

## Development and Evaluation of Multigrain Pasta

Laxmi Verma<sup>1\*</sup>, N.K. Mishra<sup>2</sup>

### Abstract

*Pasta is one of the most consumed foods among the food products prepared from cereals due to low cost, ease in preparation along with pleasant textural and sensory characteristics. This study was performed to prepare multigrain pasta by utilising the numerous health benefits of wheat, chickpea, kodo and ragi flour. Each ingredient was selected according to unique nutritional attributes which will be incorporated in pasta to make it more nutritious than traditional pasta prepared by refined wheat flour. Ingredients were ground and flours were separated according to the particle size 200–300 µm, 400–500 µm and 500–600 µm and mixed at the rates of 40:30:20:10 respectively. Guar gum (1%, 2% and 3%) was mixed to reduce the cooking loss during cooking. Pasta was prepared using homemade pasta maker machine with two different sheet thickness of 0.8 mm and 1.4 mm. Total 18 samples were obtained after combining all the treatments. The effects of particle size of flour (FPS), amount of guar gum (GG) and sheet thickness (ST) on different cooking qualities of multigrain pasta were studied. It was observed that pasta prepared from FPS of 400–500 µm obtained maximum sensory score during sensory evaluation also pasta prepared from FPS of 400–500 µm using 2% GG with 0.8 mm sheet thickness obtained maximum sensory score of 8.80 in terms of overall acceptability. Also, it was observed that pasta prepared from FPS of 200–300 µm were found to be sticky whereas pasta prepared from FPS of 500–600 µm were disintegrated after cooking.*

**Keywords:** Millet based pasta, multigrain pasta, finger millet, protein content, malnutrition, statistical analysis

### INTRODUCTION

Durum wheat (*Triticum durum*), the toughest wheat in the world, has traditionally been used to make pasta because it contains gluten, which gives the pasta its pleasing sensory and textural qualities [1]. Gluten which is a complex protein made up of glutenin and prolamins and found in grains, like wheat, rye, barley, and triticale, allows wheat to form dough [2]. Durum wheat semolina contains gluten protein, which has important features such low solid loss, great texture, little surface adhesion, and resistance to surface deterioration [3]. The basic ingredient list and ease of preparation of pasta make it a quick food alternative for people all over the world. Pasta is a most-liked food in many cultures. Pasta of the best quality is only made with durum wheat semolina flour [4]. As a result, a product with

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excellent rheological characteristics, high cooking quality, and widespread customer acceptance is produced [5]. The amino acids lysine and threonine are absent from semolina flour, which has a limited nutritional profile [6]. The need for nutrition-rich food is getting increased continuously because of increasing consumer awareness. Therefore, scientists and researchers have started looking into the potential to include healthy ingredients in food products.

Thus, it becomes very essential to incorporate such food grains which are healthy as well as taking less time to cook. By keeping above information in

mind, the health promoting benefits of pulses and millets can be utilized to prepare pasta instead of refined wheat flour which is the source of carbohydrate [7].

Since there are many different wheat quality standards, this varies according to products. Proteins, carbohydrates, iron, and B vitamins, like niacin and riboflavin, are all present in wheat endosperm [8]. In addition, it includes trace minerals and soluble fibre. Soluble fibre has more nutritional benefits than insoluble fibre. With a protein level of roughly 13%, which is rather high when compared to other major cereals, it is the main source of vegetal protein in human meals. Natural wheat provides a variety of health benefits, including the fact that every part of the entire grain carries nutrients that a person's body needs [9].

The chickpea (*Cicer arietinum L.*) is a major pulse crop that is cultivated and consumed across the world but is particularly popular in Afro-Asian nations [10]. It is a good source of protein and carbohydrates and the protein it contains is of higher quality than that found in other pulses [11]. One of the forms of essential amino acids which are low in chickpeas is the types which contain sulphur; they can be supplemented to the diet by consuming cereal grains. Chickpea (Figure 1) majorly contains starch followed by dietary fiber, simple sugars and oligosaccharides [12]. A small amount of lipids is present in chickpea; however, chickpea is high in linoleic and oleic acid, two essential unsaturated fatty acids of nutrition [13]. Chickpea oil includes important sterols, such as campesterol, stigmaterol, and  $\beta$ -sitosterol [14]. It contains low digestible carbohydrates (40–60%), protein (15–22%), important fats (4–8%), and a variety of minerals and vitamins [15]. Because fats control the texture, shelf life, flavour, aroma, and health benefits of foods made from chickpeas, the fatty acid composition of the grain adds value [16].

Compared to popular cereals, like rice, its amount of protein, fibre, and minerals is significantly higher in kodo millet [17]. Kodo millet has 8% protein. Glutalin is the main protein component of kodo millet [18]. Compared to rice (0.2%) and wheat (1.2%), kodo millet is a better source of fibre (9%). Like other millets, kodo millet has 353 kcal and 66.6g of carbs per 100g of grain. In addition, it has 2.6% minerals and 1.4% fat. According to Goñi and Valentín-Gamazo (2003) [19], the iron content of kodo millet ranges from 25.86 to 39.60 ppm. It has the least phosphorus content of all the millets [20].

Similarly, one of the less popular cereals, finger millet (*Eleusine coracana*), has several health benefits some of which can be attributed to its polyphenol and dietary fibre content. For those in low-income classes in India, it is an essential staple food [21]. Because it contains a large amount of dietary fibre (18%), phenolic compounds (0.3–3%), and calcium (0.38%), its usefulness in terms of nutrition is well understood. They are also known for positive effects on health, including their anti-diabetic, anti-tumor, anti-atherosclerogenic, antioxidant, and antibacterial characteristics [22].

