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Investigation of Physicochemical Changes of Rice and Soaking Water during Cooking

[1]S. Thupeeban and [2]N. Kannan

[1]Department of Farm Machinery Technology,
University College of Jaffna, University of Vocational Technology, Sri Lanka
[2]Department of Agricultural Engineering University of Jaffna, Sri Lanka

Abstract: Paddy rice industry plays a key role in Sri Lankan food industry. More than half of the world's population consume rice as stable food. There are various methods used to process paddy grain suitable for consumption. Cooking process leads to changes in grain properties and sensory attributes as well. Hence, an attempt was developed to investigate changes in physical properties of rice grains and soaking water during cooking. Long raw and parboiled, Short row and parboiled grains were prepared systematically to increase the accuracy of the experiment. Samples were taken for an experimentation. Samples were prepared systematically to increase the accuracy of the experiment. Samples were taken and prepared uniformly for cooking trails. Standard sampling was done for both rice and soaking water .Moisture content, elongation ratio & increase in breadth were conducted for rice grain. While Total Solids (TS), pH, Electrical Conductivity (EC), Chemical Oxygen Demand (COD) and Total Dissolved solids (TDS) were analysed for soaking water. Data were analysed using a statistical software SAS and measurement separated by DMRT. Result that an increase in temperature during cooking has increased grain moisture content has caused an increase in TDS, TS, and EC & COD values of soaking water during cooking. However, these changes are different for different treatments. moisture content and temperature, EC and temperature, TDS and temperature, COD and temperature, TS and temperature, LBR and temperature, pH and temperature, kernel Elongation and temperature, breadth and temperature are positively correlated according to R^2 values obtained. It can therefore be concluded that cooking leaches to various changes in rice grains and soaking water. However, leaching rate during cooking are to be minimized to avoid unwanted losses in order to keep COD of soaking water reactions.

Key words: Physicochemical Changes of Rice

INTRODUCTION

Paddy-rice industry has been playing a dominant role in Sri Lanka to meet food requirements of people. Different paddy verities are grown in Sri Lanka to reach self-sufficiency in rice production. However, much energy is to be invested in this sector to have desired production targets. Paddy production during *Yala* season in Sri Lanka in 2015 is 1,942,408 MT with the major contribution given by Ampara province [1]. There are two methods available to process paddy grain, row rice processing and parboiling. People in Sri Lanka consume rice daily and it is the stable food [2]. An-average annual per capita rice consumption is 101.13 kg/year [2]. which 70% is consume in parboiled form. Cooking rice leads to various physical and chemical changes occurs [3]. Parboiling is a hydrothermal treatment to increase head rice percentage in total milled rice [4]. It includes three steps soaking, steaming and drying. Soaking is to increase paddy moisture content from 14% (Wet basis) to 30% (Wet basis) while streaming is to seal all cracks and cleavages in grain by starch gelatinization, which yields high head rice percentage. This practice significantly influences. Cooking time & cooked rice nutritional profile. Rice grain contains 90% carbohydrate, 8% protein, 2% fat [5].Some soluble nutrients come out into water in cooking temperature. Cooking raw rice is easier than parboiled rice because raw rice is less hard than its parboiled form. Some researchers suggest that cooked parboiled rice is good for those who suffer from type 2 diabetes as of its low glycaemic index value compared to raw rice. Physical properties such as length, breadth & LBR do have an

Corresponding Author: Thupeeban S., Department of Farm Machinery Technology, University College of Jaffna, University of Vocational Technology, Sri Lanka.

