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Effect of freezing and hot water soaking on the functional properties of rice flour derived from four Sri Lankan traditional rice varieties

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Abstract

Rice cultivation nowadays has become as major concern to Sri Lanka due to high dependency of chemical fertilizers. There is an interest to promote utilization of rice obtained from traditional rice varieties which are well adopted to Sri Lankan environmental conditions, such varieties are highly nutritious and less dependent on agrochemicals. Thus they are ideal candidates in promoting organic food products without chemical inputs. Rice flour is a good substitute for imported wheat flour in bakery industry. However due to lack of gluten protein, rice flour cannot be used directly in bakery products without any modifications. In this study rice grains derived from four traditional rice varieties namely *Madathuwalu*, *Kaluhenati*, *Pachaperumal* and *Ratdal* were subjected to freezing at -20ºC (24 hours and 48 hours), hot water soaking at 80ºC (5 minutes and 10 minutes) individually and in dual combinations. Untreated rice flour served as the control and experiments were conducted in triplicates. Water Absorption Index (WAI), Water Solubility (WS), Swelling Power (SP) and pH values were measured in both treated and untreated rice flour. Results showed that these physical treatments to the rice grains brings about a significant difference ($p< 0.05$) on the functional properties of rice flour both individual and in dual combinations. Strong correlation ($p=0.000$) was obtained between WAI and SP. Dual modification treatments were found to be highly effective in improving functional properties of all selected traditional rice varieties compared to the single modification. Freezing at -20ºC for 48 hours was more effective than the 24 hours freezing to improve the functional properties. Therefore, this study proves that simple physical treatment methods such as freezing and hot water soaking could bring about a significant effect on the functional properties of traditional rice flour.

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Keywords: Traditional rice; freezing; hot water soaking; funtional properties

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1.0 Introduction

Rice (*Oryza sativa*) provides the main staple food for Sri Lankans as well as for three billion people worldwide. Sri Lanka has dedicated 0.77 million/ha for rice cultivation yet there is a growing deficit between rice production and consumption. Rice varieties cultivated in Sri Lanka are mainly improved commercial varieties and the percentage of cultivation of traditional rice varieties is significantly less. Traditional varieties, though average in yield, are best adapted to Sri Lankan conditions and are resistant to diseases and pests, highly nutritious and less depended on chemical fertilizers. The traditional rice varieties have been found to contain higher amounts of glutamic acid, vitamins, fiber and give a lower glycemic index compared to the commercially available rice varieties[1]. This makes traditional rice varieties better candidates for organic type of farming at the same time a possible alternative to substitute wheat flour in the bakery industry. Use of rice flour in the bakery industry would lessen Sri Lanka's dependency on imported wheat flour and it also provides a solution for those consumers who are sensitive to gluten proteins. However, limitations could be identified for rice flour when used in the bakery industry due to the lack of gluten which is an essential requirement to maintain the quality of the baked products[2]. Rice flour can be modified using chemical, physical and enzymatic methods[3]. However, this study used only physical modification methods since it is very cheap and convenient method compare to chemical and enzymatic methods. Further, consumers are reluctant to buy chemically and enzymatically modified products due to their health concerns. It has been shown that application of simple physical treatment methods such as, heat and cold water soaking of rice kernels could improve functional properties of rice which in turn gives the desired body and texture to the products made out of flour from the treated kernels[3]. The main objective of this study was to investigate the changes in functional properties of rice flour derived from four Sri Lankan traditional rice varieties after the application of single and dual physical treatment methods for the fortification of bakery products.

2.0 Methodology

Four Sri Lankan traditional rice varieties namely, *Madathawalu* (G1), *Kaluhenati* (G2), *Pachchaperumal* (G3) and *Rathadal* (G4) were selected based on the nutritional status and the availability. All these selected rice varieties were rich in proteins and antioxidants[4]. Seed samples were collected from Rural Network Farmers Organization and the identification and certification of varieties were done by the Rice Research Institute at Bathalegoda, Sri Lanka. Rice kernels polished to 100% were obtained separately for all four varieties by removing the bran by dry milling process. The milled samples were aspirated in an aspirator for 30-60 seconds to clean the rice by removing any loose bran remaining on the surface of the kernels. Two different physical treatment methods, freezing at -20^{o} C and hot water soaking at 80^{o} C were applied to rice kernels individually and in combination for various time intervals. Eight treatments methods applied to rice kernel were as follows:

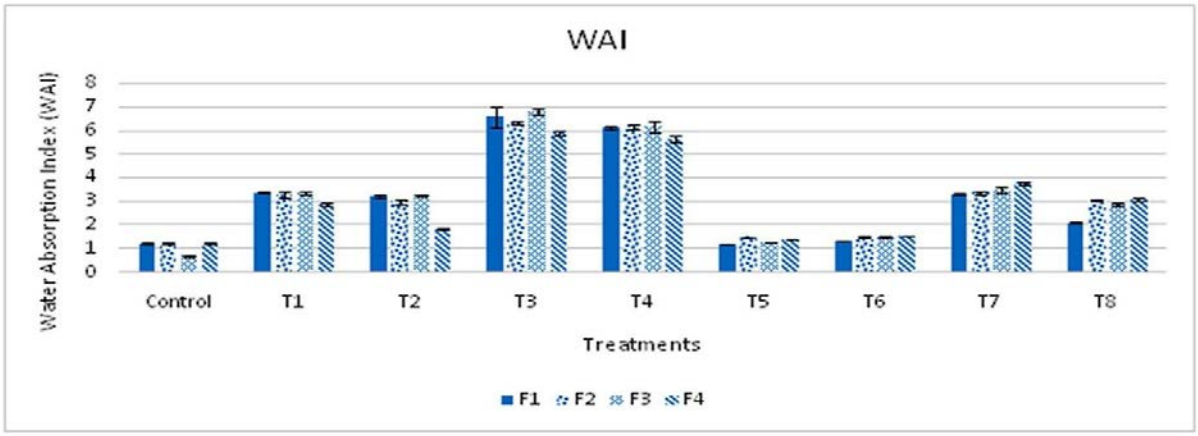
Dual modification treatments
T1 – Freezing at -20^{o} C for 24 hours followed by hot water soaking at 80^{o} C for 5 minutes
T2 - Freezing at -20^{o} C for 24 hours followed by hot water soaking at 80^{o} C for 10 minutes
T3 - Freezing at -20^{o} C for 48 hours followed by hot water soaking at 80^{o} C for 5 minutes
T4 - Freezing at -20^{o} C for 48 hours followed by hot water soaking at 80^{o} C for 10 minutes
Single modification treatments
T5 - Freezing at -20^{o} C for 24 hours
T6 - Freezing at -20^{o} C for 48 hours
T7- Hot water soaking at 80^{o} C for 5 minutes
T8- Hot water soaking at 80^{o} C for 10 minutes

Flour obtained from untreated rice kernels of all four varieties, *Madathuwalu* (F1), *Kaluhenati* (F2), *Pachaperumal* (F3) and *Ratdal* (F4) served as the control. Flour obtained from treated rice grains were ground and flour was analyzed separately for different functional properties such as water solubility (WS), swelling power (SP), water absorption index (WAI), and pH according to the standard methods respectively[5]. Experiments were conducted in triplicates and data obtained were analyzed using Minitab 16.0 software package. One-Way Analysis of Variance (ANOVA) and Tukey Simultaneous Test were performed at $p < 0.05$ level of significance to compare the individual and combined treatment effects for changes in functional properties of flour.

3.0 Results and Discussion

All eight treatments applied to rice kernels resulted in a higher WAI in flour of all four varieties tested when compared to controls Fig. 1. (a). Dual modification treatments had a significantly a higher impact ($p < 0.05$) to increase WAI of rice flour over single treatments. Out of the four dual modifications tested, T3 and T4 treatments showed significantly higher WAI values. WAI value more than six was obtained for F1, F2 and F3 flour types after T3 and T4 treatments. The highest WAI was recorded for variety F3 when treatment T3 was applied. WAI is an important functional characteristic in the development of a ready-to-eat food from cereal grains. A higher WAI may assure product cohesiveness where modified flour can form a more viscous or thicker batter[6].