## MATERIALS AND METHODS

### Materials

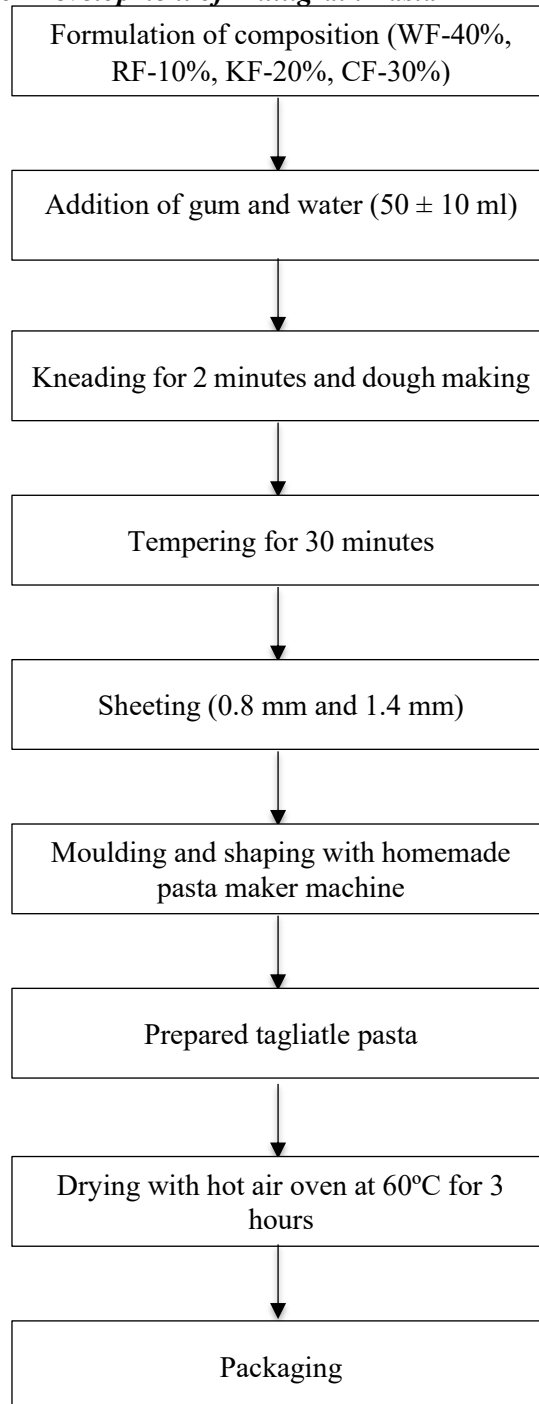
For the preparation of composite flour, different grains, i.e., wheat, chickpea, finger millet and kodo were required (Table 1). Wheat and chickpea were procured from local market of Raipur and finger millet and kodo millet were procured from Sanjeevani Vikraya Kendra, Raipur.

### Preparation of Multigrain Pasta

All ingredients were mixed with their relative proportions, and water was added according to the consistency of dough for pasta preparation, the dough should be hard so that it should not stick to the roller when sheeting. Mixture was kneaded manually for 2 minutes [23]. After preparation of dough, it was kept in food grade polyethylene bag for 30 minutes for tempering purpose [24]. After tempering the dough was pressed between tow rollers of homemade pasta machine (pasta maker machine, homemade stainless steel manual roller pasta maker with adjustable thickness settings sturdy noodles cutter with clamp for spaghetti, fettuccini, lasagna or dumpling skins) and sheet was prepared. The dough was moulded with another segment of machine which cuts the sheet into tagliatle shaped pasta.

Prepared pasta was dried using hot air oven at 60°C for 3 hours [25]. Prepared pasta was stored in LDPE polyethylene bag for further quality and nutritional tests [26].

**Flow Chart of Procedure for Development of Multigrain Pasta**



**Cooking Quality of Multigrain Pasta**

**Cooking Time**

The cooking time of multigrain pasta was determined by method described by AACC (2000). Cooking time is the time required for complete cooking of pasta. 5 g of dried pasta was poured in 250 ml boiling water. The cookedness of pasta was checked by pressing the sample between two petri plates [27]. The visibility of white core was the indication of uncookedness of pasta. It was checked at regular

interval until the white core got disappeared. The time was recorded with the help of stopwatch parallel to the cooking process [28].

**Table 1.** Formulation of composite flour for preparation of multigrain pasta.

S.N.	Pasta	WF (%)	CF (%)	KMF (%)	FMF (%)
1	Multigrain pasta	40	30	20	10
2	Control pasta	100	–	–	–

Note: WF, Wheat flour; CF, Chickpea flour; KMF, Kodo millet flour; FMF, Finger millet flour.

### Cooking Loss

The cooking loss of developed pasta sample was calculated using the method described by AACC, 2000. According to it 5 g sample pasta was boiled in 250 ml water. After the optimum cooking time pasta was separated from the gruel with the help of strainer [29]. Again 20 ml of gruelling sample was taken in a petri dish and placed in hot air oven for drying. After the complete evaporation of water from petri dish, the weight of solids remaining in petri dish was taken and cooking loss was calculated using following formula:

$$CL (\%) = \frac{(X_2 - X_1) \times V \times 100}{W_u \times 20}$$

where

- CL = Cooking loss (%).
- $X_1$  = Weight of empty petri dish (g).
- $X_2$  = Weight of total solid + petri dish after drying (g).
- V = Gruel volume (ml).
- $W_u$  = Weight of pasta sample (g).

