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Proximate composition and sensory attributes of gluten-free pasta made from jackfruit seeds

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ABSTRACT

Background: Pasta is the world's favourite food, except among those with celiac disease and other gluten sensitivities. Jackfruit seeds are a good source of nutrients and are gluten-free. Replacing wheat flour with jackfruit seeds in pasta represents a potential alternative food for those with gluten sensitivities. This investigation examined the impact of replacing wheat flour with jackfruit seeds on the proximate composition and sensory assessment of gluten-free fresh pasta (fettuccine).

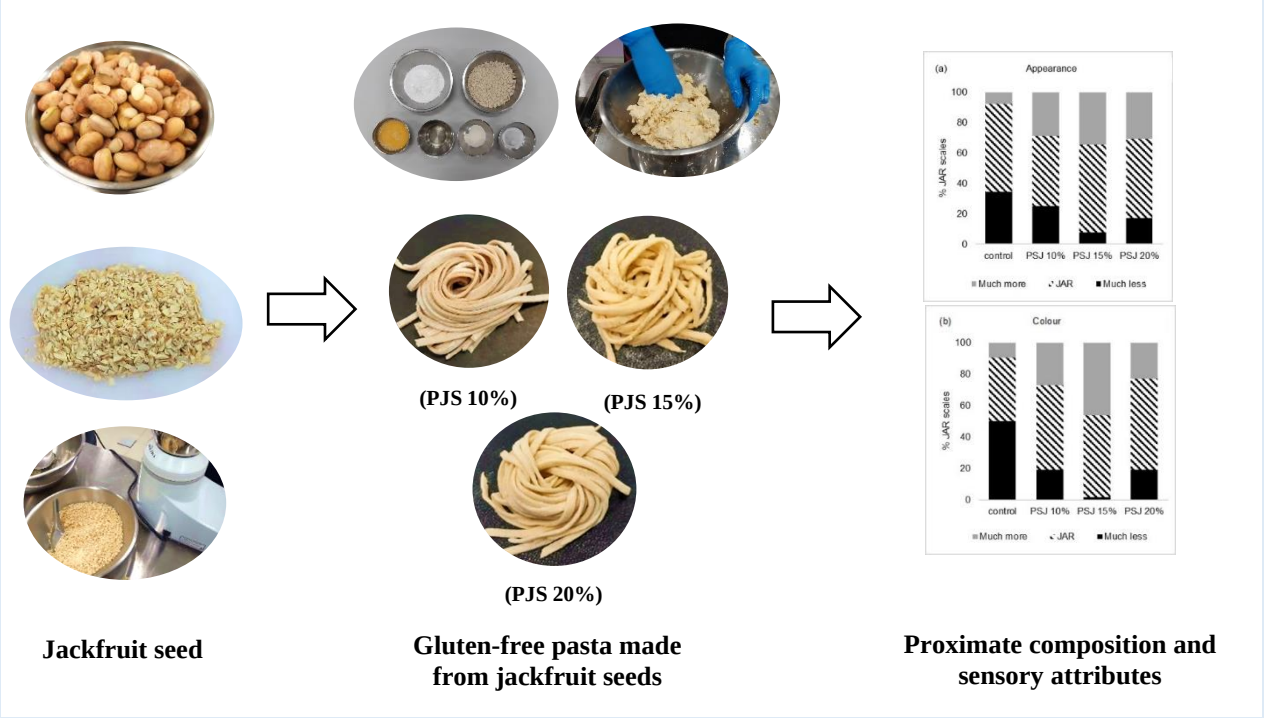
Methods: The pasta was prepared by replacing wheat flour with jackfruit seeds and adding 10% (percentage of rice flour [PJS] 10%), 15% (PJS 15%) or 20% (PJS 20%). The proximate composition and sensory attributes of the pastas were evaluated.

Results: The proximate composition of pasta was significantly improved ($p < 0.05$) when the amount of jackfruit seeds added to the pasta was increased. Results showed decreased in energy (152-174 kcal/100g) and carbohydrate (8.2-14.8%), however increased in crude fiber (0.4–0.9%) and ash (1.9–4.7%). The results of a sensory characteristic evaluation with a nine-point hedonic scale showed that pasta made from 100% wheat flour was acceptable to the participants, and the gluten-free fresh pasta was not significantly different. The gluten-free pasta's colour and texture changed as a result of adding rice flour and replacing the wheat flour with jackfruit seeds. The addition of jackfruit seeds resulted in a reduction in the flavour, cohesiveness, taste, and colour characteristics compared to wheat flour pasta. The pasta that substituted jackfruit seeds and added 15% rice flour scored highly on the sensory analysis.

Conclusion: This study showed that fresh gluten-free pasta made from jackfruit seeds can be a tasty and nutritious substitute for regular pasta, with promising potential for food variety, notably for those with celiac disease.

