Functional and Cooking Properties of Pasta Fortified with Jackfruit Seed Flour

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The aim of this study is to develop a functional pasta by partial substitution of refined wheat flour with corn flour and jackfruit seed flour. The impact of replacing refined wheat flour with jackfruit seed flour on the functional properties of pasta was examined. RWF: CF: JFSF were supplemented

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in the ratio of 80:10:10 and 70:10:20. Cooking characteristics such as optimum cooking time, cooking loss, swelling index and functional properties such as water solubility index, water absorption capacity, bulk density was observed and compared with control. Addition of jackfruit seed flour to the sample significantly changed the functional characteristics of the pasta. An increase in JFSF quantity from control to T_2 resulted in a reduction in optimum cooking time from 7.16 to 5.11 min and cooking loss from 9.25 to 5.68%. The swelling index, water solubility index and water absorption capacity were increased from 2.63 to 4.91%, 3.36 to 4.79% and 2.09 to 2062% respectively. In case of bulk density, no significant difference was noted (0.314 to 0.323 g/ml). Therefore, incorporation of jackfruit seed flour into pasta could be a promising way for developing protein-rich, high-quality pasta with improved nutritional and functional properties.

1. INTRODUCTION

"Pasta is a type of noodle and staple food of traditional Italian cuisine (Sudha et al. 2014). It is produced from unleavened dough of a durum wheat flour mixed with water and can be consumed after processing as fresh pasta or dried for future use" (Fernandes et al., 2013). "The pastas besides being good energy source due to high starch content provide dietary fiber, protein and lipids as essential fatty acids along with important micronutrients like vitamins, minerals, antioxidants and phytochemicals" (Merina et al., 2020).

Replacement of wheat flour with other cereal flours and various functional ingredients improve the nutritional and functional properties of pasta. Wheat flour can be replaced by using corn flour. Corn flour has the potential to provide all needed amounts of vitamins and minerals. The low-fat content of corn flour reduces the chances of heart disease and obesity (Seema et al., 2016).

"Jackfruit (*Artocarpus heterophyllus* Lam), a tropical fruit in the Moraceae family. It is native to the Western Ghats of India and is commonly grown in South and Southeast Asia, Africa and parts of South America" (Ranasinghe et al., 2019). "Jackfruit constitute of three major components: pulp (30- 32%), seeds (18%), and rind (5-55%). Golden-yellow pulp is arranged in fleshy bulbs that account for 30–35% of the fruit's weight and each include a single seed inside. In addition to its pulp, the jackfruit's under-utilized sections like the seed and rind have been said to contain great nutritional qualities" (Ahlawat, 2023). Among the parts often discarded, the seeds frequently overlooked and underused are now attracting interest due to their rich nutritional value and beneficial functional properties (Muskan et al., 2025).

Jackfruit seeds, comprising approximately 8–15% of the fruit's total weight, are rich in starch, protein, fiber, and essential minerals such as potassium, magnesium, calcium, and iron (Swami et al., 2012). It is a very good source of vitamin B_2 (Arpit & John, 2015). Apart from valuable source of protein and carbohydrate, it contains phytonutrients like lignans, isoflavones and saponins which contribute to various health benefits wide-ranging from anti-cancer to anti-hypertensive (Shajahan et al., 2024). Antioxidants like polyphenols, carotenoids and anthocyanin work as excellent scavengers of the free radicals, thus the human body is protected from cellular damage (Baliga et al., 2011). Haq (2006) reported that "2 types of lectins namely jacalin and artocarpin present in seeds show anti-bacterial, anti-fungal and anti-carcinogenic properties".

According to Roy et al. (2012) "jackfruit seed flour can be blended with wheat flour to explore the potential of low-cost flour from jackfruit seed as an alternative raw material for bakery and confectionary products". Veena & Suma (2017) prepared pasta using jackfruit seed flour and wheat flour ranging from 100:0 to 80:20. This composite flour boosted the nutritional content, enhanced the texture of pasta and increased yield efficiency with reduced cooking duration. Akter & Haque (2018) and Alsedik et al. (2021) recommended incorporation of jackfruit seed flour in noodles and cookies respectively.

"The functional properties of extruded product vary with types of ingredients used for the preparation. The enrichment with 10% of red amaranthus as paste to jackfruit pasta formulations reduced cooking loss, improved the cooking quality characters, nutritional quality, and sensory attributes and produced naturally coloured pasta with higher consumer

acceptability" (Swathi et al., 2019). Incorporation of jackfruit bulb flour and jackfruit seed flour to pasta significantly influences the cooking time and cooking loss depending upon the amount of flour combinations (Lakmali & Arampath, 2021). Hence, this study was taken up to investigate the variations in functional properties of corn flour and jackfruit seed flour incorporated pasta with refined wheat flour pasta.