### Cooked Weight

The cooked weight of pasta was determined by method described by AACC, 2000. 5 g raw pasta sample was taken and cooked till optimum cooking time [30]. The cooked pasta was taken out and strained out [31]. For removal of extra moisture on the surface, filter paper was used and then weight of pasta was measured. Thus, the cooked weight was obtained by weighing pasta samples after cooking it till optimum cooking time.

### Swelling Index

Swelling index of pasta samples was determined by using method described by Lai (2002) [32]. According to the method, 5 g of raw pasta sample was taken and cooked till CT [33]. Then swelling index was evaluated by drying cooked pasta at constant temperature of 105°C and weighed before and after drying. Swelling index can be calculated by using following formula:

$$SI = \frac{W_c - W_d}{W_d} \times 100$$

where

- SI = Swelling index.
- $W_c$  = Weight of pasta after cooking (g).
- $W_d$  = Weight of cooked pasta after drying (g).

### Water Absorption Index

The method described by Lucisano et al. (2012) [34] was used to determine Water Absorption Index (WAI) of different pasta sample. 2.5 g of ground pasta was weighed and suspended in water at 30°C in 50 ml centrifuge tube [35–38]. Then it was centrifuged at 3000 rpm for 10 minutes. After 10 minutes tubes were taken out and the weight of sediment in the tubes was taken separately [39]. The formula for determination of WAI is given below:

$$\text{WAI (\%)} = \frac{W_{sd}}{W} \times 100$$

where

- WAI = Water Absorption Index (g/g).
- $W_{sd}$  = Weight of sediment obtained (g).
- W = Weight of sample used (g).

### Water Solubility Index

The Water Solubility Index (WSI) of the developed pasta sample was estimated by the method described by Memon et al. (2020) [40], 2.5 g of ground pasta was weighed and suspended in water at 30°C in 50 ml centrifuge tube. Then it was centrifuged at 3000 rpm for 10 minutes. After 10 minutes tubes were taken out and supernatant was collected in a petri dish [41]. The sediments collected in petri dish were weighed after drying the supernatant at the temperature of 150°C till the constant weight is obtained. Following formula was used to determine WSI:

$$\text{WSI (\%)} = \frac{W_s}{W} \times 100$$

where

- WSI = Water solubility index (%).
- $W_s$  = Weight of dry supernatant (g).
- W = Weight of sample used (g).

### Statistical Analysis

Completely Randomized Design (CRD) was applied to check the measure of central tendency and analysis of variance (ANOVA) [42]. The effects of different parameters on cooking qualities of multigrain pasta were analysed using ANOVA with the help of OPSTAT software [43].

## RESULTS AND DISCUSSION

The values of different cooking qualities, such as cooking time, cooking loss, cooked weight, swelling index, WAI and WSI obtained from multigrain pasta prepared from the combinations of particle size, amount of guar gum and sheet thickness are discussed in this section [44].

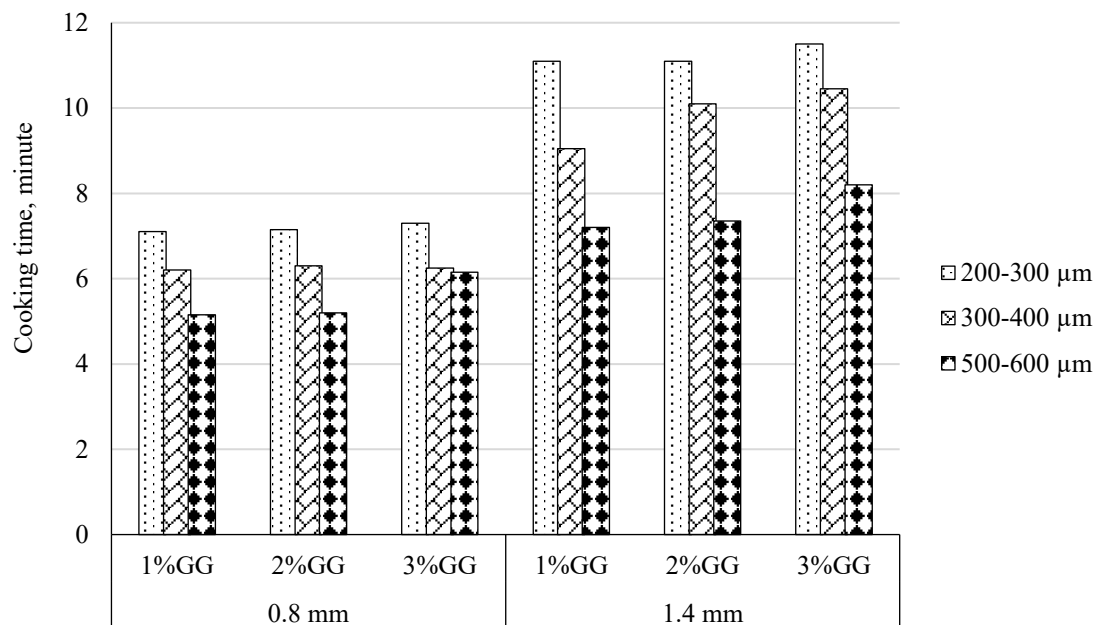
### Cooking Time

Cooking time (CT) of multigrain pasta is the time required to cook pasta completely and it is frequently checked until the white core in pasta disappears [45]. CT of different pasta samples was found to vary from 5:15 minutes to 11:50 minutes [18]. Similar results had been obtained by Mercier et al. (2016) [44]. Pasta prepared with FPS (flour particle size) 200–300  $\mu\text{m}$  (Table 2), thickness 1.4 mm and 3% GG (guar gum) took maximum time, i.e., 11:50 minutes while pasta prepared with FPS (flour particle size) 500–600  $\mu\text{m}$ , thickness 0.8 mm and 1% GG (guar gum) had least cooking time, i.e., 5:15 minutes. The cooking time for pasta based on durum wheat was found to be 10:00 minutes to 10:08 minutes [46]. The reduction in cooking time may be due to the decrease in strength of gluten network because of the presence of millets that provided path to absorb water and causes reduction in cooking time [47, 48]. The trend of change in cooking time is represented in the form of graph below.