Clinical trial registration: TCTR20220325001

Keywords: Gluten-free, jackfruit seed, just-about-right, nutrition, pasta



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INTRODUCTION

Pasta is among the most popular foods in many parts of the world. It is produced from a mixture of durum semolina, egg, and water. The high gluten content of durum semolina results in pasta qualities such as low cooking loss, high firmness, high adhesiveness, and high tolerance for overcooking [1, 2]. Gluten is significantly related to the firm structure, elasticity and chewability of pasta [2]. However, the gluten in pasta is harmful to gluten-sensitive people such as those with celiac disease (CD). In recent years, the demand for functional foods such as high-fiber and low-calorie products has grown. Therefore, pasta is a product worthy of investigation to improve its nutrient content and make it gluten-free. Normally, pasta products are made from wheat flour: an easily digestible carbohydrate, low in fiber and other bioactive compounds. Several studies have improved the nutritional value of pasta by adding fiber and protein, including those from plants, to increase the level of bioactive compounds with antioxidant activity [3-5]. In particular, adding fiber to pasta formulations can be useful for filling the gap between the recommended and current intake of fiber for consumers.

The tropical fruit known as jackfruit (*Artocarpus heterophyllus*) is popular in Asian nations. Although jackfruit seeds are less widely known, they have more

nutritional value. They could be used as a component of functional foods because it is a rich source of phytonutrients (lignan, isoflavones, and saponins) and potential prebiotic effects [6, 7-9]. According to these findings, jackfruit seeds offer good nutritional content; antioxidant and prebiotic activities; and potential protective effects and functional properties. These characteristics makes it an attractive food or ingredient in developing innovative functional products. However, the use of jackfruit seeds is still very limited. Normally, jackfruit seeds are boiled and roasted before eating, meaning that they have not been used optimally. Jackfruit seeds are a good source of insoluble fiber, protein, and starch. They can be processed into food products and used as a substitute for wheat flour [10].

Nutritional and convenience food products are in growing demand. Therefore, enriching pasta with plant-derived bioactive compounds may be useful for the health of consumers. The current study aimed to assess the nutritional content and sensory evaluation of gluten-free fresh pasta made from jackfruit seeds to provide pasta products with better functional value and an alternative food for those with sensitivities.

METHODS

Preparation of jackfruit seeds: Raw Thong Prasert jackfruit seeds were washed and boiled in a large pot (2.5 kg of jackfruit seed/5 L of water) at 93 °C for 30 min. The water was then drained, and the seeds spread out on a tray to cool and dry. After that, the outer white and brown layers were peeled off. The seeds were chopped and blended in a household blender (Panasonic MX-AC400) for 5–10 min.

Preparation of gluten-free fresh pasta from jackfruit seeds: Gluten-free fresh pasta was prepared according to the method published by Pasta Evangelists, with minor modifications [11]. The formulations of gluten-free fresh pasta and control pasta were developed as shown in Table 1. The control pasta produced with wheat flour was composed of 300 g (71%) of wheat flour mixed with 5 g (1%) of salt, 10 mL (2%) of olive oil and 110 mL (26%) of whole egg in a dough. Other formulations were produced by replacing wheat flour with jackfruit seeds and adding 10%, 15% and 20% rice flour. The fresh pasta was processed manually into fettuccine format using a pasta-making machine (Marcato of Atlas 150). The gluten-free fresh pastas are shown in Fig. 1.

Table 1. Formulation of gluten free fresh pasta dough from jackfruit seed instead of wheat flour.

Ingredients (%)	Control%	PJS 10%	PJS 15%	PJS 20%
Wheat flour	71	-	-	-
Jack fruit seed	-	59	54	49
Salt	1	1	1	1
Egg	26	26	26	26
Olive oil	2	2	2	2
Rice flour	-	10	15	20
Xanthan gum	-	1	1	1
Sodium bicarbonate	-	1	1	1

PJS 10%: pasta made from jackfruit seeds and 10% rice flour. PJS 15%: pasta made from jackfruit seeds and 15% rice flour. PJS 20%: pasta made from jackfruit seeds and 20% rice flour.

A (PJS 10%) **B (PJS 15%)** **C (PJS 20%)**

Figure 1. Gluten-free fresh pasta made from jackfruit seeds instead of wheat flour. (A) PJS 10%: pasta made from jackfruit seeds and 10% rice flour. (B) PJS 15%: pasta made from jackfruit seeds and 15% rice flour. (C) PJS 20%: pasta made from jackfruit seeds and 20% rice flour.

