



Optimisation of Buckwheat and Sago Flour Ratios for Developing Nutritious Multigrain Bread

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ABSTRACT

Background: Buckwheat and sago are gluten-free indigenous foods with an excellent nutrient profile containing considerable fibre, minerals, vitamins and antioxidants such as rutin. This study was conducted to optimise the buckwheat and sago flour ratios in developing multigrain bread and evaluate its textural and organoleptic characteristics.

Methods: The breads were prepared using the straight dough method of varying ratios of refined wheat flour, buckwheat and sago flours: T₀ (100:00:00), T₁ (50:50:05), T₂ (50:50:10), T₃ (50:50:15), T₄ (60:40:05), T₅ (60:40:10), T₆ (60:40:15), T₇ (70:30:05), T₈ (70:30:10) and T₉ (70:30:15).

Result: The results showed that increasing levels of buckwheat and sago flours led to significant ($p \leq 0.05$) higher values of hardness (11.46 to 38.61), gumminess (2.41 to 10.46), cohesiveness (0.241 to 0.383), springiness (0.723 to 0.794) and chewiness (2.06 to 7.29), while organoleptic characteristics recorded lower values of taste (6.7 to 8.5), colour (6.5 to 8.2), texture (6.81 to 8.20), flavour (6.9 to 8.0), appearance (6.8 to 8.10) and overall acceptability (6.5 to 8.5) as compared to control bread (T₀). Among all the formulations, T₉ i.e., incorporation of 26.08% buckwheat and 13.04% sago flours, recorded acceptable textural and sensory characteristics for developing commercial multigrain bread.

Key words: Composite flours, Multigrain bread, Organoleptic characteristics, Texture analysis.

INTRODUCTION

Growing consumer awareness about health and the demand for healthier food options have driven the development of bread as a functional food that combines nutritional benefits with high quality and affordability (Petrescu *et al.*, 2020). This demand has been driven by the introduction of low-carbohydrate, high-fibre, multigrain-fortified breads, which appeal to consumers who are focused on maintaining a healthy diet.

Multigrain bread is regarded as more nutritious than bread made from refined wheat flour due to its higher content of dietary fibre, protein, vitamins and essential minerals (Angioloni *et al.*, 2009). Consuming multigrain bread can offer several health benefits, such as lowering the risk of diabetes, preventing heart failure and aiding in weight management (Malik, 2015). It can also help prevent chronic non-communicable diseases such as hyperglycemia and hyperlipidemia (Shang *et al.*, 2023).

Buckwheat (*Fagopyrum esculentum* Moench), a pseudocereal and an underutilised crop, belongs to the family Polygonaceae and the genus *Fagopyrum* (Biacs *et al.*, 2002; Zamaratskaia *et al.*, 2023; Nivedha *et al.*, 2025). Buckwheat is a nutrient-dense food, containing 7-34% protein and essential amino acids like lysine (5.2-5.9%), arginine and aspartic acid (Hussain *et al.*, 2018). It is also a good source of certain vitamins viz., thiamin (vitamin B1), niacin (vitamin B3), pyridoxine (vitamin B6), vitamin E and vitamin K, fibre, essential minerals, flavonoids and antioxidants such as phenolic acid, tocopherol, rutin and quercetin (Sindhu and Khatkar, 2016; Zamaratskaia *et al.*, 2023; Gogoi *et al.*, 2023). Due to its high nutritional value, buckwheat has

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recently been recognised as a valuable food ingredient and is classified as a nutraceutical food. It's gluten-free protein makes it especially suitable for individuals with celiac disease (Ikeda, 2002; Li and Zang, 2001).

Cassava (*Manihot esculenta* Crantz), commonly called tapioca pearl or pearl sago in India, is often known as sago. In Hindi, it is called *Sabudana*. Sago is produced by extracting starch from tapioca roots (Yenkar *et al.*, 2014). Recognized as an indigenous food. Sago is easily digestible and has an extended shelf life due to its low

moisture content. When fortified with other nutritious flours, sago flour enhances its nutritional profile and consumer appeal (Sankararao *et al.*, 2016). Based on these considerations, the current study aims to optimise the ratios of refined wheat flour, buckwheat and sago flours to develop nutritionally enriched multigrain bread.

