids or intergranular spaces of starch granules are filled with air and moisture. The presence of voids, fissures, and/or cracks developed during maturity, causes breakage of rice during milling. This breakage may be eliminated by gelatinizing the starch, which fills the voids and cements the fissures and cracks. Processing and parboiling of brown rice is also advised for faster hydration due to the removal of husk (Guha and Ali,1998)

Parboiling of paddy requires three steps namely soaking, steaming and drying. During soaking water penetrates into starch granules, forms hydrates by hydrogen bonding and cause swelling. Starch granules exhibit only a limited capacity for absorbing water and swelling in cold water and it is due to the presence of hydrogen bonds between the amylose and amylopectin fractions of the starch. During hot soaking, energy supplied in the form of heat weakens the granule structure by disrupting the hydrogen bonds, therefore more surface area is available for water absorption by the starch granule. Soaking of paddy can be done at or below its gelatinization temperature. The lower the temperature used, the slower is the process of soaking and vice versa (Ali and Pandya, 1974). However the temperature should not be more than 75° C or the paddy will be cooked.

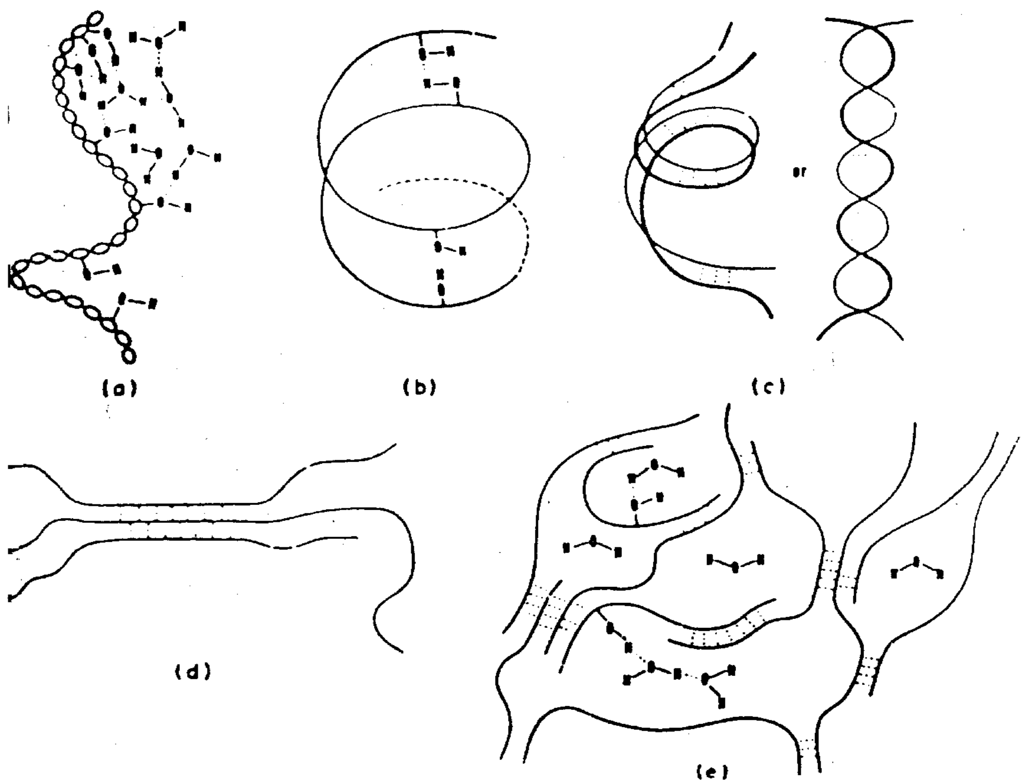

Figure 2: mode of water absorption by starch granules

(a) helical loops of polysaccharides
(b) & (c) double helices with other coiled macromolecules
(d) micelles
(e) shape of polysaccharides after absorbing water

(Source : Lineback, 1986. Current concept of starch structure and its impact on properties)

During steaming, soaked paddy is exposed to steam heat for a given duration and the starch present in the rice kernal is gelatinized (Araullo and Grahham, 1976). During this stage, the starch suddenly swells, expands many times in size and absorbs moisture several times its weight. This phase of swelling is marked by rapid rise in viscosity of starch suspension and increase in moisture content and rise in viscosity are explained by the phenomenon of breaking of hydrogen bonds between amylose and amylopectin components giving more surface for water absorption by the starch granules and spilling of amylose, that goes in to the solution and raises viscosity (Line back, 1986).

Heat for gelatinization of starch is supplied by saturated steam. The higher the temperature of steam, and the longer the steaming time, the harder the rice and the darker is its colour (Araullo and Grahham, 1976). Keeping steamed paddy in a heap is equivalent to prolonged steaming and induces the same effect. The best source of heat of gelatinization is steam, because of the following reasons:

1. The heat content is high and is given off at constant temperature.
2. The steam is produced from water, which is available in plenty.
3. It is clean and sterile without smell and any taste.
4. It can be easily piped and controlled.

2:4:1 Developments in the Parboiling System

Gariboldi (1974), Araullo and Grahham (1976), Chakravarthy and De (1981) and Pillaiyar (1988) have reviewed the various methods of parboiling practiced in the country and elsewhere in detail.

Many processes have now been developed for efficient modern parboiling. Realizing the importance of parboiling in improving the milling quality and nutrient value of rice, following improvements are done:

1. Hot water is used during soaking.

2. Drying is done artificially by hot air.
3. In some modern processes, drying is preceded by cooling whereas, the latest technique consider a long period of rest of tempering before milling.

Different Methods are:

2:4:1:1 CFTRI Method: -

This is a batch parboiling process, developed by Central Food Technological Research Institute (CFTRI), Mysore. In this process 4 or 6 cylindrical steel tanks supported on a fabricated steel frame are used for soaking as well as steaming. After soaking for about 4 hours, soaked water is drained and the water discharge valve is left open to remove the water that condenses during steaming. Soaked paddy is exposed to steam heat at a pressure of about 4 kg/cm^2 through the perforated steam pipes. CFTRI process has some drawbacks.

1. Soaked paddy is steamed in the same soaking tank, which results in dark colour of parboiled rice.
2. The Process necessitates installation of an expensive boiler in the rice mill.
3. The energy requirement per tonne of paddy parboiled is very high. (Jagannada Rao, 1991).

2:4:1:2 Jadavpur Process: -

It is a continuous process, the soaker-steamer is a horizontal steel trough in which the paddy is propelled from the inlet to the exit at a traverse time of 23 hr. The water in it is being maintained at 70° to 80° C by passing steam or hot water through a jacket. At the end of the soaker, the paddy is automatically scooped out in to the steaming zone, where it is exposed to live steam for 3 to 5 min. It is then dried continuously in a rotary dryer. (Majumder *et al.*, 1960). This process has not yet been commercialized.