Determination of proximate composition: The proximate composition of the gluten-free fresh pasta was analyzed according to the method of the Association of Official Analytical Chemists [12]. The moisture and ash content were analyzed in the oven. To determine the moisture content; samples were heated to 105 °C for 3 h until the weight stabilized; and ash content was analyzed at 550 °C. The total protein content was examined by the Kjeldahl method; using a conversion factor of 5.71; and the total lipid content was examined using the Soxhlet method [13]. The crude fiber was analyzed by digestion of samples (fat was removed with 1.25% H_2SO_4 and 1.25% NaOH). The total energy was determined with a bomb calorimeter (Model-IKA C2000). The carbohydrate content was calculated by the difference of moisture, fat, crude protein, ash, and crude fiber, subtracted from 100%:

%Carbohydrate = 100 – (%Moisture + %Fat + %Ash + %Crude fiber + %Protein).

Sensory evaluation: Fifty-two untrained evaluators participated in the sensory evaluation. The Committee on Human Rights Related to Human Experimentation, University of Phayao, Phayao, Thailand approved this study (approval no. 1.3/038/64), which was registered at the Thai Clinical Trials Registry (reg. no. TCTR20220325001) for the sensory evaluation. The participants were 18–50 years old and had no wheat flour or gluten sensitivity. The sample tasting was done in the Nutrition and Dietetic Laboratory, School of Medical Sciences, University of Phayao. First, four samples of cooked pasta were delivered randomly to the participants on disposable plates with codes (control and gluten-free fresh pasta made from jackfruit seeds by adding 10%, 15% and 20% rice flour). Second, the participants were asked to compare the gluten-free fresh pasta made from jackfruit seeds with the highest acceptability. In between tasting each sample, water was available for mouth washing.

The participants were asked to use a nine-point hedonic scale to rate the pasta's colour, flavour, texture, and general acceptability (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely). Additionally, a five-point "just-about-right" (JAR) bipolar scale was used to assess the suitability of five aspects (appearance, colour, flavour, taste, and cohesiveness), from 1 = "much less" to 5 = "much more", with a middle value of 3 = "just about right" [14].

Statistical analysis: All data are reported as average values: mean ± SD. The differences among treatments were analyzed by one-way analysis of variance. The significance of the means was tested by using Tukey's

significance for nutritional composition and sensory attributes at $p < 0.05$. Statistical software (SPSS version 26.0) was used to analyze the data.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition of the raw material (Jackfruit seed) is shown in Table 2. Energy, carbohydrate, protein, fat, crude fiber, ash and moisture contents were recorded in grams per 100 g of dry material samples. Jackfruit seed contained the most carbohydrates and moisture. The crude protein content was 11.83 ± 0.06% which assigned that jackfruit seed was a potential source of protein enriched food. Therefore, jackfruit seed can be considered a potential functional food ingredient due to its prebiotic property [9].

Table 2. Proximate composition of jackfruit seed (g/100g of dry weight)

	Energy (Kcal)	Carbohydrate (%)	Protein (%)	Fat (%)	Crud fiber (%)	Ash (%)	Moisture (%)
Jackfruit seed	175.09 ± 0.85	30.84 ±0.22	11.83 ± 0.06	0.49 ± 0.02	0.94 ± 0.03	3.16 ± 0.15	52.74 ± 0.24

Values are mean, standard deviation of triplicate determination.

The proximate composition of the control pasta and gluten-free fresh pasta made from jackfruit seeds is shown in Table 3. The carbohydrate content and energy values of the gluten-free pasta decreased with each increment in the proportion of jackfruit seeds in the sample. PJS 10% had the significantly lowest ($p < 0.05$) carbohydrate content (8.16%) and energy value (152.49 kcal/100 g), followed by PJS 15% (12.01% and 165.48 kcal/100 g, respectively) and PJS 20% (14.86% and 174.63 kcal/100 g, respectively). Another study reported a decrease in carbohydrate content associated with increasing the proportion of jackfruit seeds [15]. This could be due to the low carbohydrate content (30%) of jackfruit seeds, whereas wheat flour is 67.67% carbohydrate [16]. The starch in wheat flour can be replaced by the starch in jackfruit seed flour, which can be used as an alternative to wheat flour.

The protein content of the gluten-free fresh pastas (13.95%, 12.80% and 11.27% in formulations PJS 10%, PJS 15% and PJS 20%, respectively) was significantly lower ($p < 0.05$) than that of control pasta (14.84%) due to the former being made from jackfruit seeds and rice flour that contain no gluten. A comparison of the three gluten-free fresh pastas showed an increase in protein content along with an increase in the proportion of jackfruit seeds. This might be due to the jackfruit seeds' high protein content [10]. There were similar results for noodles fortified with jackfruit seed flour, it was found that increasing the proportion of jackfruit seeds had a significant effect on the protein level [17, 18].

The fat content of the four formulations in this study was different depending on the percentage of jackfruit seeds in each formulation. In the control formulation (wheat flour), the fat content was 6.45%. In the formulations PJS 10%, PJS 15%, and PJS 20%; it was 7.12%, 7.36% and 7.79%, respectively. As a higher proportion of jackfruit seeds was added, the fat content of the pasta also increased. The results of this study agree with prior findings that quinoa-based gluten-free spaghetti had a higher fat content than the control (6.77% vs 2.80%) [19]. The gluten-free fresh pastas were made from jackfruit seeds and 10–20% rice flour. Therefore, an increase in the proportions of jackfruit

seeds and rice flour can significantly increase the fat content due to jackfruit seeds being higher in polyunsaturated fatty acids (46%) than wheat flour [20]. Moreover, rice flour has a 1:1 ratio of monounsaturated to polyunsaturated fatty acids [21].