MATERIALS AND METHODS

Preparation of composite flours and multigrain breads

The experiment was conducted in the Processing and Food Engineering, Department of Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India during 2020-24. All the ingredients viz., refined wheat flour, sago, sugar, salt, calcium propionate and emulsifier (Glycerol Monostearate) were purchased from the local market in Prayagraj district, Uttar Pradesh. Buckwheat grains of the Tau 2 variety were obtained from Chhattisgarh. These grains were manually cleaned to remove foreign materials, thoroughly washed under tap water to eliminate dust and dirt and dried in a tray dryer at 60-70°C for 2-3 hours. Similarly, the sago was manually cleaned to remove impurities, sun-dried for 1-2 hours. Once dried, they were ground into flours, sieved using a 50 mesh sieve and stored in high-density polyethylene (HDPE) pouches at room temperature for later analysis. The processed sago was then stored in HDPE pouches at room temperature for further analysis. The composite flours were prepared by mixing refined wheat flour with buckwheat and sago flours in the following ratios: T₁ (50:50:05), T₂ (50:50:10), T₃ (50:50:15), T₄ (60:40:05), T₅ (60:40:10), T₆ (60:40:15), T₇ (70:30:05), T₈ (70:30:10), T₉ (70:30:15) (w/w). As a control T₀ (100:00:00), bread made entirely from 100% refined wheat flour. The multigrain bread was prepared using the straight dough method. The yeast was activated in warm water with sugar before being combined with the other ingredients, including the flour, while ensuring the appropriate amount of water.

The dough was kneaded and left to ferment for 60 minutes. After fermentation, it was punched down and left to proof for another 60 minutes. The dough was placed into greased baking moulds and left to proof for an additional 35 minutes. Finally, the bread was baked at 225°C for 30 minutes, then cooled and packaged in low-density polyethylene (LDPE) bags at room temperature for further analysis.

Texture analysis

The bread texture profile analysis, including hardness, gumminess, cohesiveness, springiness and chewiness, was performed using a TA HD Plus, Stable Micro Systems, Godalming, Surrey, UK (AACC, 2004).

Sensory evaluation

A sensory panel comprising of 10 panellists, including staff and students, evaluated the multigrain bread's taste, color, texture, flavor, appearance and overall acceptability using a 9-point (9- extremely like, 8- very much like, 7- moderately

like, 6- slightly like, 5- neither like nor dislike, 4- slightly dislike, 3- moderately dislike, 2- very much dislike, 1- extremely dislike) hedonic scale (Amerine *et al.*, 1965).

Statistical analysis

The collected data with three replications (n = 3) were statistically analysed using one-way analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) with significance defined at $p \leq 0.05$ was used to compare the means. The statistical analysis was performed using R (Version 2024.12.0+467).

RESULTS AND DISCUSSION

Multigrain bread texture profile analysis

The results show that the inclusion of buckwheat and sago flours in composite flours of multigrain bread significantly ($p \leq 0.05$) impacted the bread's textural properties. As illustrated in Table 1 and Fig 1, increasing the amount of buckwheat and sago flours leads to greater bread hardness (11.46 to 38.61), gumminess (2.41 to 10.46), cohesiveness (0.241 to 0.383), springiness (0.723 to 0.794) and chewiness (2.06 to 7.29). The values for control bread were 7.81, 1.42, 0.13, 0.16 and 1.48 for hardness, gumminess, cohesiveness, springiness and chewiness, respectively. All the multigrain breads' hardness was higher than the control bread (T₀). The higher water absorption of fibre-rich incorporated buckwheat flour might have caused an increase in hardness. This occurs because polysaccharides contain hydroxyl (-OH) groups, which form hydrogen bonds with water molecules (Mildner-Szkudlarz *et al.*, 2011). Bran addition disrupts the gluten network, reducing its ability to trap gas effectively. The network results in less gas expansion, leading to a tighter, harder crumb structure (Gomez, *et al.*, 2003, Curti *et al.*, 2013).



Fig 1: Multigrain bread prepared from different composite flours of refined wheat flour, buckwheat and sago flours with varying ratios.