impact on leaching rates during cooking [6]. Leaching rate in cooking is therefore to be kept minimum in order to avoid unwanted nutrient losses during such activity .Increase in temperature during cooking induces some chemical reaction which can also change availability nutrients [7] .In addition to this, addition of water and its quality have also considerable influence on cooking time and cooked rice profile. Hence, studying about changes in rice & soaking water are essential to minimize losses. Rice is the stable food in Sri Lanka [8]. There are various forms available for consumption. Rice is produced from different varieties. Physical properties have impact on sensory characteristics of cooked rice [9]. It is clear that physical properties of rice grains, processing method and working conditions do influence nutritional value of rice being consumed by people [10]. It is reported that Parboiled rice is good for health [11]. But it takes long time for cooking, which is energy intensive. Hence, an attempt is taken to investigate changes in physical properties of different rice grains taken from for two different processing conditions, raw rice processing and parboiling with an intention of minimizing leaching hours in a condition where soaking water is taken out at the end of cooking. In addition to this, the impact of physical properties and processing methods on cooked rice properly and strength of soaking water influence of COD could also justify. The aim of the present work to investigate changes in physical & chemical properties of rice during cooking, evaluate changes in grain and soaking water.

MATERIALS AND METHODS

Experimental Site: The experiment was planned at Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna, Ariviyalnakar, Kilinochchi. Sample preparation and analysis were done in the laboratory of Department of Agricultural Engineering.

Sample Selection and Preparation: At 303 (Long grain) and At 308 (Short grain) varieties were selected. The paddy (Cultivar At303 and At 308) used in this study was harvested in December 2015 at the experimental farm of the Paranthan research Institute, Kilinochchi. It was packed in polypropylene bags and stored in an air tight store-room for about 3 months. The paddy samples were taken out, cleaned thoroughly and defective grains were removed. Only sound grains were used for the experiment.

Raw Rice Preparation: The paddy samples were de-husked and milled to remove 8% bran.

Parboiled Rice Preparation: Both varieties were taken to soak inside the water for 48 hours. After that steaming was done until 80% of grains were spilt open. Finally Sun drying was done to reach moisture content 14% (dry basis). The paddy samples were de-husked and milled to remove 8% bran.

Head Rice Percentage: Rice samples were taken and weighed whole rice and total paddy weight, through this equation head rice % was found out [13]. Measurements were taken three times for a sample lot in order to increase the accuracy [14].

Head rice percentage was expressed as follows,

$$\text{Head rice \%} = \frac{\text{Weight of Whole rice grains}}{\text{Total paddy Weight}} \times 100\%$$

Broken Rice Percentage: Rice samples were taken and weighed whole rice and total paddy weight, through this equation broken rice % was found out [15]. Measurements were taken three times for a sample lot in order to increase the sensitivity [14].

Head rice percentage was expressed as follows,

$$\text{Broken rice\%} = \frac{\text{Weight of Broken grains}}{\text{Total paddy Weight}} \times 100\%$$

White Belly Grains Percentage: Parboiled Rice samples were taken and weighed whole rice and total paddy weight through this equation broken rice % was found out. Measurements were taken three times for a sample requirements directly with ease, speed and reliability [13].

White belly grains percentage was expressed as follows,

$$\text{White belly grains \%} = \frac{\text{Weight of White belly grains}}{\text{Total Weight of Parboiled milled rice}}$$

Whiteness: The whiteness value was measured by whiteness tester. The meter was calibrated to 80.0 using ceramic plate before placing samples. Rice sample were taken and put in to whiteness tester to have whiteness values. Measurements were taken three times for a sample lot in order to increase the accuracy [13].

Measurement of Parameter in Effluent Sample

TDS: TDS of soaking water was measured by HQD Potable meter (HQ40d, USA). Measurements were taken three times for a sample lot in order to increase the accuracy [13].

TS: Total solid concentration in soaking water was measured by standard oven dry method [16].

COD: COD of soaking water was measured by calorimeter Measurements were taken three times for a sample lot in order to increase the accuracy. Chemical oxygen demand is the amount of oxygen consumed during the chemical oxidation of organic matter using a strong oxidizing agents like acidified potassium dichromate [17].

Procedure: Soaking water samples were taken and diluted.2ml diluted sample was taken and mixed with Hach solution and put inside the digester for 148°C,2 hours. That digested sample was cooled down and measured COD by Calorimeter. Finally COD was calculated each sample with dilution factor [18] pH value pH of the residual cooking water was determined using a digital pH meter at room temperature (30°C) effluent in every 20°C temperature increase sample was taken and cooled in room temperature and pH was measured by PH meter [19].