The crude fiber content of the control formulation (wheat flour) was 0.41%, whereas that of PJS 10% was 0.76% and that of PJS 15% was 0.79%. PJS 20% had the highest crude fiber content at 0.88%. The pasta substituted with jackfruit seeds had more crude fiber than the control (wheat flour). This is because of the high quantity of crude fiber in jackfruit seeds, such as cellulose, lignin and hemicellulose [15]. Similar results showed that the control sample (0.45%) had less fiber than pasta samples enriched with 1–5% soy protein isolate powder (0.52–0.54%) [22]. Moreover, the fiber content of the noodles was increased (0.36–1.73%) by the inclusion of jackfruit seed flour and rice bran flour, and fortification of pasta made from rice flour and 30% soybean flour can increase its fiber content (1.3 g) to deliver a minimum of 50% of the required fiber content [3, 23]. The pasta substituted with jackfruit seed is one of the grain-based dishes as functional foods, provides not only the essential nutrients needed to sustain life but also low-energy foods and high fiber for health promotion and disease prevention [24-25].

The ash content of gluten-free fresh pastas (4.65%, 4.62% and 4.48% in formulations PJS 10%, PJS 15% and PJS 20%, respectively) was significantly higher ($p < 0.05$) than that of the control formulation (wheat flour; 1.87%). The amount of jackfruit seed substitution increased the pasta's ash content [15]. Additionally, a prior study that fortified rice flour with soybean flour revealed that the ash level of pastas increased from 0.59% to 2.17% [3]. Similar results showed that noodles made from wheat, acha, and soybeans had more ash content than the control sample [26]. The ash content of a food is related to its mineral content [27]. The minerals calcium, iron and phosphorus are particularly abundant in jackfruit seeds. Therefore, with an increase in the proportions of jackfruit seeds in pasta, the ash content increases [17].

The moisture content of the pastas varied from 50% to 65% of dry weight. The four types of samples had considerably varying moisture contents, with the sample of percentage jackfruit seeds (PJS) 10% (containing 10% rice flour) having the greatest value and the control (containing 100% wheat flour) having the lowest value. This can be explained by the moisture content of pasta increasing with the proportion of jackfruit seeds in the sample. This could be due to the gluten-free fresh pasta being prepared with wet jackfruit seeds (moisture content 52%). The gluten-free pasta absorbed more water than the control sample. These results are similar to a previous study that determined the effect of incorporating different quantities of jackfruit seed flour on the nutritional composition of noodles [17]. The moisture content of the noodles significantly increased ($p < 0.05$) when jackfruit seed flour was used instead of the control ingredient. This outcome might be explained by the pasta's addition of jackfruit seeds, which have a high fiber content. The fiber content of jackfruit seeds is shown in Table 2. These fiber components possess plenty of polar groups, which can retain water. Previous studies have reported 128.6% water absorption of pasta prepared with semolina flour [28, 29]. Hence, the use of gluten-free flour can contribute to water absorption. Moreover, xanthan gum added to gluten-free fresh pasta made from jackfruit seeds increases the moisture content because the hydroxyl groups in hydrocolloids allow more interaction of water with hydrogen bonds, resulting in better moisture retention after cooking [30, 31].

Table 3. Proximate composition of control pasta and gluten-free fresh pasta made from jackfruit seeds (g/100g of dry weight)

Pasta	Energy (Kcal)	Carbohydrate (%)	Protein (%)	Fat (%)	Crud fiber (%)	Ash (%)	Moisture (%)
Control	223.01±3.32^{d}	26.41±0.19^{d}	14.84±0.08^{d}	6.45±0.44^{a}	0.41±0.07^{a}	1.87±0.07^{a}	50.15±0.03^{a}
PJS 10%	152.49±0.41^{a}	8.16±0.17^{a}	13.95±0.05^{c}	7.12±0.09^{b}	0.76±0.04^{b}	4.65±0.08^{b}	65.37±0.14^{d}
PJS 15%	165.48±0.88^{b}	12.01±0.26^{b}	12.80±0.09^{b}	7.36±0.06^{bc}	0.79±0.03^{bc}	4.62±0.17^{b}	62.42±0.09^{c}
PJS 20%	174.63±1.77^{c}	14.86±0.32^{c}	11.27±0.18^{a}	7.79±0.15^{c}	0.88±0.02^{c}	4.48±0.07^{b}	60.72±0.25^{b}

Values are mean, standard deviation of triplicate determination. PJS 10%: pasta made from jackfruit seeds and 10% rice flour. PJS 15%: pasta made from jackfruit seeds and 15% rice flour. PJS 20%: pasta made from jackfruit seeds and 20% rice flour. Mean in the same row with different superscript are significantly different ($p < 0.05$).