2:4:1:3 'Avorio' Process: -

This process is a 1936 Italian patent. Soaking is accomplished in baskets filled with paddy, which are mechanically submerged in a tank of hot water by means of an endless chain conveyor. The soaking water is continuously circulated and aerated. Duration of soaking is controlled by the speed of the baskets in the tank and varies from 50 to 60 min, depending upon the variety. After soaking, the paddy is cooked in pressure autoclaves containing rotating perforated cylinders, which permit the introduction of steam throughout the paddy. Paddy is charged and discharged by special valves or ports functioning alternately. Steam pressure depends upon the temperature and duration of the operation and varies from 0.5 to 1.0 kg/cm^2. Injection of steam into the paddy reduces parboiling time to 15 to 20 min. Cooling operation effected with a stream of cold air precedes drying of the steamed paddy. The cooled paddy then passes to a series of columnar hot-air dryers and dried at 45° to 50° C. This process, which is well controlled in all phases of operation, produces a parboiled rice of high head-rice yield with excellent cooking characteristics and amber colour. The name of the process derives from the Italian word 'avorio' which means ivory, since the amber colour suggests that of ivory (Pillaiyar, 1980).

2:4:1:4 'Converted' Process: -

This is the first American parboiling process initiated in 1941- 42. The product is obtained by the complete gelatinization of the entire kernal, resulting from a series of processing operations. The parboiled product has an amber colour, completely vitreous throughout and without any white starchy centre. Soaking in the autoclaves begins with deaeration of the paddy by means of vacuum. This facilitates saturation and softening of the grain in water; then follows a pressure treatment effected on the soaking water in the autoclave in such a manner that the action of vacuum and pressure renders the soaking action more rapid (less than 3 hr soaking). After soaking, the paddy is cooked in a rotary steam-jacketed autoclave. Applied vacuum then frees the grain of excess moisture, the steam pressure being held at less than 1 kg/cm^2 for about 1 hr. Final drying is carried out in the same autoclave by applying vacuum and heating with steam (Pillaiyar, 1980).

2:4:1:5 'Fernandes' Process: -

The soaking, steaming and drying take place in three apparatuses, almost similar in construction, each consisting of rotary horizontal cylinder provided with internal helical conveyors for movement of paddy. At the centre of the rotary cylinder and extending along its length, a perforated tube carries hot water for soaking in the first cylinder, steam for cooking in the second and hot air for drying in the third (Pillaiyar, 1980).

2:4:1:6 'Melek' Process :-

In this process, parboiled rice is prepared by successive unit operations and its colour is amber. Hardness of the grains is very remarkable. Paddy is soaked in tanks filled with hot water for 3 to 6 hr. The soaked paddy is cooked by injection of steam into a vertical cylindrical autoclave, having a truncated cone bottom and provided with charging and discharging ports or valves at the inlet and outlet respectively. Movement of the paddy in and out of the autoclave is by gravity.

Drying is performed in two stages: first in a steam heated rotary cylindrical dryer, and then in a forced hot-air columnar dryer at lower temperatures (Pillaiyar,1988).

2:4:1:7 Cristallo Process: -

This process was invented by Franco Gariboldi in Italy. The paddy is first subjected to a special cleaning in water for eliminating the trash and imperfect grains. Soaking takes place in an open tank in which hot water of controlled temperature is circulated. Steaming and drying are performed in the same rotary autoclave with pressure and vacuum. The steam-jacketed autoclave is also equipped with means for uniformly distributing the steam throughout the interior of the autoclave. The operation is a well-controlled process and produces a range of varied products, depending upon the varieties processed and market demands. In Italy parboiled rices are sold under the brand name ‘Cristallo’ (Borasio and Gariboldi, 1965).

2:4:1:8 RPEC Method: -

The method was developed at the Rice Process Engineering Centre, Kharaghpur. It consists of soaking the paddy in water at or a little above the gelatinization temperature of the starch, for a suitable period, which depends upon the paddy variety. During soaking, the paddy absorbs moisture and heat, and the parboiling process is completed. The milling quality of the paddy produced by the RPEC method is similar to that of paddy parboiled by conventional methods, and after milling both rices look alike. The degree of gelatinization of starch in hot-soaked parboiled rice was slightly less than in the rice produced by conventional methods, however this reduces the optimal cooking time. Both parboiled rices when optimally cooked have nearly the same swelling indices. The main advantage of this method is the elimination of boiler, which is one of the most costly items in a parboiling plant. The water for soaking the paddy can be directly heated by a suitable husk furnace (Ali and Ojha, 1976).

2:4:1:9 Brine Solution Method :-

This is a modified CFTRI method. In this method, a 15 % brine solution (sp.gr.1.10) is circulated for 10 to 20 min through hot paddy that has been soaked at 65 ° C. The paddy is then open steamed for 15 to 20 min. The paddy does not open during steaming operation. The salt withdraws moisture by exosmosis and does not enter the paddy. The moisture content at the completion of steaming is about 30 %. The parboiled paddy produced by this method requires only 2 hr for mechanical drying to bring its moisture content to 14-15%. The residual salt in rice is negligible (0.03 - 0.05%) (Pillaiyar, 1988). Because of the corrosion problem (which could be avoided by suitably coating the vessels) and low efficiency of shelling and paddy separation, this method was subsequently given up.

2:4:1:10 Kisan Continuous Parboiling Method: -

A hexagonal tank with 12 compartments is filled with hot water into which paddy is discharged from an elevator head. The compartments are filled in a sequential order starting with No.1 and leaving an interval of 15 min for filling of successive compartments. By the time the 12th compartment is filled, the first one is ready for steaming. A screw conveyor removes the soaked paddy for steaming. A series of batches emptied from the hexagonal tank continuously feeds the parboiling tank. The steaming device is a simple one, in which the paddy flows vertically down an annular chamber as a horizontal flow and the steam radially heats and gelatinizes the grain. The steaming unit can serve as paddy dryer if hot air is used instead of steam (Kuppuswamy, 1972).

2:4:1:11 Conduction parboiling (sand parboiling) :-

Detailed studies on conduction parboiling, using sand as the medium, were carried out by Khan *et al*.(1974). Paddy with high initial moisture (>22 percent) is better suited for parboiling by this method (Srinivas *et al*., 1981). In a large scale trial conducted by Iengar *et al*.(1971), paddy with initial moisture of 32.0 % was parboiled and dried to a moisture content of 17.4 %, in 10 min. A sand and paddy mixture of 5:1 was found optimum for getting desired result when the sand was maintained at 170^{o} to 200^{o} C. After keeping the resultant paddy overnight the moisture content dropped to 14.5 %. The breakage in milling was 2.5 %, and the colour of rice was normal.