Measurement of Rice sample

Kernel Length and Breadth: Kernel was taken in 3 places in rice cooker. (Top, bottom & middle portion) during cooking each temperature increase as earlier said. After that in each sample kernel length and breadth was measured by vernier scale [20].

Cooked Length–breadth Ratio: This was determined by dividing the cumulative length of 10 cooked kernels by the breadth of 10 cooked kernels. A mean of 10 replications was reported [13].

Moisture Content (Dry Basis): Standard oven dry method was used for the measurement of moisture content. A moisture can in its inverted lid was placed in thermostatically controlled oven at 130° C for about 30 minutes [22] Moisture can and lid were transferred to a desiccator, cooled and weighed. Rice samples were weighed by using an electronic balance. Then sample was placed in an oven at 105°C and dried for 24 hours. After drying the lid was replaced on the can, and was transferred to a desiccator and can was weighed immediately after cooling. This procedure was repeated 3 times for each sample [24].

$$\text{Moisture content (dry Basis)} = \frac{\text{Initial weight-Oven Dry Weight}}{\text{Oven Dry Weight}}$$

Elongation Ratio: Cumulative length of 10 cooked rice kernels was divided by length of 10 un- cooked raw kernels and the result was reported as elongation ratio. Length and width of milled grains were measured on 10 unbroken milled grains by ruler [24].

Cooking Trails: Cooking Trails were planned properly to analyse changes in chemical [25] and physical properties [26] of rice grains and soaking water during cooking.

Amount of Sample: 400g rice sample with 1000g distilled water were taken for each treatment.

Energy Source: Rice cooker was used for energy source [27].

Cooking Time: Cooking time was measured by stopwatch at different interval.

Experimental Setup:

- T1 (At 303 long grain red rice –raw rice at 8% bran remove.)
- T2 (At 303 long grain red rice –Parboiled rice at 8% bran remove)
- T3 (At 308 short grain white rice –raw rice at 8% bran remove)
- T4 (At 308 short grain white rice –parboiled rice at 8% bran remove).

Each treatment has 3 replicates.

Statistical Analysis: Analysis of variance for different parameter was performed using DMRT [28].

RESULTS AND DISCUSSION

In this Research Work Two Variety of Rice Raw and Parboiled Form for this Each Treatments.

Table 1 shows that rice parameters of each treatment. Water absorption by cooked rice Water absorption by cooked grains increased in all the rice varieties studied [12]. This agrees with experiments on rice varieties in which increase of water uptake when increasing temperature. Water absorption by polished cooked rice grains was larger than that by brown rice grains (Table 2). Higher cooking temperatures increased the water absorption by cooked rice grains. The long-grain rice variety absorbed more water than other varieties.

Table 1: Rice parameters

	(T1)	(T2)	(T3)	(T4)
Head rice %	33.5±0.12	43.8±0.02	48.8±0.01	61.3±0.02
broken rice %	20.5±0.01	16.8±0.01	61.3±0.21	8±0.02
Whiteness	18±0.10	14±1.10	27.9±0.10	20.7±0.10
Length– breadth ratio (L/B)	20.7±0.02	3.2±0.03	1.623±0.02	1.70±0.03
Bulk density	0.855±0.01	0.81±0.01	0.86±0.02	0.85±0.02

Table 2: Statistical output of grain parameters

Grain Parameters		Treatments T1	T2	T3	T4
Moisture content (dry Basis)	30°C	33.6750±0.345^{d}	42.9700±0.000^{c}	57.3850±1.075^{a}	48.740±1.69^{b}
	70°C	93.335±3.335^{a}	95.695±4.305^{a}	71.380± 0.27^{b}	93.360±3.48^{a}
	97°C	122.500±2.5^{b}	127.0±5^{b}	127.515± 0.945^{b}	137.57±3.73^{a}
Kernel Breadth	97°C	2.750±0.05^{b}	2.70000±0.025^{b}	3.00000±0.05^{a}	3.00±0.05 ^{a}
Elongation Ratio	70°C	0.044± 0.0015^{b}	0.045 ± 0.0029^{b}	0.023 ± 0.002^{c}	0.077±0.0032^{a}
	97°C	0.186 ± 0.0002^{b}	0.143±0.0001^{d}	0.1595±0.0006^{c}	0.261±0.0003^{a}