The outcomes of the sensory study of the control pasta and pasta made from jackfruit seeds are shown in Table 4. The sensory scores for appearance, flavour, taste, cohesiveness, and overall liking were significantly lower for the gluten-free fresh pasta ($p < 0.05$). Among the samples, the control was the most acceptable. The JAR scale results are shown in Table 5. This shows the adequacy of each attribute, the degree of liking and the penalty-analysis outcomes. For the control pasta, all the attributes were primarily scored in the "just about right" category, ranging from 40.38% (colour) to 72.55% (taste). The most remarkable finding was that 50% of consumers considered the colour of the control pasta to be "much less". However, no discernible significant difference existed in the colour scores across all samples because the control pasta (wheat flour) contained food colouring so that it was close in colour to the pasta made from jackfruit seeds.

Table 4. Sensory evaluation of control pasta and gluten-free fresh pasta made from jackfruit seeds.

Pasta	Appearance	Colour	Flavour	Taste	Cohesiveness	Overall liking
Control	6.90±1.76^{b}	6.69±1.71^{a}	6.73±1.68^{b}	6.63±1.83^{b}	6.58±1.96^{b}	7.02±1.42^{b}
PJS 10%	5.96±1.58^{a}	6.08±1.83^{a}	4.54±2.28^{a}	5.46±2.15^{a}	5.37±2.09^{a}	5.85±1.82^{a}
PJS 15%	6.10±1.47^{a}	6.25±1.52^{a}	4.85±2.42^{a}	5.42±1.86^{a}	5.12±1.89^{a}	5.73±1.79^{a}
PJS 20%	6.15±1.55^{a}	6.20±1.70^{a}	4.69±2.16^{a}	5.37±1.85^{a}	5.12±1.80^{a}	5.67±1.69^{a}

Values are mean, standard deviation of triplicate determination. PJS 10%: pasta made from jackfruit seeds and 10% rice flour. PJS 15%: pasta made from jackfruit seeds and 15% rice flour. PJS 20%: pasta made from jackfruit seeds and 20% rice flour. Mean in the same row with different superscript are significantly different ($p < 0.05$)

Table 5. Penalty analysis of the control pasta and gluten-free fresh pasta made from jackfruit seeds.

Sample	%Consumers		
	Much less	JAR	Much more
Control			
Appearance	34.62	57.69	7.69
Colour	50.00	40.38	9.62
Flavour	25.00	55.77	19.23
Taste	27.45	72.55	0
Cohesiveness	17.31	67.31	15.38
PJS 10%			
Appearance	25.00	46.15	28.85
Colour	19.23	53.85	26.92
Flavour	15.38	21.15	63.46
Taste	18.00	32.00	50.00
Cohesiveness	46.15	28.85	25.00
PJS 15%			
Appearance	7.69	57.69	34.62
Colour	1.92	51.92	46.15
Flavour	13.46	21.15	65.38
Taste	17.65	43.14	39.22
Cohesiveness	50.00	25.00	25.00
PJS 20%			
Appearance	17.31	51.92	30.77
Colour	19.23	57.69	23.08
Flavour	15.38	11.54	73.08
Taste	15.69	33.33	50.98
Cohesiveness	44.23	26.92	28.85

PJS 10%: pasta made from jackfruit seeds and 10% rice flour. PJS 15%: pasta made from jackfruit seeds and 15% rice flour. PJS 20%: pasta made from jackfruit seeds and 20% rice flour

The percentage of "just about right" responses for the gluten-free pastas was lower than that for the control pasta (Fig. 2). As the amount of jackfruit seed product addition increased, the percentage of flavour, taste and cohesiveness decreased. Flavour had the greatest variance compared to the control pasta because consumers considered the gluten-free pastas to have "much more" flavour of jackfruit seed. These results are similar to other studies that found that increased incorporation of jackfruit seed flour slightly decreased the appearance, colour, taste, texture, flavour, and overall acceptability [18, 32]. Furthermore, the cohesiveness decreased as the amount of jackfruit seed product added increased. Consumers considered this gluten-free pasta to have "much less" cohesiveness. Similarly, the increased addition of red amaranth affected the taste, cohesiveness, and overall liking of pasta because it is high in crude fiber [33]. Therefore, a high fiber content of pasta results in low cohesiveness. Adding high-fiber ingredients to pasta has a significant effect on the texture and participants' acceptance of it [18, 32, 34].

