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Quality Standard Improvement of Traditional Paddy Parboiling Process in Northern Sri Lanka

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ABSTRACT

Parboiled rice (Brown-rice) exhibits several advantages over raw rice (Red-rice), such as, increased milling recovery, strengthening kernel integrity by forming resistant starch with preventing the loss of nutrients during cooking and improve the Glycemic Index. In this study to investigates the three key stages of parboiling process as soaking, steaming, and drying at small scale for the improvements by the different hydrothermal treatment combinations such as duration of soaking in days, and methods of steaming as closed steaming as Pressurized-Soaking Steam (PSS), semi open as Un-soaked Steam (USS) and Soak Steam (SS) as open steaming. rice quality standard through milling yield and cooking quality standards, which refer as Head Rice Yield (HR) during milling and resistance starch formation (RS) after cooking. Paddy varieties, of Ambalanthota rice (At 362), Bathalagoda rice (Bg 366) and one traditional rice variety "Adakari" were selected. Closed streaming (PSS) for 30 minutes of steaming duration and 2 days of soaking duration (48 hrs.) was recorded higher milling recovery as highest head rice yield (80 ± 5%) in milling analysis. Traditional steaming methods semi-open and open (USS and SS) achieved moderate levels of head rice yield 70 ± 5% at same soaking level in all three varieties. There was a significant different between soaking duration and steaming methods at ($p < .005$) level and there was no significant difference in between variety ($p = 0.759$). Raw paddy (Non soaked and non-steam) as control. Texture investigation of further improvement in parboiled rice cooked, which was performed by texture analyzer. Radiational rice variety (Adakari) performed better in the formation of resistant starch under the closed steam (PSS) processing condition which was yield a higher texture compression as 10-12 Newton force than other improved paddy varieties tested. Non-parboiled sample (control) was yielding a lower level of head rice 60 ± 5% and low texture analyser compression 6-7 Newton force in all three varieties. Therefore, practice of closed steaming method (PSS) in parboiling was performed better quality standard parboiled rice with good texture after cooking, which improve the quality standard traditional parboiling processes in northern Sri Lanka.

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Introduction

Rice (*Oryza sativa* L.) is one of the world's most important food crops, second only to wheat in terms of annual production for human consumption. It is the primary source of nutrition for more than half of the world's population. The parboiling method accounts for a significant portion of the global rice processing industry. Before milling, paddy undergoes a hydrothermal treatment known as parboiling. The requisite hardness is imparted to the grain when paddy is parboiled properly. Different parboiling techniques have traditionally been followed and scientifically developed for the preparation of parboiled rice [1]. Parboiling results in higher milling recovery, more transparent kernels, and increased swelling, when cooked to the perfect softness [2]. Is the most common way to complete the three stages of parboiling soaking, steaming, and drying. Soaking paddy in cold water for 24–72 hours, until the kernels are saturated, to obtain 80 percent gelatinized starch, the soaked paddy is boiled or steamed for 20-30 minutes at 100°C. Finally, during sun-drying the boiled paddy is dried to a moisture content of 14 percent in wet basis. The amylose, resistant starch (RS) and their relative changes with total starch (TS) in different varieties of rice from Northern Sri Lanka with the different traditional cooking methods were determined [3].

Objective of the Study

- To investigate the quality standard improvements on head rice yield and resistant starch formation by the soaking duration and steaming methods of selected traditional and improved paddy varieties.

Materials and Method

Location

Improved Paddy samples were collected from Paranthan seed farm (Government) and traditional paddy variety in the region of Kilinochchi farm (Private) commonly cultivated varieties in Kilinochchi district. Research work was carried at the Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna, Sri Lanka. Milling and further aanalysis of texture-by-texture extrusion after cooking, which were carried out at the laboratory of Pot-Harvest Technology division for Both raw (Non-Parboiled) and parboiled rice.