### Cooking Loss

Pasta quality is checked by the amount of residue remaining in water during boiling. Least residues are the indicators of high quality of pasta [49]. Cooking loss of multigrain pasta (Figure 2) varied from 5.64% to 17.32%. Maximum cooking loss was obtained from sample with particle size 500–600  $\mu\text{m}$  having 1% guar gum and sheet thickness 1.4 mm and minimum cooking loss was obtained from pasta sample with particle size 200–300  $\mu\text{m}$  having 3% guar gum and sheet thickness 0.8 mm. Awoyale et al. (2020) [50] have obtained the similar results for cooking loss of millet flour blend incorporated

composite flour noodles, and according to Babajide et al. (2010) [51], the ideal CL values of pasta should be in range of 7 to 8%, also, pasta with  $CL < 6\%$  is considered to be good and fair when CL is between 6 to 6.9% (Table 3).



**Figure 1.** Cooking time of multigrain pasta.

**Table 2.** ANOVA of cooking time.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	F-Tabulated ( $p \leq 0.01$ )
Factor ST	1	72,476.741	72,476.741	41.062	7.40
Factor GG	2	65,254.926	32,627.463	18.416	5.25
Int ST X GG	2	132,188.037	66,094.019	37.307	5.25
Factor FPS	2	17.148	8.574	0.005	5.25
Int ST X FPS	2	56,693.815	28,346.907	16.000	5.25
Int GG X FPS	4	34,059.296	8,514.824	4.806	3.89
Int ST X GG X FPS	4	367,011.074	91,752.769	51.789	3.89
Error	36	63,779.333	1,771.648		
Total	53	791,750.370			

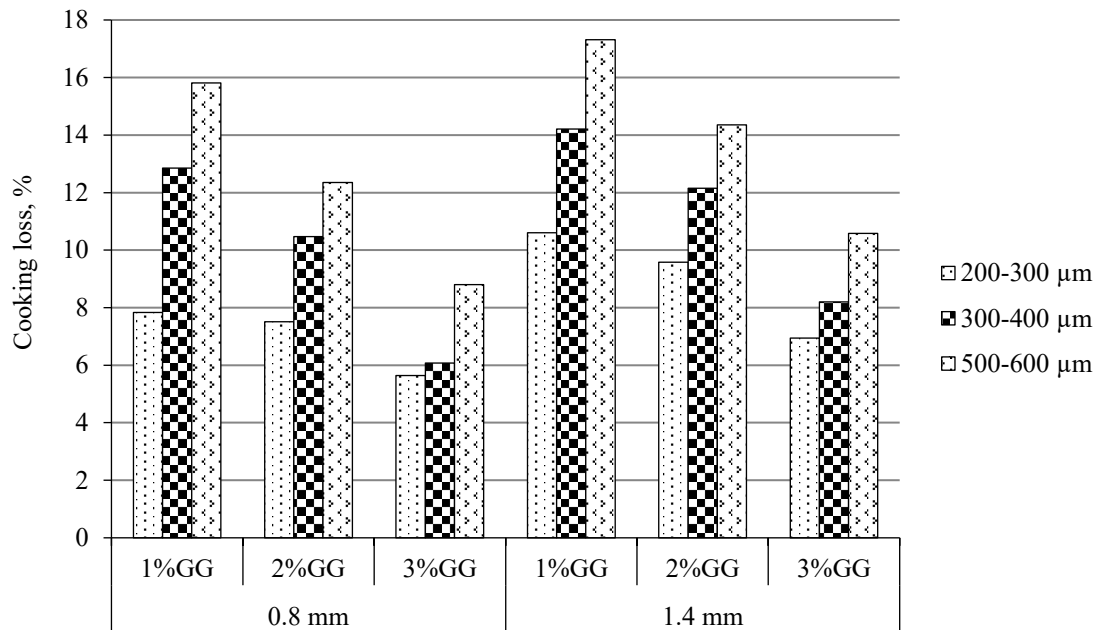
Note: ST, Sheet thickness; GG, Guar gum; FPS, Particle size of flour.

**Table 3.** ANOVA of cooking loss.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	F-Tabulated ( $p \leq 0.01$ )
Factor ST	1	147.788	147.788	17.397	7.40
Factor GG	2	63.362	31.681	3.729	3.26*
Int ST X GG	2	41.638	20.819	2.451	5.25
Factor FPS	2	0.013	0.006	0.001	5.25
Int ST X FPS	2	3.077	1.539	0.181	5.25
Int GG X FPS	4	0.137	0.034	0.004	3.89
Int ST X GG X FPS	4	36.523	9.131	1.075	3.89
Error	36	305.819	8.495		
Total	53	598.357			

Note: ST, Sheet thickness; GG, Guar gum; FPS, Particle size of flour.