2. MATERIALS AND METHODS

2.1 Raw Materials

The present study was carried out at the College of Food and Dairy Technology, Koduveli, Chennai, Tamil Nadu. The raw materials selected for this study were refined wheat flour, corn flour and roasted jackfruit seed flour. The former two were procured from the local market in Chennai and the latter one from Valley Spices, Kerala. The other ingredients like Xanthan gum, salt and rice bran oil were purchased from the local market in Chennai.

2.2 Formulation of Pasta

"Two combinations of pasta were formulated by incorporating the refined wheat flour (RWF), corn flour (CF) and jackfruit seed flour (JFSF). For the preparation of pasta, the flours were mixed at different ratios as mentioned in Table 1. The flour was supplemented with 1% xanthan gum, 45-50% water, 2% salt and 10% rice bran oil were also added. The mixture was kneaded for 15 minutes. The moist flour aggregate was placed in a metal extruder attachment of the pasta extruder machine (Model: La Monferrina- Mini Pasta Making machine) fitted with an adjustable die followed by cutting. After extrusion, steaming process carried out for 15 minutes for complete starch gelatinization. Then drying of steamed pasta was carried out in a solar dryer for about 5 hours" (Raghu et al., 2022).

2.3 Functional Properties of Pasta

Cooking Characteristics:

The cooking quality of pasta in terms of optimal cooking time, swelling power and cooking loss were determined.

Optimum Cooking Time:

"Optimum cooking time was determined by cooking the pasta of 25 g in 100 ml of water. The product was cooked until the white line disappears and the time taken was noted. Pressing the cooked product in between two glass slides will test the end point" (Gull et al., 2015).

Cooking Loss:

"Cooking loss is determined by evaporating the pasta water to dryness in hot air oven at 100°C. The initial weight and the dried weight were noted" (Giuberti et al., 2015).

$$Cooking\ Loss\ \% = \frac{Dried\ residue\ in\ cooking\ water\ (g)}{Pasta\ weight\ before\ cooking\ (g)\ x\ 100}$$

Swelling Index:

One gram of the sample was dispensed into a calibrated 50 ml measuring cylinder. To the sample, 10 ml of distilled water was added and the volume was noted. The cylinder was left to stand undisturbed for about 1 hour. Volume occupied by the sample was recorded and the swelling capacity was calculated as outlined by Nwabueze & Anoruoh (2011).

$$Swelling\ Index = \frac{Volume\ occupied\ by\ the\ sample\ after\ swelling}{Initial\ value\ occupied\ by\ the\ sample}$$

Water Solubility Index:

The Water solubility index was the weight of dry solids in the supernatant expressed as a percentage of the original weight of sample (Sharma et al., 2017).

$$Water\ Solubility\ Index\ (\%) = \frac{Weight\ of\ dry\ solids\ in\ supernatant\ x\ 100}{Dry\ weight\ of\ extrudate}$$

Water Absorption Capacity:

"It indicates the quantity of water absorbed by a known amount of sample while cooking. 300 ml of distilled water was boiled in a cooking pan and 30 g pasta sample was cooked in it for 4 min. The cooked pasta was drained and after 5 min, the surface moisture was removed with a blotting paper and the final weight of pasta was measured" (Pakhare et al., 2017).

$$Water\ Absorption\ Capacity\ (g/g) = \frac{Weight\ of\ gel\ after\ removal\ of\ supernatant}{Weight\ of\ the\ sam}$$

Bulk Density:

The bulk density was determined using the method by Amandikwa et al. (2015). 10 g of sample was added in a calibrated 25 ml measuring cylinder and the volume was recorded as the loose volume. The bulk density was determined using the following relationship.

$$Bulk\ Density\ (g/cm^3) = \frac{Mass\ of\ extrudate}{Volume\ of\ extrudate}$$

Table 1. Combination of ingredients used for the formulation of jackfruit seed flour incorporated pasta

Sample	Refined Wheat Flour (g)	Corn Flour (g)	Jackfruit Seed Flour (g)	Xanthan Gum (g)	Water (ml)	Salt (g)	Rice Bran Oil (ml)
Control	100	-	-	-	35	2	8
T_1	80	10	10	1	48	2	10
T_2	70	10	20	1	50	2	10

Statistical Analysis: The statistical analysis was done by SPSS software package for windows (IBM SPSS Statistics, Version 20.00). The data were analyzed using one-way analysis of variance ANOVA and means were separated using Duncan's multiple range test and statistical significance was determined at 95% confidence level (p<0.05). All determination was made in triplicate and data were expressed as mean with standard error.

3. RESULTS AND DISCUSSION

The functional dried pasta incorporated with corn flour and jackfruit seed flour was given in Fig. 1. The functional properties were analyzed for three samples as per standard procedures and is given in Table 2.

Optimal cooking time: The results showed with an increase in the addition of jackfruit seed powder in noodles caused a highly significant reduction in the optimal cooking time. The control sample takes a longer time to cook i.e., 7.16 min. This might be due to the high gelatinization temperature of the flours due to the possibility of lower starch content in the flours. Sample with 20% JFSF having lowest cooking time of 5.11 min. Singh et al. (2023) also reported that the addition of JFSF from 6 to 24% caused a significant (p < 0.05) decline in the minimum cooking time from 7.02 to 6.20 min.