a



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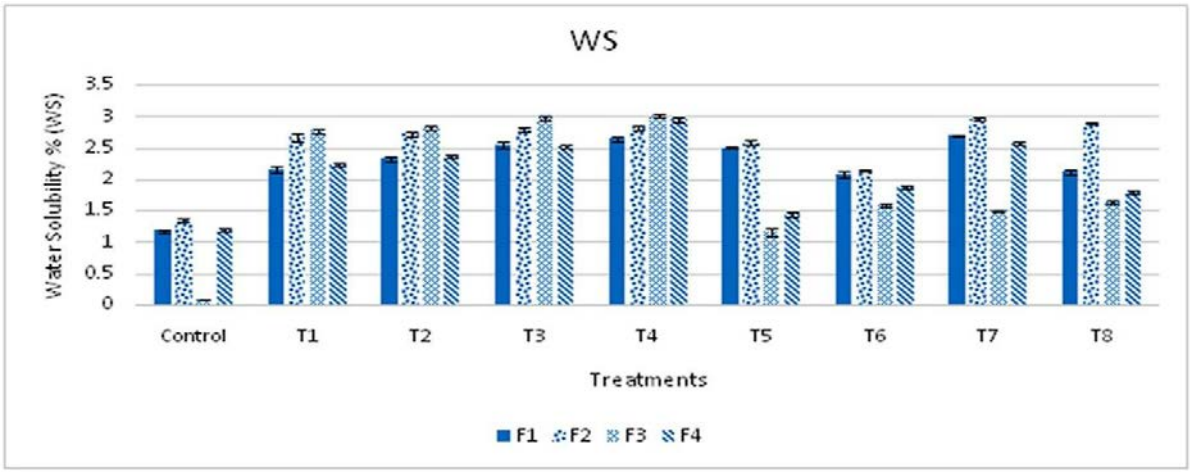

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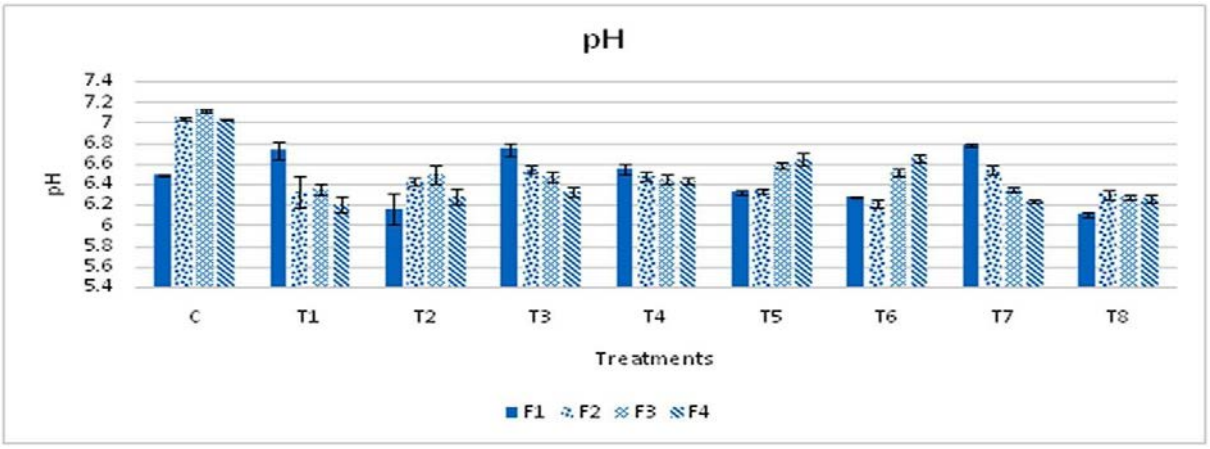

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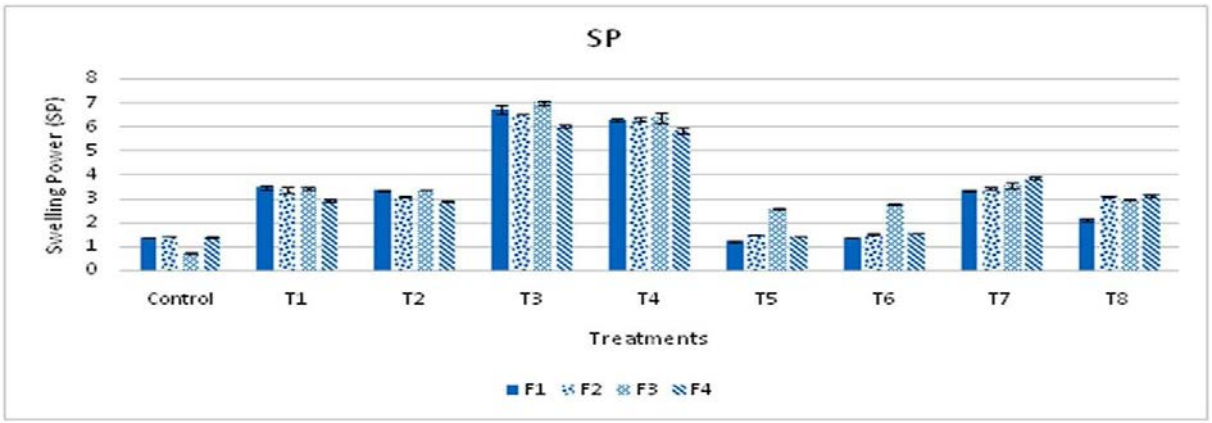