While conventional steam-parboiled rice cooked slower than ordinary raw-milled rice, conduction-parboiled rice had better cooking (i.e., hydration) quality. This difference was due to the gelatinized starch getting partially re-associated or retrograded in the most conventionally parboiled rice (Ali and Bhattacharya, 1976) whereas such retrogradation was hindered in the conduction-parboiled rice due to the simultaneous rapid dehydration during gelatinization by roasting with sand (Ali and Bhattacharya, 1980) at the roasting temperature of 130^{o} to 140^{o} C. The roasted paddy at the discharge end attained a temperature of 97^{o} to 98^{o} C and a moisture content of about 21 % (wb).

Cooling and aerating the hot paddy by spreading it on the floor could quickly reduce the moisture content. The immediate EMC-S and alkali test showed that the rice was mildly parboiled, and the rice obtained after shade drying and milling had typical parboiled-rice appearance. In the severely parboiled rice produced by sand-roasting method, the grains appeared rather flat and compressed and with somewhat pronounced ridges. These ridges could be a disadvantage for milling, which would indicate that the process should be so controlled as not lead to very severe parboiling (Ali and Bhattacharya, 1980).

2:4:1:12 Use of hot air for parboiling and drying :-

By repeatedly feeding fully soaked paddy through the cylindrical drying chambers of a portable husk-fired dryer, the paddy was parboiled and dried to a moisture content of 14.4 % in three passes. Direct flame heating of soaked paddy resulted in parboiling and drying (Arboleda, 1973). When soaked paddy (MC - 24%) was passed through a stream of hot air at 180^{o} C, it got parboiled. However grain-to-grain variations in the degree of parboiling were observed. (Ali and Bhattacharya, 1980).

2:4:1:13 Parboiling by closed heating: -

It has been indicated that the soaked paddy can be parboiled without the necessity of steaming it. Soaked paddy could be parboiled by simply heating in a closed jacketed rotating drum to about 100^{o} C (Pillaiyar *et al.*, 1977). This eliminated the need of boiler and the product obtained also had a low moisture content (4 to 8 % less) than the normal steam-parboiled paddy.

2:4:1:14 Low-Temperature Parboiling Technique: -

By adopting the principle of closed heating, soaked paddy was parboiled at 70^{o}, 80^{o}, 90^{o}, and 100^{o} C and its quality was determined. The low temperature parboiled rice had cooking and eating qualities close to those of raw rice, but did not break in milling (Pilliaiyar and Mohandoss, 1981). Low-temperature parboiling-cum-vacuum drying and its effect on quality have also been studied (Pillaiyar and Mohandoss, 1982).

2:4:1:15 Electrical Heating of Soaked Paddy for Parboiling :-

In this method three positive phases of the current were connected to the electrodes fixed in a conical vessel. The body of the vessel was connected to the negative phase and then high-voltage electrical current was passed through the soaked paddy, which generated heat and parboiled the paddy. The colour, cooking time, solid loss on cooking and swelling ratio of the rice produced by this method are similar to those of open-steamed paddy (Vasan and Ganesan, 1981).

2 : 4:1:16 Continuous Steaming Process :-

In the CFTRI process, the soaked paddy is steamed for 10 - 30 min in the same tank in which paddy is soaked. The steamed paddy is then discharged for drying, which takes 5 to 30 min depending on the capacity of the tank since the retention time of hot paddy intensifies the colour (Bhattacharya and Subba Rao, 1966). A process for continuous steaming of paddy during discharge from soaking vessel was developed (Rama Rao *et al.,* 1977). In this process the paddy is exposed to steam for 4 to 5 sec only by passing soaked paddy through a quick steamer. Large-scale trial is still in progress.

2:4:1:17 Hot-humid air-soaking method :-

Soaking is accomplished by passing hot-humid air into paddy kept in a rectangular bin made of G.I. sheet. There are arrangements for varying the rate of flow of air and steam. It is reported that a combination of 60 °C and 95 % relative humidity for 4 hr is suitable to achieve completion of soaking. The paddy is then steamed and dried (Ramalingam *et al*.,1976).

2 :4 :2 PRESSURE PARBOILING OF PADDY

To further quicken the process of parboiling, paddy is parboiled under pressure in pressure parboiling method. It involves penetration of moisture in the form of water vapour under pressure. Paddy is loaded in specially designed pressure parboiling tanks. Water is circulated through the paddy. After draining the water, paddy is open steamed for some time and pressure of the steam is increased. After reducing the pressure, paddy is discharged and dried. Various steam pressures and duration of steaming has been suggested to produce various types of parboiled rice (Pillaiyar, 1988).

According to Iengar *et al* (1974) the time of parboiling could be considerably reduced and complete parboiling could be attained within one hour, by soaking at 35° for 25 minutes and then steaming under pressure for 20 minutes. By elevating the soaking temperature and pressure, the operation can be done fast.

Iengar *et al.*, 1974, suggested the following procedures

1. Soaking in cold water for 5 minutes, drain water, open steaming for 30 minutes, followed by steaming for 10 minutes with 20 psi pressure.

2. Wetting with cold water circulation for 5 minutes, followed by 20 minutes steaming at 5 psi and 5 minutes at 25 psi.

3. Hot soaking in water at 90 °C for 30 minutes followed by steaming at 50 psi for 10 minutes.

The principle of parboiling method is essentially to wash the paddy in water in a pressure vessel. Keep the contents under saturated steam to effect quick penetration of water into the kernal followed by steaming of paddy at high steam pressure to effect full gelatinization of starch.

Pressure parboiling studies were conducted by Ali and Bhattacharya (1982). Steaming was carried out in a line connected auto clave. Before steaming, paddy was subjected to various level of moisture content ranging from 12 to 28 %. Steaming was done for 10, 20, 40 and 60 minutes for 0.5 kg/cm^2 and 5, 10, 20 and 40 minutes for 1 kg/m^2 and 5, 10, 15, 30 minutes for 2 and 3 kg/cm^2. It was found that each parboiling property increased with increase in moisture content, pressure and time of steaming. Complete parboiling could be achieved even at very low grain moisture, when steamed under high pressure. However such rice was too hard to cook. The moisture content of the parboiled paddy by pressure parboiling was less than the other methods (Iengar *et al*., 1974).

Ali and Bhattacharya (1982) studied the translucence index, gelatinization index, retrogradation index, cooking resistance index, colour and head rice recovery of pressure parboiled rice by adjusting and varying different parameters like initial moisture content, steaming pressure and steaming duration. Higher levels of moisture, steaming pressure and steaming time led not only to increase the levels of gelatinization but also to increase the degree of retrogradation. This would explain why the normal-pressure parboiled rice was so hard to cook and hard in texture.

Ali and Bhattacharya (1982) suggested that, a brief soaking of about 15 minutes, followed by pressure steaming at 1 to 2 kg / cm^2 for 20 to 30 minutes would be upper limit of treatment for giving rice with reasonably acceptable cooking quality and colour.