The multigrain breads also exhibited higher cohesiveness than the control bread. This increased cohesiveness may be attributed to greater moisture retention, which enhances the structural integrity of the crumb (Bhavsar *et al.*, 2013). Additional water-binding components in the composite flours could have enhanced hydration, leading to more cohesiveness (Goksen and Ibrahim, 2016). The results of this study align with the findings of (Abdelghafor *et al.*, 2011), (Nasar-Abbas and Jayasena, 2012) and (Chhavi and Sarita, 2012), who reported an increase in chewiness with higher levels of multigrain flour in composite bread compared to the control. This increase in chewiness may be attributed to the dilution of wheat gluten due to the incorporation of fibre-rich other buckwheat flour, which weakens the overall gluten network. As shown in Fig 2, the gumminess and springiness of the multigrain breads were also higher compared to the control bread; this may be due to the decreased amount of gluten with the addition of the buckwheat (Kowalski *et al.*, 2022), however, (Lin *et al.*, 2013) observed the contrary results that the inclusion of only 15% buckwheat flour increases these mechanical features of the bread.

Sensory evaluation

The sensory properties of multigrain breads developed using refined wheat flour, buckwheat and sago flours were evaluated and results are present in Table 2, which are significant ($p \leq 0.05$). It provides a comprehensive view of how different formulations of these ingredients affect multigrain breads' organoleptic characteristics like taste, colour, texture, flavour, appearance and overall acceptability. The control bread obtained the highest scores for all attributes evaluated. The results indicate that increasing amounts of buckwheat and sago flours lead to a decline in all the attributes with lower values of taste (6.7 to 8.5), colour (6.7 to 8.2), texture (6.81 to 8.20), flavour (6.9 to 8.0), appearance (6.8 to 8.10) and overall acceptability (6.5 to 8.5). The values for control bread (T_0) were 8.7, 8.7, 8.5, 8.1, 8.2 and 8.5 for taste, colour, texture, flavour, appearance and overall acceptability, respectively.

However, these findings align with (Brites *et al.*, 2022) who found that 30% buckwheat flour inclusion did not differ significantly from control bread (T_0), with positive results for the acceptance of the attributes, flavour, texture and overall impression. Similarly, (Cordoba *et al.*, 2024) and

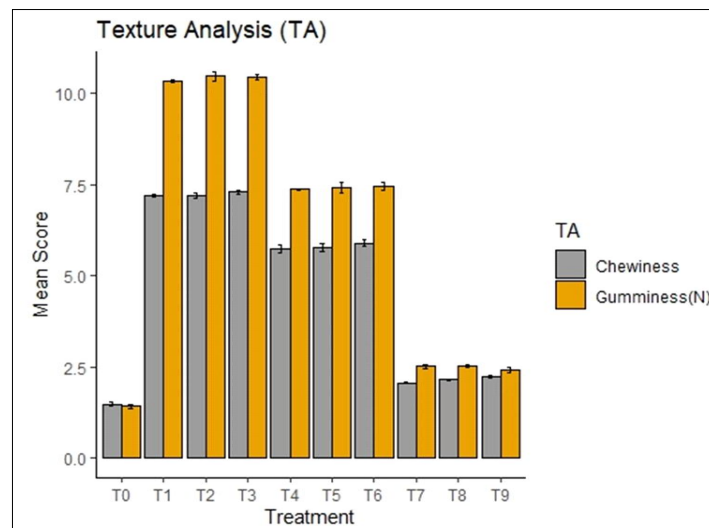


Fig 2: The effect of buckwheat and sago flours fractions on multigrain bread texture: Chewiness and Gumminess.

Table 1: Textural analysis of the multigrain breads.