Fig. 1. Functional properties of rice flour modified after different treatments. Fig. 1. (a) Water Absorption Index (WAI) of modified rice flour for different treatments; Fig. 1. (b) Water Solubility (WS) of modified rice flour for different treatments; Fig. 1. (c) pH of modified rice flour for different treatments; Fig. 1. (d) Swelling Power (SP) of modified rice flour for different treatments. Treatments: T1: -20º C Freezing 24 hours followed by 5 minutes hot water soaking at 80º C, T2 : -20º C Freezing 24 hours followed by 10 minutes hot water soaking at 80º C, T3: -20º C Freezing 48 hours followed by 5 minutes hot water soaking at 80º C, T4: -20º C Freezing 48 hours followed by 10 minutes hot water soaking at 80º C, T5: -20º C 24 hours freezing, T6: 5 minutes hot water soaking at 80ºC, T7: -20º C 48 hours freezing, T8: 10 minutes hot water soaking 80ºC Flour types:F1- *Madatuwalu*, F2- *Kaluhenati* , F3- *Pachaperumal*, F4-*Ratdal*

A significant increment in water solubility (WS) was observed with flour of treated rice kernels of all four varieties when compared to the controls Fig. 1. (b). Dual modification treatments had a significantly higher impact over single modification treatments to increase WS. The highest WS was obtained with F3 flour type after T4 treatment. It has been reported that WS is closely associated with amylose content of rice kernels[7]. Increased WS observed with flour of treated rice kernels of this study may be due to leaching of amylose of rice kernels after freezing at -20º C or hot water soaking at 80º C. After all eight treatments applied on rice kernels, pH value of flour of all four varieties ranged in between 6-7 Fig. 1. (c) Which is the desirable range in fabrication of food products[7].

According to Fig. 1(d), the SP of the modified flour increased significantly ($P<0.05$) compared to the controls. SP had a strong correlation with the WAI ($r =0.985$, $p=0.000$). Dual modified flour types have shown high SP values compared to the single modification treatments. T3 and T4 dual modification treatments were shown to have the highest impact on increasing SP of all four flour types compared to other treatments. The highest SP was obtained with F3 flour type after T3 treatment that also resulted in a higher WAI with the same variety. SP is also related to the water absorption index of the starch-based flour during heating. The SP is an indication of presence of amylase which influences the quantity of amylose and amylopectin present in the flour[2]. Therefore, the variation in the swelling power indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water. The results of this study have been supported by the previous studies on enhancing the functional properties such as WAI, WS and SP in various cereal flours by different types of physical treatment methods[2 5].

4.0 Conclusion

The results of this study indicated that the functional properties such as Water Absorption Index, Water Solubility and Swelling Power of rice flour could be enhanced by application of simple physical treatments. The treatments applied in this study, freezing at -20º C or hot water soaking at 80º C, had a significant effect on improving the functional properties of rice four of all four traditional rice varieties tested. Dual modification treatments were shown to have a significant impact in improving the functional properties compared to the single modification treatments. Among the single modification treatments, T7 (48 hours freezing) and T8 (10 min hot water soaking) resulted in higher Water Absorption Index and Swelling Power values for all four rice varieties. Dual treatments T3 (48 hours freezing and 5 min hot water soaking) and T4 (48 hours freezing and 10 min hot water soaking) resulted in higher WAI, WS and SP values for all selected rice varieties than the other two dual treatments methods. Therefore, 48 hours freezing was more effective when compared to 24 hours freezing to enhance the functional properties of rice flour. This study indicates that the functional properties of rice flour can be enhanced by physical treatment methods and it could be made suitable to replace wheat flour in the bakery industry, further improving its physio chemical properties.

5.0 References

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