MATERIALS AND METHODS

3.MATERIALS AND METHODS

In this study a laboratory model pressure parboiling unit replete with all accessories has been designed and fabricated. The details of the unit and the experimental methods are discussed in this chapter

3.1 LABORATORY MODEL PRESSURE PARBOILING UNIT

The parboiling unit consists of a parboiling tank with steam distribution pipes, steam generator and instrumentation for measuring pressure and temperature. The unit is shown in Figure.3 and detailed drawing in Plate.1

3.1.1 Parboiling tank

The parboiling tank is a leak proof tank made of a mild steel sheet. The design of the tank is detailed in 3.1.1.1.

3.1.1.1 Design

From the preliminary studies it was decided to design a pressure parboiling tank to withstand a maximum pressure of 4kg/ cm^2 with a holding capacity of 5 kg per batch.

Assumptions: - (1) bulk density of paddy = 590 kg/m^3 (jagannada Rao, 1991)

(2) factor of safety = 4 (khurmi and Guptha,1987)

(3) paddy container is to be filled only upto 60% of total capacity

Therefore,the reqired capacity of paddy container = $\dfrac{5\ kg \times 100}{60}$

$= 8.33$ kg ~ 9 kg

Volume occupied by 9 kg of paddy = 9/590 = 0.01525m^3 ……………………(1)

Taking H/D ratio as 1.5 ,also height of conical part h_1=2/3H and height of cylindrical part as h_2 =1/3 h

Sustituting all the values in the equation for volume of the tank

$$Volume\ of\ container = \frac{\pi}{4} D^2 h_2 + \frac{1}{3} \frac{\pi}{4} D^2 h_1$$

V = 0.9158 D^2 ………………………….. (2)

Equating (1) and (2)

D = 0.256m ~ 30 cm

h_1 = 30cm

h_2 = 15cm

Therefore the dimensions of pressure vessel are:

Inside diameter of pressure vessel = 300mm

Height of cylindrical part = 150mm

Height of conical part = 400mm

According to the equation for the stress in the cylinder.

F = PD / 2T (Black peter, 1966)

Where F = Tensile stress for mild steel.

= 300-380N/mm^2 (khurmi and Guptha, 1987)

F = 350 N/mm^2 =3567 kg/cm^2

P = Pressure = 4 kg/cm^2

D = diameter of vessel =30cm

T = thickness of vessel

Substituting the values, T = 0.017 cm ~ 0.2 mm

Taking factor of safety as 4,

Required thickness = 0.2x4 = 0.8

Thickness of pressure vessel is taken as 2mm for convenience.

3.1.1.2 Construction

The mild steel sheet was rolled into a cylindrical and conical shape as per the design dimensions and the joints were welded. A mild steel cover plate was bolted on to the top of the cylindrical tank. The tank is provided with a raw paddy inlet opening of diameter 50 mm at the top. The paddy outlet opening at the conical bottom is 50 mm in diameter. These openings are closed with the help of suitable lids with rubber gaskets to make the vessel airtight and leak proof. There is a central opening to let steam into the parboiling tank. The tank is kept at a height of 1.5 m above the ground on a tripod.

3.1.2 Steam generator

A 5 litre capacity pressure cooker bought from the market was modified and used as steam generator. A hole was drilled on the cylindrical body of the cooker and a G I pipe of diameter 12.5 mm and length 300 mm was attached to it through suitable couplings and gaskets to withstand pressure and to prevent any leakage. The other end of the G I pipe was connected to the parboiling tank so that high pressure steam could get into the paddy bulk uniformly through the steam distribution assembly. On the steam pipe, a steam regulating valve was fitted to release the steam into the parboiling tank.

3.1.3 Steam Distribution Assembly

A Galvanised Iron pipe of 12.5 mm diameter was used for fabricating the steam distribution assembly. A main pipe of length 300 mm was welded at the conical bottom vertically. Four lateral pipes,each of samesize and length 90 mm, were placed radially, two each at a spacing of 180^0 and 115 mm apart. Slots of diameter 6 mm were cut along the pipe to let the steam into the paddy bulk. The steam entering into the steam distribution assembly from the bottom was distributed through the main pipe and the laterals.

3.1.4 Measuring meters

Instrumentation for measuring steam pressure and temperature of paddy were connected to the system.

3.1.4.1 Pressure gauge

A pressure gauge (Bourdan tube type) of dial diameter 5.0 cm having a range of 0 – 7.0 kg/cm^2 was fitted to the steam pipe between the steam generator and pressure parboiling tank.

3.1.4.2 Thermometer

A digital thermometer with range of –15 to 200 ^{0}C was used to measure the temperature of the paddy held in the parboiling tank.