Materials

Two improved Srilankan rice varieties Ambalanthota red rice (At 362), Bathalagoda white rice (Bg 366) and one traditional rice variety "Addakari" with red pericarp were used in this study. Parboiling process was initiated with the raw paddy samples were soaked in water at room temperature (30°C) with the intervals of 1-3 days and then steaming was practiced in three different ways, closed steam as Pressurized Soak Steam (PSS), semi-open as -Un-soaked Steam (USS) and Soak Steam (SS) as open, which practices was in an electric steam cooker (Panasonic SR-MP 300K). The steamed paddy was dried in an electric conventional oven (Memmert UN-110) at 60˚C for 3-4 hours for the safe milling analysis [4]. A texture analyzer to test the internal strength of the rice kernel after cooking performed the hardness texture analysis. Parboiled rice was cooked with excess water with duration of 30 minutes in electric rice cooker (SR-UH 36 P-W). Hardness analysis was done at 30˚C, with a 10mm dick displacement and the speed of 30 m/s [5].

Physical Properties of Paddy Variety Tested

The measurements were taken in triplicate. Length (L), thickness (T) and width (W) of the milled rice kernels were measured using a micrometer. Size and shape were classified according to the method described by Cruz and Kush [6].

Table 1: Physical Properties of Selected Paddy Variety Tested

Variety Characteristics	Attakari	BG 366	At 362
1000 grain weight (g)	25.4 ± 0.3	24.8 ± 0.2	25.7 ± 0.5
Grain shape	Long Cylinder	Intermediate Bold	Long Medium
Raw milling recovery (%)	75.6 ± 0.4	73.4 ± 0.6	68.2 ± 0.3
Raw head rice yield (%)	70.2 ± 0.5	67.4 ± 0.3	55.6 ± 0.4

Parboiling Treatments

Experimental Setup

Parboiling was done in three important steps. Such as soaking (steeping), steaming, and drying. Three different steaming methods were implemented in this study. Paddy varieties of "At 362", "Bg 366", and "Adakari" were soaked in water at ambient temperature (30°C) for up to 72 hours (1-3 days). Paddy grains were then steamed in electric steamer (Panasonic SR-MP 300K) for 30-40 min until husk split off (5.0±0.5%).

Pressure-Soaked Steam Parboiling (PSS)

A 500g of paddy sample was put into the pressure steam cooker, and water was added 1.5 times higher than the paddy volume. Paddy grains were steamed under pressure at 1.5 psi (121°C) for 30-40 min until their hulls split by using the pressure steamer. After steaming, paddy was kept for tempering, then oven-dried for 3 hours at 60°C.

Un-Soaked Steam Parboiling (USS)

A 500g of paddy sample was placed on wire mesh of steamer, and water was added 1.5 times of paddy volume (v/v) into cooker, then wire mesh in steamer was kept above the water. After steaming for 30-40 min, paddy was kept for tempering, and then oven-dried for 3 hours at 60°C [7].

Soaked Steam Parboiling (SS)

A 500g of paddy sample was put into the steamer, and water was added 1.5 times higher than the paddy volume and started heating up to 30-40 min. After steaming, paddy was kept for tempering, then oven-dried for 3 hours at 60°C .

Analysis of Milling Yield and Head Rice Percentage

Milling Yield Determination

All the parboiled samples 500 grams were de-husked by using a Satake paddy husker at 100 r.p.m. (Satake Engineering Co.Ltd). Then all the de-husked samples were winnowed by electric conventional fan (1500W) to remove the husk and foreign materials. Then milled paddy was measured and separate the head rice. It was done by using a head rice separator (Satake Engineering Co.Ltd).

$$\text{Degree of milling (\%)} = \frac{weight\ of\ milled\ rice}{weight\ of\ raw\ paddy}\ \% \quad \text{----------Eq-01}$$

Head Rice Yield (HY) Percentage

Kernels that should be at least three-fourths of the original kernel length were considered as head rice (USDA, 2005). After separation head rice was weighed by using a weighing balance of analytical grade (Satake Engineering Co.Ltd). Milling yield determination was carried out by using the IRRI formula [1].

$$\text{Head rice (\%)} = \frac{weight\ of\ head\ rice}{weight\ of\ \text{milled}\ rice}\ \% \quad \text{----------Eq-02}$$

Analysis of Texture Quality

Rice Grain Hardness

The hardness of grain after parboiling without re-cooking was determined as the rice grain hardness. This analysis was performed by using Kiya Grain Hardness Tester Instrument. Ten grains of black rice sample were tested. The needle was set displacement to 10 mm. The grain was pressed by using tester spindle until it back. The needle would show the hardness value in N. This analysis was performed by using Kiya Grain Hardness Tester Instrument. The needle was set displacement to 10 mm. The cooked grain was pressed by using tester spindle until it back. The needle would show the hardness value in Newton (N). Rice kernels and water were placed in an automated electric rice cooker (Satake Engineering Co.Ltd) with proper rice-to-water weight ratio.