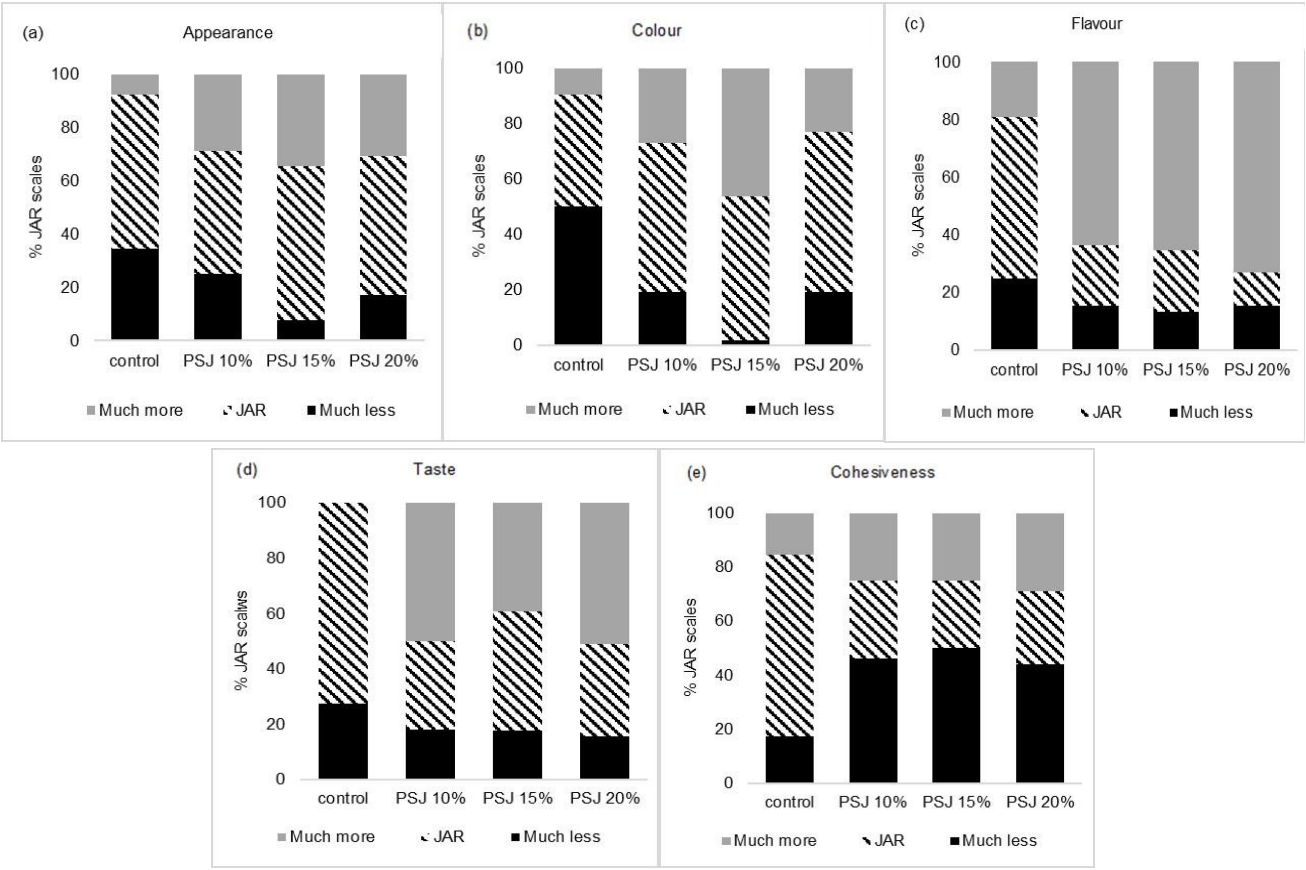

Figure 2. JAR scale response percentages for each attribute, divided into three levels for the control and gluten-free fresh pasta prepared from jackfruit seeds (n=52). PJS 10%: pasta made from jackfruit seeds and 10% rice flour; PJS 15%: pasta made from jackfruit seeds and 15% rice flour; PJS 20%: pasta made from jackfruit seeds and 20% rice flour

CONCLUSION

Replacing wheat flour with jackfruit seeds and adding rice flour led to changes in the colour and textural properties of the gluten-free pasta. Although consumers complained that some sensory elements were not as "ideal", the sensory analysis showed that this new gluten-free fresh pasta made from jackfruit seeds was generally well-received. Moreover, the pasta based on jackfruit seeds with 10% rice flour had higher nutritional content than those with 15% and 20% rice flour. Although a penalty analysis suggested that the cohesiveness of pasta made with jackfruit seeds would affect its acceptability, the recommendation to use jackfruit seeds in the formulation and their physical characteristics may be able to solve this problem. Thus, further studies are required to study the physical properties, storage, and shelf life. Presenting these to consumers during the evaluation would help fully understand the willingness to purchase new healthier products. Furthermore, the JAR scale and penalty-analysis results suggest that a fresh gluten-free pasta made from jackfruit seeds and containing 15% rice flour could be a good alternative to creating a new gluten-free pasta.