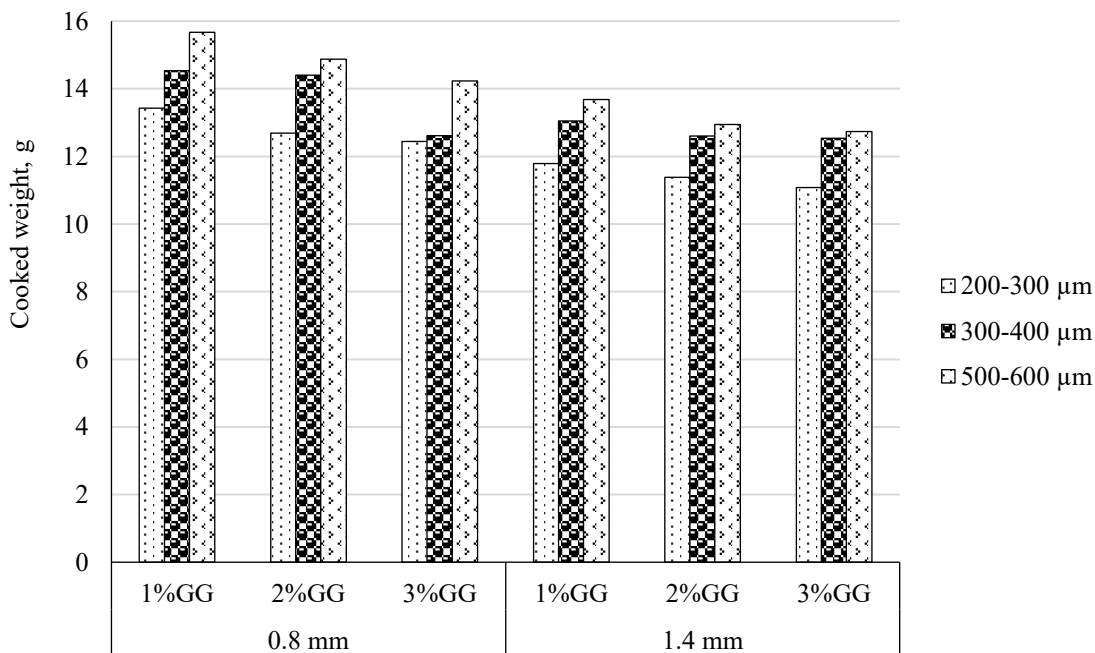
\*F – Tabulated value at 5% level of significance.



**Figure 2.** Cooking loss of multigrain pasta.

### Cooked Weight

The cooked weight of completely cooked pasta is three times the weight of dry sample [52]. The cooked weight (CW) (Figure 3) of developed pasta samples ranged from 11.07 g to 15.66 g pasta of FPS 500–600 μm, 0.8 mm thickness prepared by using 1% GG had highest cooked weight of 15.66 g which is similar to the recommended weight [30] and pasta of FPS 200–300 μm, 1.4 mm thickness prepared by using 3% GG had least cooked weight of 11.07 g. The increased cooked weight of different FPS pasta may be due to the increased swelling ability of starch [53]. Large particles were containing more starch as compared to fine particles thus cooked weight is increasing according to particle size (Table 4).



**Figure 3.** Cooked weight of multigrain pasta.

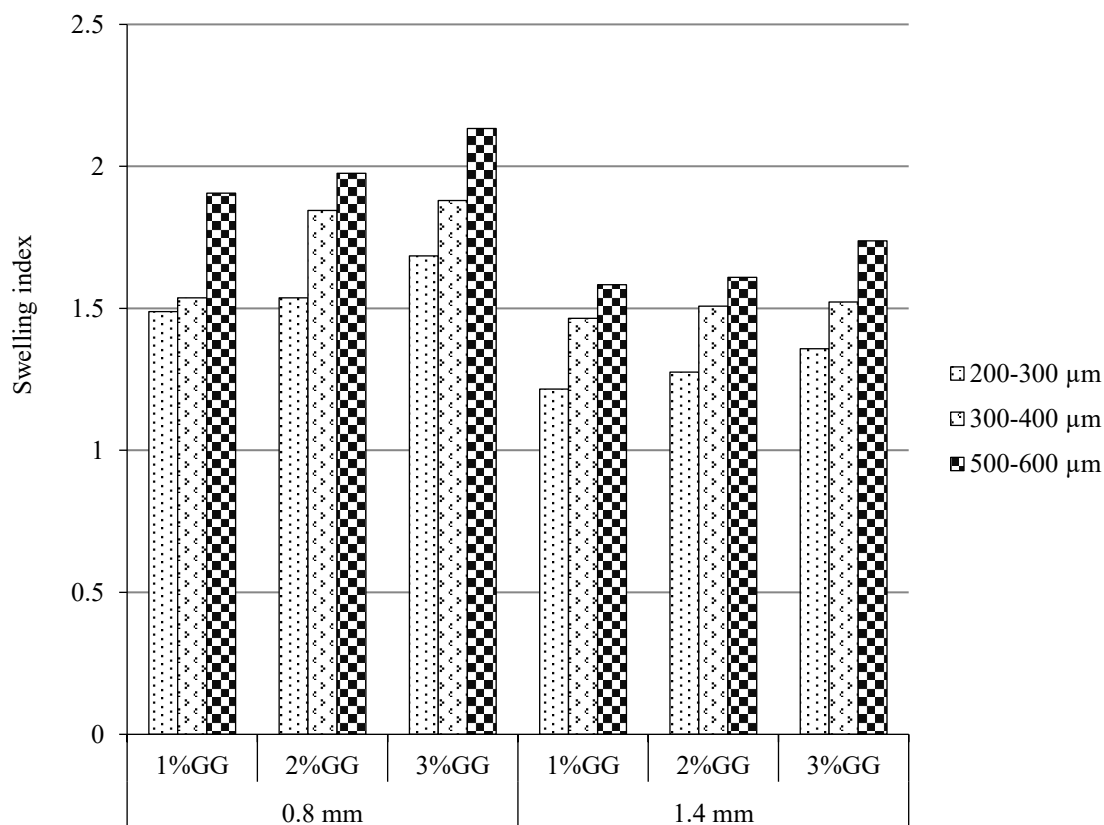
**Table 4.** ANOVA of cooked weight.