Results and Discussion

Figure 1, shows the relationship between steaming time (min) and the soaking duration (days) of three different methods of steaming in parboiling process, Steaming time decreases, when soaking duration goes up in all three paddy varieties in all steaming methods in parboiling process. Considerably closed steaming as Pressure-Soaked Steam Parboiling takes lesser time to other investigated steaming methods. Figure 2, shows the changes of moisture percentage with drying duration. Moisture percentage was decreasing with drying duration increased. Paddy kernels it takes 3 hours of time when it was under oven drying at 60˚C ttemperature for moisture percentage of kernels should be less than 12% for safe milling.

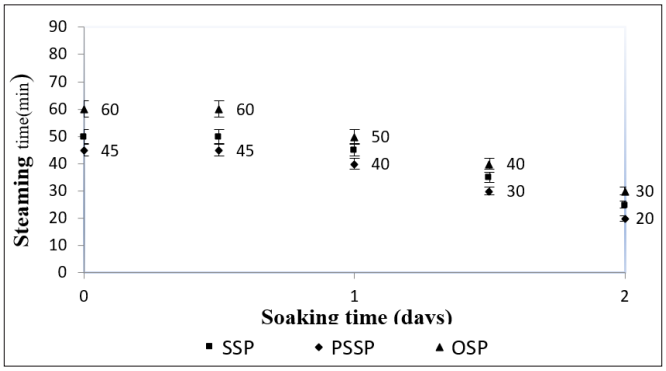

Figure 1: Steaming Duration (mints) with Soaking Duration in Days of Parboiling
SSP - Soaked Steam Parboiling, PSSP - Pressure-Soaked Steam Parboiling, OSP - Open steam Parboiling and Without steaming as Control

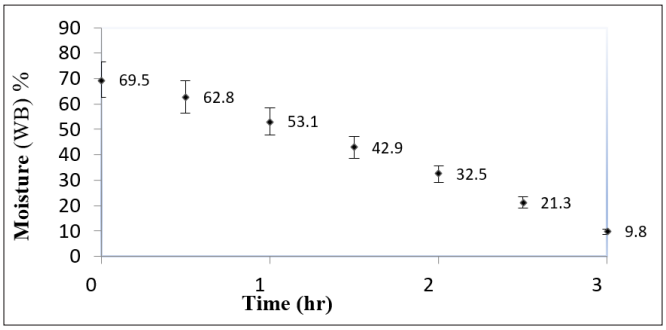

Figure 2: Drying Duration with Moisture Content (Wb) in hrs of Raw Paddy Variety in Parboiling

Milled Head Rice Yield

Milled head rice percentage increases with soaking duration increases in all three varieties in all steaming treatments investigated in parboiling process. According to the figures 3, 4 & 5 shows increment of soaking duration yield a higher milled head rice percentage than control (Raw Paddy).. How-ever rate of such increase in pressure-soaked steam parboiling is higher (90%) than other investigated steaming methods. All other tested steaming methods (USS & SS) achieved moderate head rice yield as (70±5) %. Non-parboiled samples (Raw rice) showed lower milling recovery yield (65 ±5%) than parboiled rice samples investigated

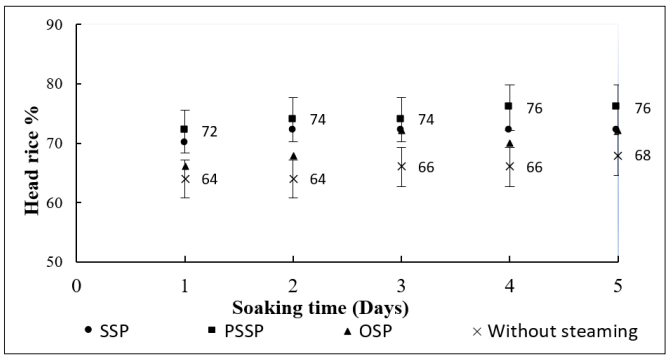

Figure 3: Effect of Parboiling Treatment on Yield of Head Rice % of Variety At 362
SSP - Soaked Steam Parboiling, PSSP - Pressure Soaked Steam Parboiling, OSP - Open Steam Parboiling and Without Steaming as Control.