Cooking loss: Cooking loss is recorded highest for control sample and a declining trend is observed with the least being in the case of the sample T_2 i.e., 5.68%. This might be due to a reduction in flour binding agents (gluten) with increasing incorporation of the jackfruit seed powder. Additionally, there might be leaching of the soluble starch as well as other solid components that have caused a rise in the solid loss (or) cooking loss. Noodles prepared with varying ratio of refined wheat flour: jackfruit seed flour: jackfruit bulb flour showed decline in cooking loss from 15.37 to 9.13% by increasing amount of JFSF (Veena & Suma, 2017).

Control   Sample T_1 Sample T_2

Fig. 1. The functional dried pasta samples incorporated with jackfruit seed flour

Table 2. Functional properties of the cooked formulated pasta samples

Properties	Control	T_1	T_2	F value
Optimal Cooking Time (min)	7.16±0.07	6.08±0.04	5.11±0.04	359.88**
Cooking Loss (%)	9.25±0.07	7.84±0.03	5.68±0.02	1778.46**
Swelling Index (%)	2.63±0.06	3.72±0.04	4.91±0.03	672.64**
Water Solubility Index (%)	3.36±0.04	4.04±0.05	4.79±0.02	348.79**
Water Absorption Capacity (g/g)	2.09±0.03	2.32±0.05	2.62±0.03	44.38**
Bulk Density (g/ml)	0.323±0.01	0.315±0.00	0.314±0.01	1.10^{NS}

*Triplicate; Data is expressed as Mean±SE; **Highly significant (p≤0.01); NS- Non-significant (p≥0.05)*

Swelling Index: SI is an indicator of the water absorbed by the starch and protein during cooking, which is utilized for the gelatinization of starch and hydration of proteins. As the addition of jackfruit seed powder increased, the swelling index also increased significantly from 2.63 to 4.91%. Omeire et al. (2014) reported an increased swelling index from 1.27 to 1.45% in the noodles developed from wheat, acha and soybean flours. According to Cleary & Brennan (2006), "increased swelling index values might be related to greater water absorption during cooking due to the high water-binding capacity of fibre".

Water solubility Index: Addition of jackfruit seed flour increased the water solubility index of the pasta significantly and more value is observed in the T_2 sample (4.79%) compared to control (3.36%). The increase in the values may be due to the high conversion rate of starch during processing. These results are par with the research done by Singh et al. (2023) using semolina and jackfruit seed flour which reported WSI values in the range of 3.56 to 4.90%.

Water absorption capacity: High significant differences ($p > 0.05$) were absorbed in the samples' water absorption capacity. The T_2 sample had the highest water absorption capacity (2.62 g/g) while the control sample recorded the lowest score (2.09 g/g). The water absorption capacity increased as the incorporation of jackfruit seed powder increased. This could be attributed to the protein content of the powder that denatured during heat processing which significantly influences the amount of water it can absorb. This is agreed with the findings of Timilsena et al. (2016) that "increased porosity and also due to protein denaturation, starch gelatinization and raw fiber swelling during drying changes the orientation of residual amino acids". Addition of JFSF from 6 to 24% in pasta increases WAC from 2.25 to 2.63% (Singh et al., 2023).

Bulk density: The values of density ranged between 0.310 – 0.328 g/ml. No significant difference was noted among the bulk density values of the samples. Bulk density was lower in the noodle samples incorporated with jackfruit seed flour than in the control sample. The lower bulk density of these samples could result from the lower bulk density of jackfruit seed flour. Low bulk density is desirable in infant feeding (Iwe & Onadipe, 2001). A study done by Palamthodi et al., (2020) reported that pasta incorporated with

80% wheat flour, 10% ragi flour, 10% jackfruit seed flour and 70% wheat flour, 10% ragi flour, 20% jackfruit seed flour shown bulk density of 0.33 and 0.37 ml respectively.

"The sensory analysis of these samples with a nine-point hedonic scale showed that pasta incorporated with 10% corn flour and 10% JFSF was acceptable. The colour and appearance, flavour, body and texture of pasta with JFSF obtained an acceptable score" (Anusha et al., 2023).

4. CONCLUSION

Pasta is a widely accepted convenience food around the world. In the present study, pasta was supplemented with corn flour and jackfruit seed flour which meets the nutritional requirements. The ratio of RWF: CF: JFSF was adopted as 80:10:10 and 70:10:20. The functional and cooking properties of fortified pasta was compared with control sample. Swelling index, water solubility index and water absorption capacity were increased while optimum cooking time and cooking loss decreased with increased JFSF amount. No significant difference observed in case of bulk density between control and samples. Replacement of wheat flour with these ingredients improved the functional characteristics of pasta. The study revealed that incorporation of jackfruit seed flour affects both cooking characteristics and functional properties of pasta.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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