Source of Variation	DF	Sum Squares	of Mean Squares	F-Calculated	F- Tabulated ( $p \leq 0.01$ )
Factor ST	1	24.408	24.408	48.657	7.40
Factor GG	2	8.592	4.296	8.564	5.25
Int ST X GG	2	0.916	0.458	0.913	5.25
Factor FPS	2	0.023	0.011	0.023	5.25
Int ST X FPS	2	1.954	0.977	1.948	5.25
Int GG X FPS	4	1.245	0.311	0.621	3.89
Int ST X GG X FPS	4	26.655	6.664	13.284	3.89
Error	36	18.059	0.502		
Total	53	81.851			

Note: ST, Sheet thickness; GG, Guar gum; FPS, Particle size of flour.

### Swelling Index

The ranges of SI (Figure 4) were obtained to be 1.21 to 2.13. Pasta sample of FPS 500–600  $\mu\text{m}$ , 0.8 mm thickness prepared by using 3% obtained to have highest swelling index of 2.13 and pasta having FPS 200–300  $\mu\text{m}$ , 1.4 mm thickness prepared by Swami et al. (2021) [54] using 1% GG had least swelling index of 1.21. The increase in swelling index may be due to swelling (Table 5) capacity of starch [55]. The range of values of swelling index obtained in this study are found like the values of swelling index obtained by Romano et al. (2021) [56].

**Figure 4.** Swelling index of multigrain pasta.

### WAI

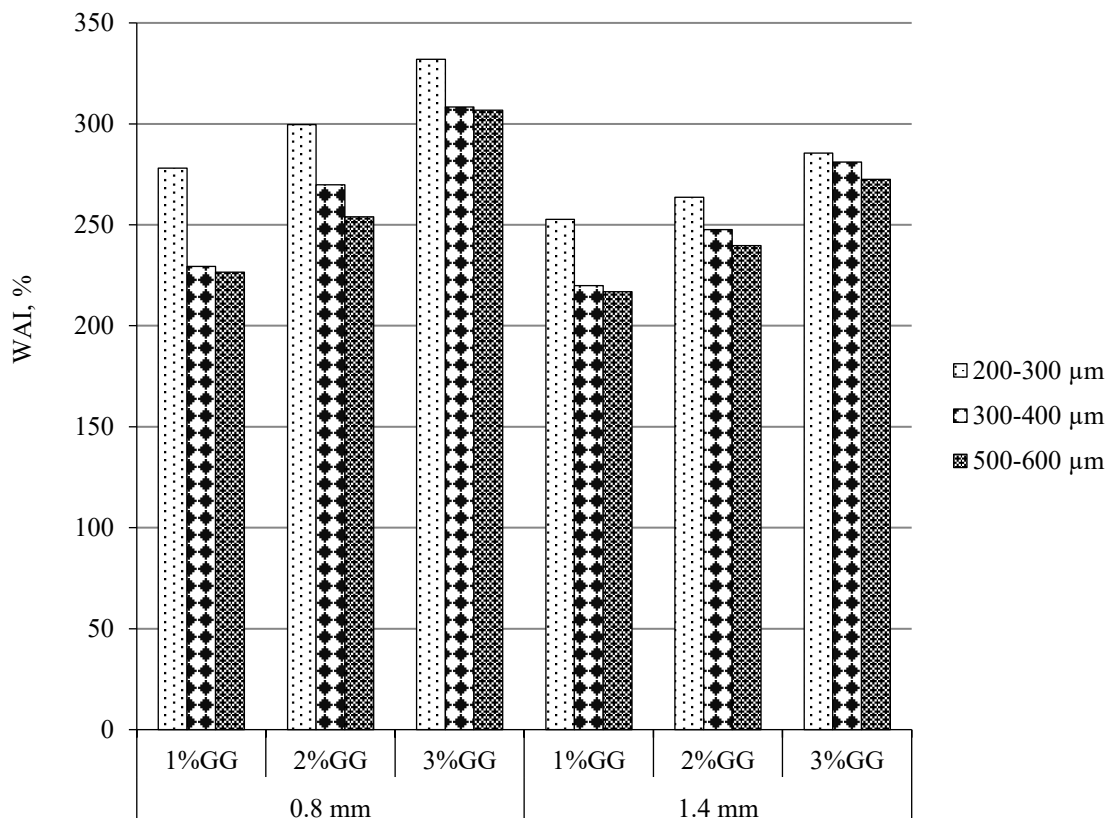
The ranges of WAI (Figure 5) of different samples obtained from the study were found to vary from 216.94% to 331.92%. The highest value of WAI was obtained from sample with FPS 200–300  $\mu\text{m}$ , 0.8

mm thickness prepared by using 3% GG which had lower particle size, highest amount of guar gum and smaller thickness and pasta sample prepared by FPS 500–600  $\mu\text{m}$ , 1.4 mm thickness prepared by using 1% GG had lowest WAI, i.e., 216.94% which had higher particle size, least amount of guar gum and higher thickness (Table 6). Similar results were obtained by Jukanti et al. (2012) [27].

**Table 5.** ANOVA of swelling index.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	F-Tabulated ( $p \leq 0.01$ )
Factor ST	1	1.207	1.207	70.133	7.40
Factor GG	2	0.245	0.122	7.105	5.25
Int ST X GG	2	0.014	0.007	0.420	5.25
Factor FPS	2	0.018	0.009	0.517	5.25
Int ST X FPS	2	0.052	0.026	1.498	5.25
Int GG X FPS	4	0.010	0.003	0.146	3.89
Int ST X GG X FPS	4	0.853	0.213	12.384	3.89
Error	36	0.620	0.017		
Total	53	3.018			

Note: ST, Sheet thickness; GG, Guar gum; FPS, Particle size of flour.