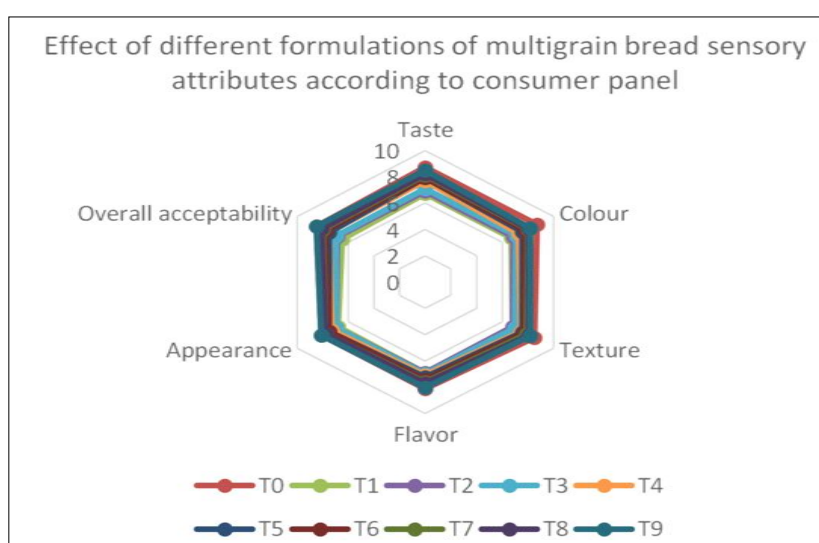
Treatments	Hardness(N)	Gumminess(N)	Cohesiveness	Springiness	Chewiness
T ₀	7.81±0.04f	1.42±0.04d	0.13±0.02f	0.16±0.15f	1.48±0.04f
T ₁	38.46±0.10a	10.32±0.03a	0.257±0.01cde	0.750±0.00d	7.18±0.03a
T ₂	38.57±0.14a	10.46±0.14a	0.246±0.00de	0.732±0.00e	7.20±0.08a
T ₃	38.61±0.14a	10.43±0.05a	0.241±0.00e	0.723±0.00e	7.29±0.04a
T ₄	31.06±0.04c	7.36±0.01b	0.273±0.00c	0.758±0.00cd	5.73±0.11c
T ₅	31.27±0.15bc	7.41±0.13b	0.268±0.00c	0.755±0.00cd	5.78±0.10bc
T ₆	31.54±0.47b	7.46±0.10b	0.262±0.01cd	0.753±0.00cd	5.88±0.09b
T ₇	11.47±0.16e	2.51±0.06c	0.383±0.00a	0.794±0.00a	2.06±0.02e
T ₈	11.46±0.30e	2.52±0.04c	0.333±0.00b	0.780±0.00b	2.15±0.01de
T ₉	12.83±0.19d	2.41±0.06c	0.320±0.01b	0.761±0.00c	2.23±0.04d

Values expressed mean ± SD (standard deviation). Means within columns with different letters are significantly different ($P \leq 0.05$).

Table 2: Average scores of multigrain breads for the parameters; Taste, colour, texture, flavour, appearance and overall acceptability.

Treatments	Taste	Colour	Texture	Flavour	Appearance	Overall acceptability
T ₀	8.70±0.10a	8.70±0.10a	8.50±0.10a	8.10 ±0.10a	8.20±0.10a	8.50±0.10a
T ₁	6.70±0.10g	6.70±0.10g	6.81±0.01g	6.90±0.10f	6.80±0.10f	6.50±0.10f
T ₂	6.90±0.05f	6.90±0.10f	6.81±0.01g	6.90±0.10f	7.00±0.10e	6.90±0.10e
T ₃	7.10±0.10f	7.10±0.15e	7.00±0.10f	7.0±0.10ef	7.00±0.15e	7.00±0.10e
T ₄	7.70±0.10e	7.30±0.10e	7.50±0.10e	7.13±0.15de	7.30±0.10d	7.50±0.10d
T ₅	7.90±0.10d	7.60±0.10d	7.60±0.10de	7.20±0.10d	7.50±0.10c	7.53±0.15d
T ₆	7.90±0.10d	7.80±0.05c	7.70±0.10d	7.46±0.11c	7.50±0.10c	7.80±0.10c
T ₇	8.10±0.10c	8.00±0.10c	7.90±0.10c	7.60±0.10bc	7.80±0.10b	8.00±0.10b
T ₈	8.20±0.17c	8.10±0.15b	8.13±0.05b	7.70±0.10b	7.80±0.10b	8.10±0.10b
T ₉	8.50±0.10b	8.20±0.10b	8.20±0.10b	8.00±0.10a	8.10±0.10a	8.50±0.10a

Values expressed mean ± SD (standard deviation). Means within columns with different letters are significantly different ($P \leq 0.05$).

**Fig 3:** Sensory characteristics of the multigrain bread as evaluated using a 9-point hedonic scale.

(Ghimire *et al.*, 2021) observed that buckwheat flour positively affected sensory qualities. However, at higher substitution levels, there is a noticeable shift in sensory characteristics, which is also seen in this study at the 50% supplementation level with lower mean scores, Fig 3. Incorporation of 26.08% buckwheat and 13.04% sago flours was found to be satisfactory from both sensory and nutritional points of view. Increased fibre content was assumed to add to the health benefits of multigrain bread.

CONCLUSION

Based on the findings of this study, it can be concluded that 26.08% buckwheat and 13.04% sago flour incorporation with refined wheat flour is optimum for developing more appealing, nutritious multigrain bread attractive to consumers.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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