Table 3: Statistical outcome of soaking water parameters

Soaking water Parameters With different temperature		Treatments T1	T2	T3	T4
TS (g/ml)	30°c	0.0560 ±0.004^{a}	0.0010±0.0007^{b}	0.0020±0.00035^{b}	0.0020± .001^{b}
	70°C	0.1910±0.006^{a}	0.0250±0.0014^{c}	0.0640± 0.0021^{b}	.0210± 0.0014^{c}
	97°C	0.3270±0.007^{a}	0.0670±0.0014^{c}	0.1180± 0.0218^{b}	0.0490±0.0028^{d}
pH	30°C	5.690±0.028^{b}	5.600±0.07^{c}	5.470± 0.07 ^{d}	6.505± 0.007 ^{a}
	70°C	5.615±0.021 ^{a}	5.545± 0.049^{b}	5.395±0.007 ^{c}	5.565±0.007 ^{d}
	97°C	5.5950 ±0.007^{a}	5.3700± 0.014 ^{c}	5.2350± 0.021 ^{d}	5.430±0.014 ^{b}
COD (mg/L)	30°C	7676.67 ± 50^{a}	4758.33± 111^{b}	4758.33± 12 ^{c}	3005 ± 125^{d}
	70°C	11529.17±75^{b}	8633.3±149 ^{d}	16710.00±515^{a}	9540.00 ±156 ^{c}
	97°C	48072.67±1900^{a}	26050 ±310^{c}	29719.33±779^{b}	17050± 388^{d}
TDS (mg/L)	30°C	33.300± 0.7^{b}	36.800± 0.7^{b}	128.000± 0.7 ^{a}	34.35±5.02^{b}
	70°C	113.70 ± 0.7^{b}	80.00 ±0.7 ^{c}	140.40± 2.12 ^{b}	159.95± 4.03 ^{a}
	97 °C	162.30± 0.7^{b}	179.70 ±1.41 ^{b}	173.60 ± 0.7^{b}	235.55 ± 4.87^{a}
EC (S/L)	30°C	67.15±0.0035^{c}	88.20± 0.28^{b}	267.40± 0.42^{a}	64.75± 0.7^{d}
	70°C	239.27± 0.31^{b}	231.85± 0.07^{c}	290.17± 0.028^{a}	211.25± 7.42^{d}
	97°C	338.10± 0.14^{d}	412.15± 0.21^{a}	353.57 ± 0.106^{c}	406.00± 2.82^{b}

Table 2 shows statistical output of grain parameters obtained after analysis for different treatments were developed. Grain parameter such as moisture content breadth of kernel and elongation ratio has been considered in this analysis. Values indicated by same letter are not significantly different while the values marked with different letters are significantly different at ◎ = 0.05 accuracy to Duncan's grouping.

Table 3 represents statistical outcome of soaking water parameters considered for analysis. Parameters such as TS, PH, COD, TDS and EC were taken for this interpretation. Their changes with an increase in temperature during cooking are displayed with numerical values with cross ponding standard deviation. Values indicated by same letters are not significant at ◎ = 0.05 whereas values indicated by different letters are significant at ◎ = 0.05.

CONCLUSIONS

There are many changes to happen in rice grain & soaking water during cooking as of the increase in temperature. Grain moisture content, elongation ratio & breadth value increase with increasing temperature. Furthermore, as temperature goes up chemical reactions are induced that lead to higher TS, TD, EC & COD values of soaking water. However, rice grain morphology & processing method do have influence on grain properties and soaking water quality during cooking. Long grain give higher leaching rates than short grains because of larger surface area for leaching. Parboiling process reduces such leaching rate significantly. However, it takes long time for cooking.

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