**Figure 5.** WAI of multigrain pasta.

### WSI

Water solubility index is also considered (Table 8) as the important parameter to check the quality of pasta [57]. Higher the WSI (Figure 6), lower will be the quality characteristics of pasta [58]. The water solubility index of developed multigrain pasta (Table 7) varied from 11.30% to 18.97%. Pasta sample having FPS 400–500  $\mu\text{m}$ , 1.4 mm thickness prepared by using 1% GG was observed to have least WSI, i.e., 11.30% and pasta having FPS 500–600  $\mu\text{m}$ , 0.8 mm thickness prepared by using 1% GG had highest WSI, i.e., 18.97% (Table 9). Similar results were obtained by Zweifel et al. (2003) [59].

**Table 6.** ANOVA of water absorption index.

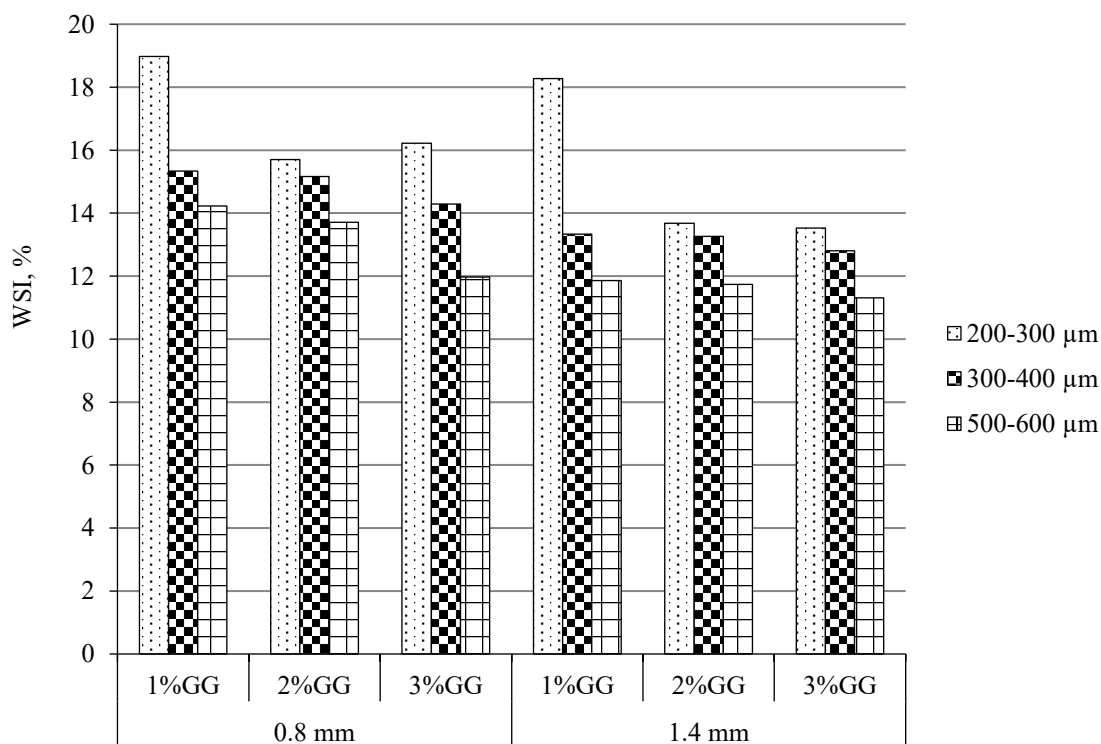
Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	F- Tabulated ( $p \leq 0.01$ )
Factor ST	1	2,022.972	2,022.972	1.549	7.40
Factor GG	2	1,731.909	865.955	0.663	5.25
Int ST X GG	2	2,933.360	1,466.680	1.123	5.25
Factor FPS	2	137.442	68.721	0.053	5.25
Int ST X FPS	2	718.927	359.464	0.275	5.25
Int GG X FPS	4	257.103	64.276	0.049	3.89
Int ST X GG X FPS	4	3,669.983	917.496	0.703	3.89
Error	36	47,016.117	1,306.003		
Total	53	58,487.813			

Note: ST, Sheet thickness; GG, Guar gum; FPS, Particle size of flour.

**Table 7.** ANOVA of water solubility index.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	F- Tabulated ( $p \leq 0.01$ )
Factor ST	1	88.834	88.834	35.279	7.40
Factor GG	2	29.868	14.934	5.931	5.25
Int ST X GG	2	2.379	1.189	0.472	5.25
Factor FPS	2	0.553	0.276	0.110	5.25
Int ST X FPS	2	3.591	1.795	0.713	5.25
Int GG X FPS	4	2.397	0.599	0.238	3.89
Int ST X GG X FPS	4	40.669	10.167	4.038	3.89
Error	36	90.651	2.518		
Total	53	258.941			

Note: ST = Sheet thickness, GG = Guar gum, FPS = Particle size of flour.