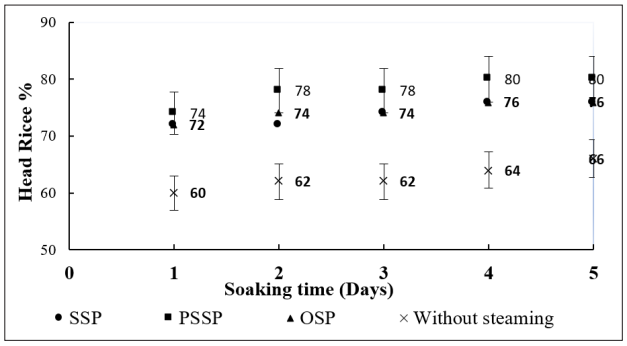

Figure 4: Effect of parboiling treatment on yield of Head rice % of variety Bg 366.
SSP - Soaked Steam Parboiling, PSSP - Pressure Soaked Steam Parboiling, OSP - Open steam Parboiling and Without steaming as control.

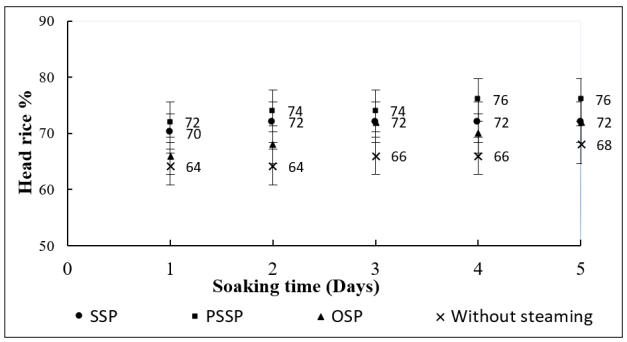

Figure 5: Effect of parboiling treatment on yield of Head rice % of variety Adakari.
SSP - Soaked Steam Parboiling, PSSP - Pressure Soaked Steam Parboiling, OSP - Open steam Parboiling and Without steaming as control.

Hardness Expressed in Terms of Texture Analyser (N)

The rice kernel had high resistant starch content after cooking texture analyser outcome (Newtan-N) outcome is high. Figure 6, 7 & 8 shows the relationship between texture analyser outcome (N) and the soaking time of three different paddy varieties in different steaming methods. Hardness of all three varieties increases with soaking duration in all steaming methods. Control (Non-steamed) sample shows a lower texture analyser outcome (N) than parboiled cooked rice samples and pressure-soaked steam (PSS) cooked rice sample shows a higher texture analyser outcome (10-12N) than other methods investigated. Pressure-soaked steam cooked samples show higher texture analyser outcome (N) therefore pressure-soaked steam parboiling method was performed better in terms of cooking quality as whole parboiled rice than other investigated treatments. Non-parboiled sample (control) was yielding a lower texture analyser outcome (6-7N) than parboiled rice samples tested.

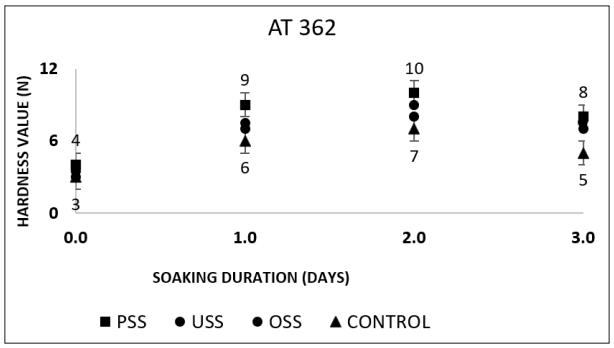

Figure 6: Effect of Parboiling Treatment on Yield of Texture Value (N) Variety At 362.

SSP - Soaked Steam Parboiling, PSSP - Pressure-Soaked Steam Parboiling OSP - Open Steam Parboiling and Without Steaming as Control.