Abbreviations: CD: Celiac disease, PJS: pasta made from jackfruit seeds, H_2SO_4: sulfuric acid, NaOH: sodium hydroxide, JAR: just about right.

Authors Contribution: Concept and design: NP. Analysis and interpretation: NP, NT. Data collection: NP, PS.

Writing the article: NP. Critical revision of the article: NP. Final approval of the article: all authors. Statistical analysis: NP. Obtained funding: NP, AD. Overall responsibility: NP.

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REFERENCES

1. Marti A, Seetharaman K,Pagani MA. Rheological approaches suitable for investigating starch and protein properties related to cooking quality of durum wheat pasta. J Food Qual. 2013;36(2):133-8. doi: https://doi.org/10.1111/jfq.12015.
2. Sozer N. Rheological properties of rice pasta dough supplemented with proteins and gums. Food Hydrocoll. 2009;23(3):849-55. DOI: https://doi.org/10.1016/j.foodhyd.2008.03.016.
3. Bolarinwa IF,Oyesiji OO. Gluten free rice-soy pasta: proximate composition, textural properties and sensory attributes. Heliyon. 2021;7(1):e06052. DOI: https://doi.org/10.1016/j.heliyon.2021.e06052.
4. Rachman A, Brennan MA, Morton J,Brennan CS. Effect of cassava and banana flours blend on physico-chemical and glycemic characteristics of gluten-free pasta. Journal of food processing and preservation. 2019;43(9):e14084. DOI: https://doi.org/10.1111/jfpp.14084.
5. Biernacka B, Dziki D, Gawlik-Dziki U,Różyło R. Common wheat pasta enriched with cereal coffee: Quality and physical and functional properties. LWT. 2021; 139:110516. DOI: https://doi.org/10.1016/j.lwt.2020.110516.
6. Swami SB, Thakor N, Haldankar P,Kalse S. Jackfruit and its many functional components as related to human health: a review. Comprehensive Reviews in Food Science and Food Safety. 2012;11(6):565-76.
7. Prasertsit K, Rugwong T,Chetpattananondh P. Possible prebiotics and gallic acid separations from jackfruit seed extract. Songklanakarin Journal of Science & Technology. 2015;37(3).
8. Trejo Rodríguez IS, Alcántara Quintana LE, Algara Suarez P, Ruiz Cabrera MA,Grajales Lagunes A. Physicochemical Properties, Antioxidant Capacity, Prebiotic Activity and Anticancer Potential in Human Cells of Jackfruit (*Artocarpus heterophyllus*) Seed Flour. Molecules. 2021;26(16). doi: 10.3390/molecules26164854.
9. Wichienchot S, Youravong W, Prueksasri S,Ngampanya B. Recent researches on prebiotics for gut health in Thailand. Functional Foods in Health and Disease. 2015;5(11):381-94. DOI: http://dx.doi.org/10.31989/ffhd.v5i11.214.
10. Waghmare R, Memon N, Gat Y, Gandhi S, Kumar V,Panghal A. Jackfruit seed: an accompaniment to functional foods. Braz J Food Technol. 2019; 22:1-9. DOI: http://dx.doi.org/10.1590/1981-6723.20718.
11. Pasta Evangelists. How to make fresh egg pasta dough. https://www.youtube.com/watch?v=da_CvQB_KO0
12. AOAC M. Association of official analytical chemists. Official methods of analysis. Washington DC, USA. 2000.
13. Goyal K, Singh N, Jindal S, Kaur R, Goyal A,Awasthi R. Kjeldahl Method. Advanced Techniques of Analytical Chemistry: Volume 1. 2022; 1:105.
14. Ortega-Heras M, Gómez I, de Pablos-Alcalde S,González-Sanjosé ML. Application of the just-about-right scales in the development of new healthy whole-wheat muffins by the addition of a product obtained from white and red grape pomace. Foods. 2019;8(9). DOI: https://doi.org/10.3390/foods8090419.
15. Hestiningtyas KA, Wardani HE,Kurniawan A. Proximate analysis of noodles with substitution of jackfruit seed flour and branch flour as alternative food for diabetes patients. Proceedings of the 3rd International Scientific Meeting on Public Health and Sports (ISMOPHS 2021) 2022 Jan 25. Negeri. p90. DOI: https://dx.doi.org/10.2991/ahsr.k.220108.017.
16. Verem T, Dooshima I, Ojoutu E, Owolabi O,Adetunji O. Proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours. Agric Sci. 2021;12:18-38. DOI: https://doi.org/10.4236/as.2021.121003.
17. binti Ishak MQ, binti Darus NA,Arau KK. Determination of proximate composition and colour characteristic of noodles

incorporated with different levels of jackfruit seed flour. Proceedings of the Persidangan Pendidikan (CiE-TVET 2013). 2013 Sep 11. Kuala Terengganu, Malaysia. p159.