**Figure 6.** WSI of multigrain pasta.

**Table 8.** Comparison of cooking characteristics of control and multigrain pasta.

Sample	Cooking Time (minute)	Cooking Loss (%)	Cooked Weight (g)
P14	11:10 ± 0.08*	10.61 ± 0.29*	11.79 ± 0.09
P24	11:10 ± 0.07*	9.58 ± 0.15*	11.37 ± 0.28*
P34	11:50 ± 0.17*	6.49 ± 0.47*	11.07 ± 0.24*
P15	7:10 ± 0.17*	7.83 ± 0.07*	13.42 ± 0.15*
P25	7:15 ± 0.32*	7.50 ± 0.05*	12.68 ± 0.10*
P35	7:30 ± 0.03*	5.64 ± 0.19	12.44 ± 0.10*
Q14	9:05 ± 0.19*	14.21 ± 0.05*	13.04 ± 0.82*
Q24	10:45 ± 0.02*	12.15 ± 0.12*	12.60 ± 0.43*
Q34	10:10 ± 0.17*	8.19 ± 0.15*	12.53 ± 0.30*
Q15	6:20 ± 0.08*	12.85 ± 0.08*	14.53 ± 0.02*
Q25	6:30 ± 0.06*	10.47 ± 0.08*	14.40 ± 0.16*
Q35	6:25 ± 0.07*	6.07 ± 0.04*	12.61 ± 0.33*
R14	7:20 ± 0.01*	17.32 ± 0.19*	13.68 ± 0.21*
R24	7:35 ± 0.04*	14.35 ± 0.15*	12.54 ± 0.24*
R34	8:20 ± 0.02*	10.58 ± 0.13*	12.32 ± 0.19*
R15	5:15 ± 0.02*	15.81 ± 0.04*	15.66 ± 0.13*
R25	5:20 ± 0.05*	12.35 ± 0.16*	14.87 ± 0.17*
R35	6:15 ± 0.02*	8.79 ± 0.20*	14.22 ± 0.23*
Control	7:25 ± 0.28	5.64 ± 0.46	11.82 ± 0.14
F value	767.51 <sup>S</sup>	1097.08 <sup>S</sup>	58.81 <sup>S</sup>
LSD	0.12	0.17	0.27

Note: Values are means ± SD of three replications; P, FPS of 200–300 µm; Q, 400–500 µm; R, 500–600 µm; 1, 2 and 3, Amount of GG in %; 4 and 5, thickness of sheet (1.4 mm and 0.8 mm respectively); \*Means are significantly different at  $p \leq 0.01$ ; <sup>S</sup> = Significant.

**Table 9.** Comparison of cooking characteristics of control and multigrain pasta.

Sample	Swelling Index	WAI (%)	WSI (%)
P14	1.21 ± 0.05*	252.63 ± 0.12*	18.27 ± 0.11*
P24	1.27 ± 0.06*	263.63 ± 0.22*	13.67 ± 0.74*
P34	1.34 ± 0.04	285.50 ± 0.05*	13.53 ± 0.67
P15	1.48 ± 0.004*	278.13 ± 0.11*	18.98 ± 0.07*
P25	1.53 ± 0.02*	299.63 ± 0.17*	15.70 ± 0.42*
P35	1.68 ± 0.03*	331.92 ± 0.02*	16.22 ± 0.46*
Q14	1.46 ± 0.04*	219.85 ± 0.02	13.33 ± 1.16*
Q24	1.50 ± 0.09*	247.64 ± 0.04*	13.26 ± 0.63*
Q34	1.52 ± 0.09*	281.15 ± 0.29*	12.80 ± 0.71*
Q15	1.53 ± 0.006*	229.46 ± 0.04*	15.34 ± 0.30*
Q25	1.84 ± 0.04*	269.85 ± 0.11*	15.16 ± 0.008*
Q35	1.93 ± 0.005*	308.27 ± 0.25*	14.29 ± 1.19*
R14	1.58 ± 0.06*	216.94 ± 0.006	11.86 ± 0.43*
R24	1.60 ± 0.16*	239.693 ± 0.03*	11.74 ± 1.23*
R34	1.73 ± 0.04*	272.509 ± 0.05*	11.30 ± 0.78*
R15	1.90 ± 0.005*	226.473 ± 0.02*	14.22 ± 0.76*
R25	1.97 ± 0.03*	254.030 ± 0.05*	13.70 ± 0.95*
R35	2.13 ± 0.02*	306.750 ± 0.06*	11.97 ± 1.49*
Control	1.36 ± 0.03	210.23 ± 8.98	8.10 ± 0.35
F value	49.29 <sup>S</sup>	18.89 <sup>S</sup>	21.55 <sup>S</sup>
LSD	0.05	12.37	0.76

Note: Values are means ± SD of three replications; P, FPS of 200–300 µm; Q, 400–500 µm; R, 500–600 µm; 1, 2 and 3, Amount of GG in %; 4 and 5, thickness of sheet (1.4 mm and 0.8 mm respectively); \*Means are significantly different at  $p \leq 0.01$ ; <sup>S</sup> = Significant.

## CONCLUSIONS

The present study was conducted to develop multigrain pasta by incorporating flours of wheat, chickpea, kodo millet and finger millet of particle sizes 200–300 µm, 400–500 µm and 500–600 µm in ratio of 40:30:20:10 with 1%, 2% and 3% of guar gum to study the effects of them in cooking characteristics, such as cooking time, cooking loss, cooked weight, swelling index, WAI and WSI of multigrain pasta. The study showed that pasta prepared with FPS (flour particle size) 400–500 µm, thickness 0.8 mm and 3% GG (guar gum) had cooking time of 6:25 minutes with cooking loss of 6.07% which is near recommended loss for millet-based pasta. Also, the WAI was found to be maximum as 308.27%. All the parameters were found significantly different from the responses of control pasta samples. The study revealed that multigrain pasta with least cooking time and loss can successfully be made from above mentioned four ingredients in selected ratios using flour of particle size 400–500 µm, thickness 0.8 mm and 3% GG which are significantly better than control pasta prepared from 100% wheat flour.

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