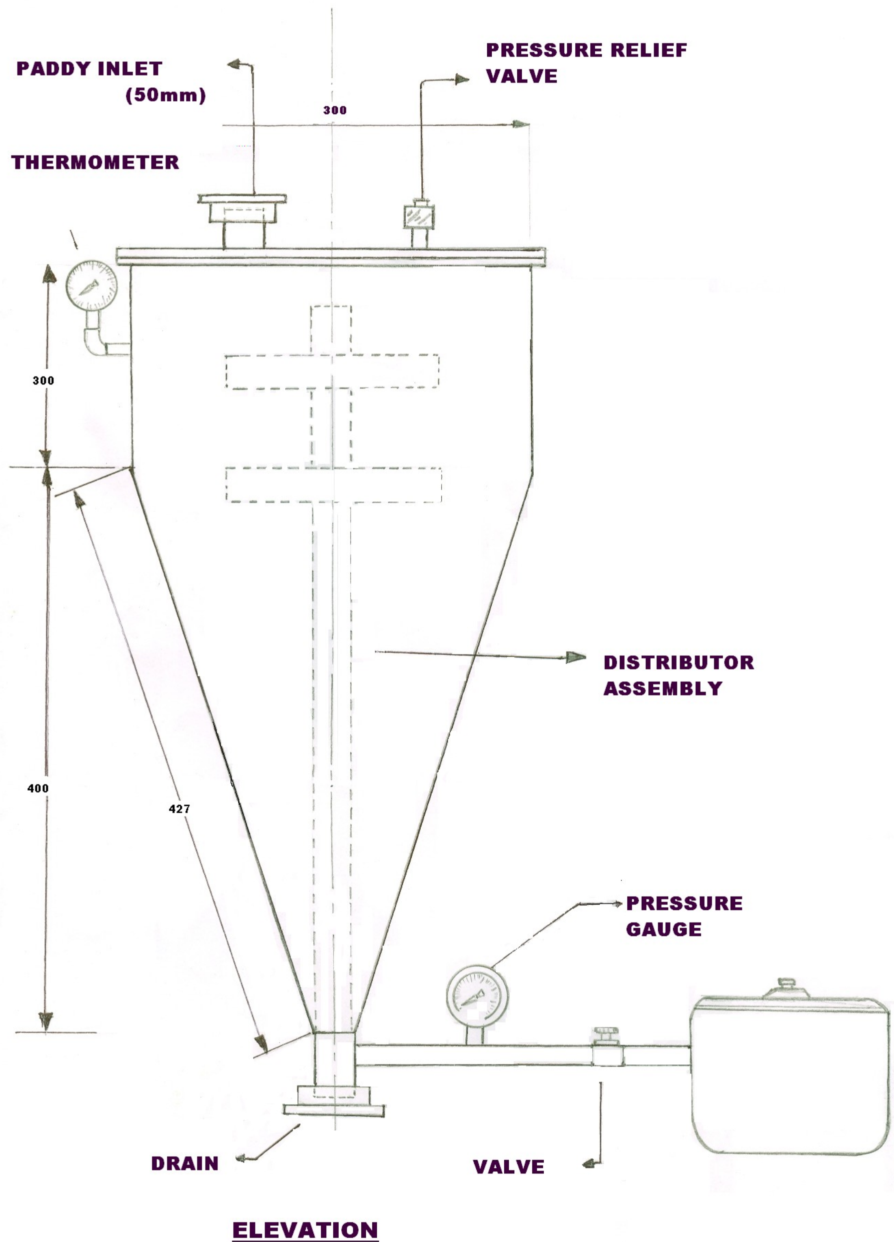

Figure.3 PRESSURE PARBOILING UNIT

Plate . 1 E xperimental Set up

3.2 EXPERIMENTAL DESIGN

In pressure parboiling of paddy, washing/rinsing of paddy is practised by water circulation to clean the paddy (Shivanna, 1976). In soaking of paddy hot soaking at 70^0 C has proved to be effective (Ali and Pandya, 1974). As the washing or rinsing by water circulation results in leaching of soluble sugars (Antoniraj and Singaravadivel, 1980) water circulation was not carried out in this study. In the present study hot soaking was carried out at different temperatures for different durations. Steaming followed this for different pressures and parboiling time was noted. Splitting of husk was taken as the indication of completion of parboiling. Parboiling by traditional method was adopted as control.

3.3 EXPERIMENTAL METHOD

Local variety of paddy, Jyothi, with a moisture content of 11% (wb) procured from the college farm was used for the experiments. The paddy was cleaned by removing chaff and other impurities.

3.3.1 Pressure parboiling

About three-fourth of the cooker was filled with water and heated on a gas stove. After about 10 minutes, water in the cooker boiled and steam generated. When sufficient pressure was built up, the steam-regulating valve was opened to let the steam into the parboiling tank. The opening and closing of the valve varies the steam pressure as required, which can subsequently be noted from the pressure gauge. The parboiling tank was filled with 2 kg of paddy. Soaking of paddy was done for 10, 20, 30, 40, 50 and 60 minutes durations at temperatures 60, 65 and 70 ° C. After each soaking, steaming was carried out at a pressure of 1 kg/cm^2 and the duration of parboiling was noted. Splitting of husk was taken as an indication of completion of parboiling process. The parboiling pressures during the experiment were measured by the pressure gauge and controlled by the steam-regulating valve. At the end of parboiling steam was closed and the parboiled paddy outlet was opened to discharge the parboiled paddy. From the results obtained, the set of readings, which gave minimum parboiling time, were chosen and the same experiments were carried out for that set of treatments at 0.5 kg/cm^2 parboiling pressure. Three sets of experiments were conducted for each treatment and the average value was taken as the final reading.

3.3.2 Experiments with the control

A sample of paddy parboiled by the traditional method was taken as the control in the experiments. For traditional method of parboiling, paddy (2kg) with moisture content of 11 % (wb) was soaked in cold water for 24 hours. This soaked paddy was parboiled by heating the paddy in the same container on a gas stove. The time for completion of the parboiling process was noted .The completion of parboiling was judged by the characteristic smell and splitting of husk. The parboiled paddy was then dried. The parboiled paddy sample was packed in a polythene bag and used as control.

3.3.3 Determination of moisture content

The moisture content of discharged paddy is an important dependent variable of the treatments. The moisture content of all the samples were determined by taking a sample of 10g from the discharged paddy and drying it in a thermostatically controlled electrical oven maintained at 105 ° C for 1 hour.

3.3.4 Drying

Parboiled paddy was dried in a Tray drier by maintaining a temperature of 65° C for 8 hours. The paddy was then taken out and tempered by keeping it in atmospheric conditions for 1.5 hours for equilibration of moisture and then further dried in the tray drier at same temperature to a moisture content of 12 to 14 % (wb).

3.3.5 Milling of parboiled paddy

The dried parboiled paddy samples each weighing 1kg with 12-14% (w.b) moisture content, were milled in a local mill employing a rubber roll sheller. The brown rice obtained from each sample were weighed and packed in polythene bags for further analysis.

3.3.6 Analysis of samples

The brown rice was analysed for physical properties, milling quality and cooking quality.

3.3.6.1 Physical Properties

Physical properties of the brown rice like dimensions, 1000 kernel weight and bulk density were determined for pressure parboiled rice and controls.

3.3.6.1.1 Dimensions

The length, breadth and thickness of 5 kernals of brown rice in each of the treatments was measured using a travelling microscope having a least count of 0.01.

3.3.6.1.2 1000 Kernel weight

The 1000 Kernal weight of brown rice is a major response as affected by premilling treatments.1000 kernals of brown rice from selected treatments (sample) was manually collected and weighed. This was replicated for 3 times and the average weight was taken.

3.3.6.1.3 Bulk Density

The bulk density of brown rice was determined by filling rice gently in a regular cylindrical shaped container of known volume without compaction and then measuring the weight of the rice. From this, the bulk density was calculated as their ratios. This was carried out for selected treatments.

3.3.6.2 Milling Quality

The milling quality of parboiled paddy samples was found by calculating the percentage of broken rice in the milled samples. Percentage Broken Rice is the ratio of weight of broken rice to the weight of total milled sample, expressed as %.

3.3.6.3 Cooking Quality

Time required for cooking the pressure parboiled samples and controls to an average softness was noted .

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

In this chapter outcome of the experiments conducted as per the experimental design are given and results are discussed.

The effect of various treatments on parboiling time, moisture content of parboiled paddy, milling quality, physical qualities like dimensions, 1000 kernal weight, bulk density and cooking quality were studied and are reported in this chapter.

4.1 Effect of soaking temperature and soaking time on parboiling time

The time required for the completion of parboiling process under each set of soaking temperature and soaking duration at parboiling pressure of 1kg/cm^2 and 0.5 kg/cm^2 is shown in Table 2 and 3. Variation of parboiling time with soaking time, at soaking temperature of 70 °C ,65 °C and 60 °C at a parboiling pressure of 1 kg/cm^2 and 0.5 kg/cm^2 is shown in figure 4 and 5.

The results shown in Tables 2 and 3 as well as figures 4 and 5 reveal that, at a soaking temperature of 70 °C, the parboiling time was found to be a minimum of 30 minutes for a soaking period of 30 minutes. Further increase in soaking time was found to have no effect on the parboiling time.