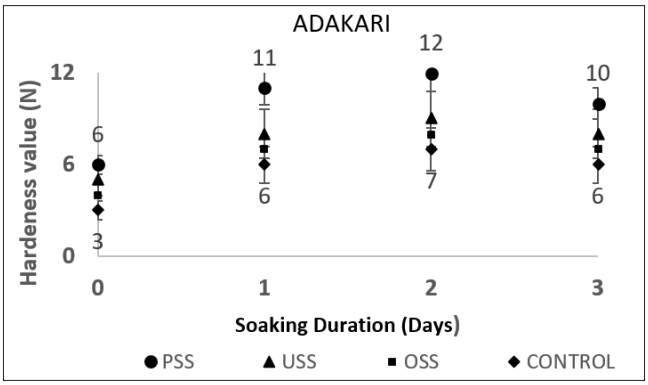

Figure 7: Effect of parboiling treatment on yield texture value (N) variety Adakari. SSP - Soaked Steam Parboiling, PSSP - Pressure-Soaked Steam Parboiling OSP - Open steam Parboiling and Without steaming as control.

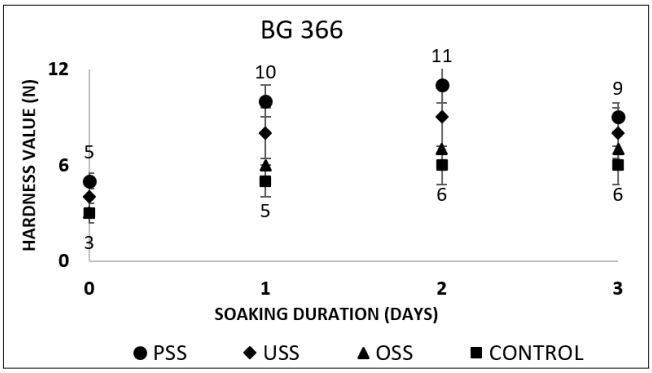

Figure 8: Effect of parboiling treatment on yield of texture value (N) variety Bg 366 SSP - Soaked Steam Parboiling, PSSP - Pressure-Soaked Steam Parboiling, OSP - Open steam Parboiling and Without steaming as control.

Statistical Analysis Anova -Two Factor with Replication

The particular rows are tested in the " soaking days "," Steaming methods" and " Interaction "and these are highlighted above table 3.3. These rows represent the independent variables and their interaction have a statistically significant effect on the dependent variable; you can see from the "Significant." column that have a statistically significant interaction at the $p < .0001$ level. From the table above that there was no statistically significant difference in between variety ($p = 0.759$), but there were statistically significant differences between steaming methods ($p < .005$)[7-12].

Table 3.3 Anova: Two-Factor With Replication

SUMMARY Total	Soaking days	PSS(high)	SSP (medium)	OSP (low)	CONTROL	Total
Count	9	9	9	9	9	
Sum	18	672	647	636	580	
Average	2	74.67	71.88	70.66	64.44	
Variance	0.75	7	1.61	8	2.78	
Source of Variation	SS	df	MS	F	P-value	F crit
Sample (Soaking)	43.2	2	21.6	6.39474	0.00486	3.31583
Columns (Steaming)	34205.68	4	8551.422	2531.67	1.8E-37	2.68963
Interaction	16.578	8	2.072	0.61349	0.75942	2.26616
Within	101.333	30	3.38			
Total	34366.8	44				

Conclusion

In milling analysis Closed streaming (PSS) for 30 minutes of steaming duration and 2 days of soaking duration (48 hrs.) was recorded higher milling recovery as highest head rice yield (80 ± 5%). Traditional steaming methods semi-open and open (USS and SS) achieved moderate levels of head rice yield 70 ± 5% at same soaking level in all three varieties . There was a significant different between soaking duration and steaming methods at ($p < .005$) level and there was no significant difference in between variety ($p = 0.759$).

Raw paddy (Non-soaked and non-steam) as control. Radiational rice variety (Adakari) performed better in the formation of resistant starch under the closed steam (PSS) processing condition, which was yield a higher compression Hardness as 10-12 Newton force than other improved paddy varieties tested. Non-parboiled sample (control) was yielding a lower level of head rice 60 ± 5% and low texture analyser compression Hardness as 6-7 Newton force. Practice of closed steaming method (PSS) in parboiling was performed better quality standard parboiled rice with good texture after cooking of traditional parboiling processes, which improve the Glycemic Index related issues in the future.

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