18. Nandkule V, Masih D, Sonkar C,Patil D. Development and quality evaluation of jackfruit seed and soy flour noodles. Int J Sci Eng Technol. 2015; 3:802-6. DOI: https://doi.org/10.2348/ijset06150802.
19. Caperuto L, Amaya-Farfan J,Camargo CRO. Performance of quinoa *(Chenopodium quinoa Willd*) flour in the manufacture of gluten-free spaghetti. J Sci Food Agric. 2001;81:95-101. DOI: https://doi.org/10.1002/1097-0010(20010101)81:1%3C95::AID-JSFA786%3E3.0.CO;2-T.
20. Ojwang RA, Runo S, Ben M,Ogoyi D. Lipid profile and levels of omega-3 polyunsaturated fatty acids present in jackfruit *(Artocarpus heterophyllus)* Lam.(Moraceae) seeds and variation in different treatments. Afr J Biotechnol. 2015;14(16):1409-17. DOI: https://doi.org/10.5897/AJB2014.14345.
21. Lazova-Borisova I, Angelov L. Fatty acid composition of rice flour millet and chickpeas for the production of gluten free bread. AgroLife Sci J. 2020; 9:175-8.
22. Mishra P,Bhatt D. Development of quality characteristics of dried pasta enriched with soya protein isolate powder. IOSR J Environ Sci Toxicol Food Technol. 2017; 11:1-6.
23. Chillo S, Laverse J, Falcone PM,Del Nobile MA. Quality of spaghetti in base amaranthus wholemeal flour added with quinoa, broad bean and chickpea. Journal of Food Engineering. 2008;84(1):101-7. DOI: http://dx.doi.org/10.1016/j.jfoodeng.2007.04.022.
24. Martirosyan D,Ekblad M. Functional foods classification system: exemplifying through analysis of bioactive compounds. Functional Food Science. 2022;2(4):94-123. DOI: https://doi.org/10.31989/ffs.v2i4.919.
25. Martirosyan D, Lampert T,Ekblad M. Classification and regulation of functional food proposed by the Functional Food Center. Functional Food Science. 2022;2(2):25-46. DOI: https://doi.org/10.31989/ffs.v2i2.890.
26. Omeire GC, Umeji OF,Obasi NE. Acceptability of noodles produced from blends of wheat, acha and soybean composite flours. Niger Food J. 2014;32(1):31-7. DOI: https://doi.org/10.1016/S0189-7241(15)30093-X.
27. Edet EA, Onwuka GI,Orieke COM. Nutritonal properties of composite flour (blends of rice (Oryza sativa), acha (Digitaria exilis) and soybeans (Glycine max) and sensory properties of noodles produced from the flour. Asian Journal of Advances in Agricultural Research. 2017;1(2):1-13. DOI: https://doi.org/10.9734/AJAAR/2017/34429.
28. Dharmaraj U, Sathyendra Rao BV, Sakhare SD,Inamdar AA. Preparation of semolina from foxtail millet (Setaria italica) and evaluation of its quality characteristics. Journal of Cereal Science. 2016;68:1-7. DOI: https://doi.org/10.1016/j.jcs.2015.11.003.
29. Lorusso A, Verni M, Montemurro M, Coda R, Gobbetti M,Rizzello CG. Use of fermented quinoa flour for pasta making and evaluation of the technological and nutritional features. LWT. 2017; 78:215-21. DOI: https://doi.org/10.1016/j.lwt.2016.12.046.
30. Rosell CM, Rojas JA,De Barber CB. Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocoll. 2001;15(1):75-81. DOI: https://doi.org/10.1016/S0268-005X(00)00054-0.
31. Sanguinetti AM, Secchi N, Del Caro A, Fadda C, Fenu PAM, Catzeddu P,Piga A. Gluten-free fresh filled pasta: The effects of xanthan and guar gum on changes in quality parameters after pasteurisation and during storage. LWT - Food Science and Technology. 2015;64(2):678-84. DOI: https://doi.org/10.1016/j.lwt.2015.06.046.
32. Prajakta H, Babar K,Bornare DT. Development and physico-chemical evaluation of spaghetti enriched with jackfruit seed flour. Food Sci Res J. 2018;9(2):396-401. DOi: http://dx.doi.org/10.15740/HAS/FSRJ/9.2/396-401.
33. Swathi BS, Lekshmi GPR,Sankarakutty S. Cooking quality, nutritional composition and consumer acceptance of functional jackfruit pasta enriched with red amaranthus. Environ Conserv J. 2019;20(3):89-97. DOI: https://doi.org/10.36953/ECJ.2019.20313.
34. Habibah NU, Albaar N,Rasulu H. The effect of substitution of seed flour of jackfruit (artocarpus heterophyllus lam.) on the physicochemical and organoleptic characteristics of macrons. IJ-FANRes. 2021;2(1):19-24. DOI: https://doi.org/10.46676/ij-fanres.v2i1.25.