When soaking temperature was reduced by 5 °C that is at 65 °C, and with a soaking time of 30 minutes, the parboiling time increased to 40 minutes. When soaking time was increased by 10 minutes i.e., to 40 minutes, the reduction in the parboiling time was marginal, to the extend of 2 minutes only. Further increase in soaking time was found to have no significant effect on parboiling time.

A similar trend was observed when soaking temperature was further reduced by 5 °C i.e at 60 °C. With a soaking time of 30 minutes, the parboiling time increased to 47 minutes, a 17 minutes increase in parboiling time compared to parboiling at 70 °C soaking temperature and 30 minutes soaking time. When soaking time was increased by 10 minutes i.e to 40 minutes, the same trend as observed in the previous treatment was observed with only a marginal reduction in parboiling time. Further increase in soaking time at this soaking temperature showed no significant effect on parboiling time.

From the results it was also revealed that for the same soaking time, when soaking temperature was reduced by 5 °C, the parboiling time increased in the range of 5 to 10 minutes , which indicates that reduction in soaking time has a significant effect on increasing the parboiling time. Also an increase in soaking time could lead to leaching out of nutrients, development of foul smell, increased energy requirement and delay in the process. Therefore it may be concluded that a soaking temperature of 70 °C and soaking time of 30 minutes which gives a parboiling time of 30 minutes when parboiling pressure was 1 kg/cm^2 is considered optimum for pressure parboiling of Jyothi variety of paddy.

Based on these conclusions, experiments were also conducted to see the effect of parboiling pressure on parboiling time. The results of these studies are shown in Table 3 and Figure 5. In this study, the parboiling pressure was reduced to 0.5 kg/cm^2 and soaking time varied from 30 minutes to 45 minutes in the increments of 5 minutes and soaking temperature reduced from 70 °C to 60 °C in the decrements of 5 °C. It was revealed from the experiments that at 70 °C soaking temperature and 30 minutes soaking time, the parboiling time was 52 minutes, 22 minutes more than the corresponding treatments at 1 kg/cm^2 parboiling pressure. When soaking time was increased to 35 minutes, the parboiling time reduced by 2 minutes only. Further increase in soaking time does not show any appreciable reduction in parboiling time. When soaking temperature was reduced by 5 °C i.e. at 65 °C, and with the soaking time of 40 minutes, the parboiling time observed was 55 minutes. Further increase in soaking time does not show any appreciable reduction in parboiling time. A similar trend was observed when the soaking temperature lts confirm that a soaking temperature of 70 °C and soaking time of 30 minutes that give a parboiling time of 30 minutes, when parboiling pressure was 1 kg/cm^2 may be taken as optimum treatment for pressure parboiling of Jyothi variety of paddy.

4.2 Effect of Pressure Parboiling on Milling and Parboiling Quality

The moisture content of the parboiled paddy and percentage breakage on milling were assessed for the selected pressure parboiling treatments and are hereby reported under this section.

Plate .2 Pressure parboiled paddy after treatments 1, 2,3 and 4.

Plate . 3 Pressure parboiled paddy after treatments 5, 6 and control.

4.2.1 Effect of Pressure Parboiling on Moisture content of parboiled paddy

The moisture content of the pressure parboiled paddy after selected treatments and for the control sample are given in Table 4. The moisture content varied in the range of 25 to 35 %.

For a soaking time of 30 minutes, as soaking temperature decreased, the moisture content of pressure parboiled paddy at 1 kg/cm^2 parboiling pressure were in the range of 28 to 30 % (wb). Similarly for a soaking time of 40 minutes, as soaking temperature decreased, the moisture content of pressure parboiled paddy at 0.5 kg/cm^2 parboiling pressure varied in the range of 34 to 35 %.The moisture content of paddy control (traditional parboiling) was found to be very high i.e. 48 % (wb). The reduction in moisture content of pressure parboiled paddy compared to the traditional method of parboiling was found to be in agreement with Iengar *et. al* (1974). The reduction in moisture content of pressure parboiled paddy reduces the energy requirements in drying of paddy.

4.2.2 Percentage Broken during Milling as effected by parboiling treatments

The percentage brokens of the pressure parboiled after selected treatments and control are given in Table 5. The percentage brokens for the pressure parboiled paddy ranged between 1.78 % and 5.32 % whereas for the control it was 7 %. From this it is evident that pressure parboiling has definite advantage over the traditional parboiling process. It was revealed from the results that with reduction in soaking temperature and therefore with an increase in soaking time, the percentage brokens increased from 1.78 % to 4.92 % when the parboiling pressure was 1 kg/cm^2 . A similar trend was observed when the parboiling pressure was 0.5 kg/cm^2 with the percentage brokens increasing from 2.6 % to 5.32 %. From these results it may be concluded that pressure parboiling at a soaking temperature of 70 °C and soaking time of 30 minutes with a parboiling pressure of 1 kg/cm^2 resulted in minimum broken percentage of 1.78 and may be taken as the optimum treatment conditions for Jyothi variety of paddy. The decrease in brokens for the treatment could be attributed to the increase in hardness of the rice kernel due to proper gelatinization and cementing of cracks formed in the rice kernel during maturity, handling and processing (Pillaiyar *e.al.,*1981).

4.3 Physical properties of Pressure Parboiled Rice

The physical properties like dimensions (length, breadth and thickness) ,1000 kernal weight and bulk density for the brown rice obtained from pressure parboiling were determined and the effects of these characteristics on the process are discussed below.

4.3.1 Dimensions of Pressure Parboiled Paddy

During parboiling, the paddy swells (all the dimensions increase) by the absorption of moisture and by the subsequent drying, the paddy shrinks on removal of moisture. The change in dimensions due to parboiling treatments were not found reported. In some cases of the pressure parboiling treatments , the length, breadth and thickness of the paddy are less than the paddy obtained by the traditional parboiling method and in some cases it is reverse for which the reasons are not known. The length, breadth and thickness of the pressure parboiled paddy and control are shown in Table 6. From the results it was found that no significant change in dimensions could be observed due to various treatments.

Table 2. Effect of soaking temperature and soaking time on parboiling time at parboiling pressure of 1 kg/cm^2

Treatment No:	Soaking Temperature (° C)	Soaking Time (minutes)	Parboiling Time (minutes)
T1	70	10	45
T2		20	38
T3		30	30
T4		40	30
T5	65	30	40
T6		40	38
T7		50	38

T8	60	30	47
T9		40	44
T10		50	43
T11		60	43
control	ambient	24 hrs	75

Table 3. Effect of soaking temperature and soaking time on parboiling time at parboiling pressure of 0.5 kg/cm^2.

Treatment No.	Soaking Temperature (° C)	Soaking Time (Minutes)	Parboiling Time (Minutes)
T12	70	30	52
T13		35	50
T14		40	45
T15		45	45
T16	65	40	55
T17		45	53
T18		50	53
T19	60	40	60
T20		45	60
T21		50	57
T22		55	57
control	ambient	24 hrs	75

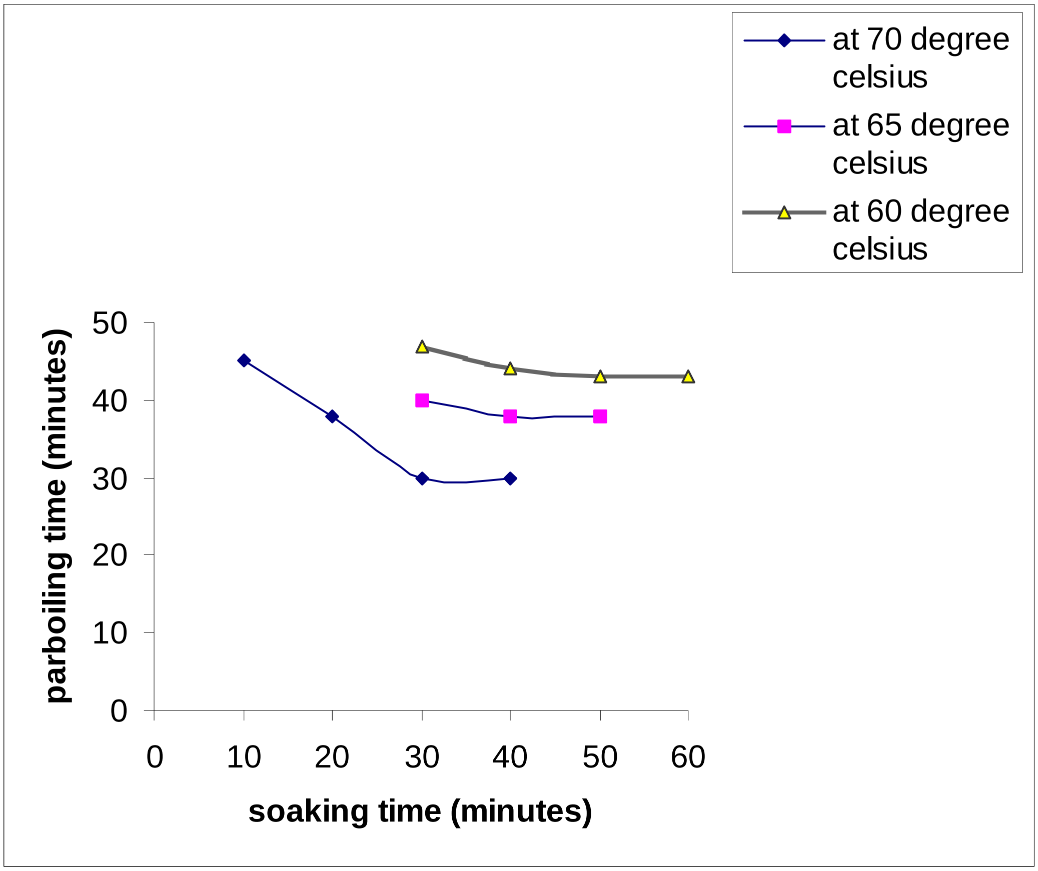

Figure 4: Variation of parboiling time with soaking time at parboiling pressure 1 kg/cm^2

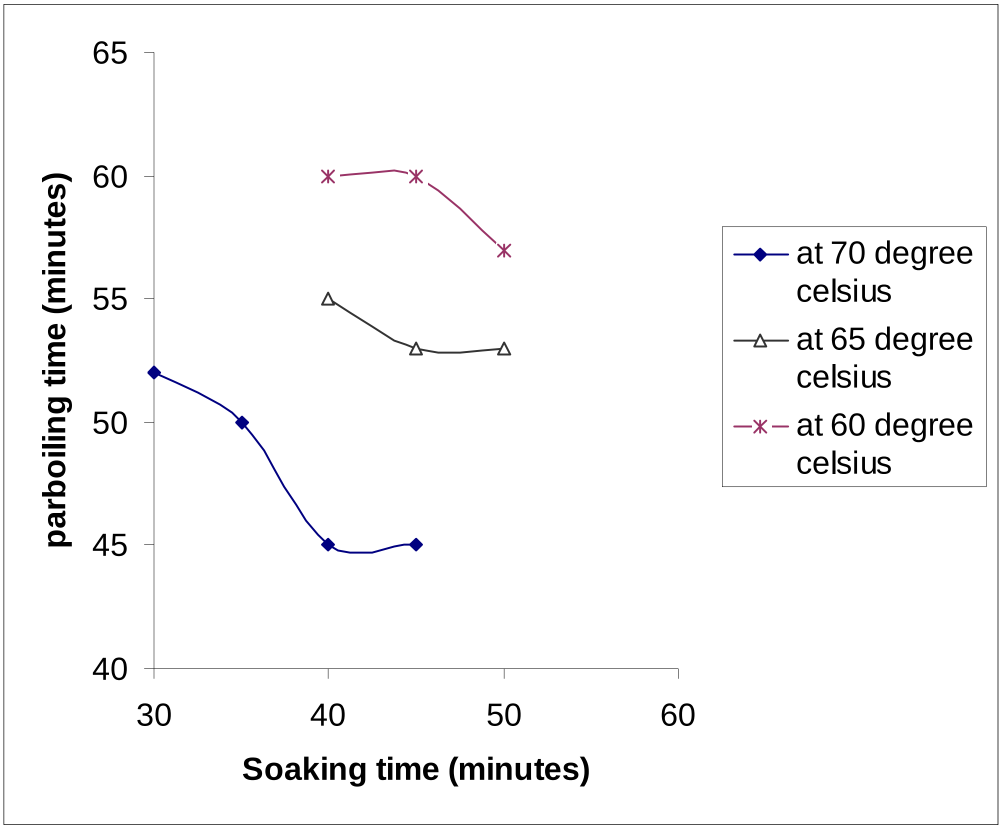

Figure 5. Variation of parboiling time with soaking time at parboiling pressure 0.5 kg/cm^2

4.3.2 Thousand Kernal weight

The values of the 1000 kernal weight for the selected treatments of pressure parboiling are shown in Table 7. The 1000 kernal weight ranged from 12.4 to 18.9 grams whereas it was 15.7 grams for the control (traditional parboiling). The probable reason for the variations in the 1000 kernal weight as affected by the parboiling treatments may be due to the gelatinization characteristics.

4.3.3 Effect of Pressure Parboiling Treatments on Bulk Density

The values of bulk density are given for the selected treatments of pressure parboiling and control in Table 7. The bulk density ranged from 532 to 623. The dimensions and 1000 kernal weight may also have influenced the effect of pressure parboiling treatments on bulk density. Bulk density of the control sample was found to be 590. As in the case of other physical properties,the bulk density also have exhibited both decrease and increase in the values when compared with the response by traditional method and therefore, no specific conclusions could be drawn from these results.

4.4 Cooking quality

The cooking time for selected treatments of pressure parboiling and control are shown in Table : 8. From the results it was revealed that there is a 10 minute reduction in cooking time for control when compared to pressure parboiled paddy soaked at 70 °C for 30 minutes and parboiled at 1 kg/cm^2 parboiling pressure. But this reduction is marginal. For all other treatments, the cooking time showed an increasing trend.

Table 4. Effect of pressure parboiling on moisture content of parboiled paddy

Treatment No.	Soaking temp. (°C)	Soaking time (minutes)	Parboiling pressure (kg/cm^2)	Parboiling time (minutes)	Moisture content (%) (wb)
T3	70	30	1	30	30
T5	65	30	1	40	28
T8	60	30	1	47	28
T14	70	40	0.5	45	35
T16	65	40	0.5	55	33
T19	60	40	0.5	60	34
control	ambient	24 hrs	atmospheric	75	48

Table 5: Effect of pressure parboiling on milling qualities

Treatment No.	Soaking temp. (°C)	Soaking time (minutes)	Parboiling pressure (kg/cm^2)	Parboiling time (minutes)	Broken (%)
T3	70	30	1	30	1.78
T6	65	40	1	38	3.26
T10	60	50	1	43	4.92
T12	70	30	0.5	52	2.6
T16	65	40	0.5	55	4.86
T21	60	50	0.5	57	5.32
Control	ambient	24 hrs	atmospheric	75	7

Table 6: Effect of pressure parboiling on dimensions of paddy

Treatment No.	Length (mm)	Breadth (mm)	Thickness (mm)
T3	8.43	3.0	2.41
T6	8.11	3.0	2.05
T9	8.3	3.08	2.56
T12	7.85	2.75	2.43
T16	8.09	3.05	2.18
T19	8.31	3.12	3.0
Control	8.12	3.08	2.45

Table 7: Effect of pressure parboiling on 1000 kernal weight and Bulk density of paddy

Treatment No.	1000 kernal weight	Bulk Density (kg/cm^2)
T3	12.4	542
T6	14.5	540
T9	16.4	603
T12	13.9	617
T16	17.6	532
T19	18.9	623
Control	15.7	590

Table 8. Effect of pressure parboiling on cooking time

Treatment No.	Soaking temp. (^{o} C)	Soaking time (minutes)	Parboiling pressure (kg/cm^2)	Cooking time (minutes)
T3	70	30	1	80
T6	65	40	1	85
T9	60	40	0.5	90
control	ambient	24hr	atmospheric	70

SUMMARY

AND

CONCLUSION

5. SUMMARY AND CONCLUSIONS

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Rice has been used as a staple food since ancient times. Parboiling is a pre-milling treatment of paddy to improve its milling, nutritional and keeping qualities. A quarter of the world's paddy production is parboiled. Conventional methods of parboiling require high energy per tonne of paddy parboiled and quality of parboiled paddy is comparitively low. Pressure parboiling includes washing the paddy and hot soaking followed by steaming under pressure to effect full gelatinization of starch.

In this study, a pressure parboiling system for paddy was designed and fabricated. The fabricated pressure parboiling setup consists of a pressure parboiling tank with steam distribution pipes, a steam generator and instrumentation for measuring pressure and temperature. The paddy was loaded into the pressure parboiling tank and washed with potable water. It was then soaked in hot water at different soaking temperatures, maintained by passing steam into the tank for different soaking periods. The paddy was then steamed using steam generated in the steam generator, for different parboiling pressures. For each treatment, the parboiling time as indicated by the splitting of the husk was recorded. Studies on pressure parboiling was conducted for the local variety Jyothi, procured from college farm. The same variety of paddy parboiled by traditional methods by soaking in cold water for 24 hr and open heating the soaked paddy on a gas stove till parboiling is complete was taken as the control. Moisture content of the parboiled paddy under different treatments were also determined. Pressure parboiled paddy was then dried in a laboratory tray drier to a moisture content of 12 - 14 %(wb).

From the different treatment studies it was concluded that a soaking temperature of 70 °C for a soaking period of 30 min at a parboiling pressure of 1 kg/cm^2 gave minimum parboiling time of 30 min. Besides, this treatment also resulted in parboiled paddy with low moisture content compared to other treatments. Whereas the traditional parboiling process (control) required a parboiling time of 75 minutes with a high moisture content of 48% (wb). As the moisture content of the pressure parboiled paddy is less, only less energy is required for subsequent drying of paddy per tonne of product. Therefore, pressure parboiling at 70 °C soaking temperature and 30 min soaking time at a parboiling pressure of 1 kg/cm^2 saves considerable amount of energy per tonne of paddy parboiled.

In order to assess the milling and cooking quality of pressure parboiled paddy, dried paddy samples under selected treatments choosen based on the results of treatment studies were milled in a rubber roll sheller and the brown rice so obtained were subjected to determination of physical characteristics such as dimensions, 1000 kernal weight and bulk density. Evaluation of milling quality by determining percentage broken and evaluation of cooking quality by determining the time for cooking to average softness were also carried out. It was found from the analysis that a minimum percentage broken of 1.78 % was found for pressure parboiled paddy which was soaked at a temperature of 70 °C for 30 min and pressure parboiled at 1 kg/cm^2 pressure, when compared to other treatments. Also the percentage brokens were high of the order of 7% for traditionally parboiled paddy. The cooking time for pressure parboiled paddy under optimum treatment conditions as explained above was only 10 min more than traditionally parboiled paddy.

From the results of the study on pressure parboiling, it may be concluded that pressure parboiling with a soaking temperature of 70 °C and soaking time of 30 min with a parboiling pressure of 1 kg/cm^2 during steaming may be considered optimum for Jyothi variety of paddy.

Suggestions:-

1. In this study a parboiling pressure of upto 1 kg/cm^2 only could be used. The effect of parboiling pressure above 1kg/cm^2 also need to be studied.

2. Factors such as geletinization, nutritive and organoleptic qualities of pressure parboiled rice also need to be studied.

3. The cost economics of the process also need to be worked out.

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ABSTRACT

STUDIES ON PRESSURE PARBOILING OF PADDY

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ABSTRACT OF THE

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ABSTRACT

A pressure parboiling system for paddy was designed and fabricated which consists of a pressure parboiling tank with steam distribution pipes, a steam generator and instrumentation for measuring pressure and temperature. Studies on pressure parboiling was conducted for local variety Jyothi, using the fabricated setup. Paddy was treated under different soaking temperature for different soaking periods with different parboiling pressures and parboiling time and moisture content of the parboiled paddy were found. The milling quality, cooking quality and physical characteristics of the pressure parboiled paddy under selected treatments were also found and the results were compared with the traditional parboiling process. It was concluded from the studies that pressure parboiling at a soaking temperature of 70°C for a soaking period of 30 minutes with a parboiling pressure of 1 kg/cm^2 may be considered optimum for Jyothi variety of paddy.