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Pearl Millet-Based Pasta and Noodles Incorporated with *Jamun* Seed Powder: Quality Analysis

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ABSTRACT: Noodles and pasta were made using a blend of refined flour, pearl millet flour, and *jamun* seed powder. Pasta and noodles were made with varying amounts of *jamun* seed powder (5% to 20%) and a substantial proportion of pearl millet flour (40% to 50%). The findings indicate that adding *jamun* seed powder and pear millet flour affects the sensory characteristics. With up to 10% *jamun* seed powder in pasta and 5% in noodles, the taste is still acceptable. *Jamun* seed powder incorporation changed the amount of nutrients in pasta and noodles. There were notable differences in ash content, which ranged from 0.81% to 1.24% in pasta and 0.81% to 1.101% in noodles. Calcium levels varied between 52.46 to 68.05 mg/100g in pasta and 50.78 to 58.53 mg/100g in noodles. Zinc content ranged from 1.92 to 2.45 mg/100g in pasta and 1.97 to 2.25 mg/100g in noodles. Phosphorus levels were observed between 195.80 to 176.14 mg/100g in pasta and 198.86 to 188.70 mg/100g in noodles. Significant differences were noted in phytic acid and polyphenol content in pasta, while noodles showed non-significant variations. The digestibility of starch was not affected, but protein digestibility decreased in *jamun* seed powder incorporated in pasta and noodles. Products containing *jamun* seeds maintained their sensory profile in terms of taste, appearance, and texture during the storage study (90 days). The samples retained their color, appearance, texture, taste, and overall acceptability better than control samples. Additionally, the significant reduction in peroxide value and fat acidity in products incorporated with *jamun* seed powder suggested potential antioxidant and anti-rancidity properties. The development of noodle and pasta products incorporating pearl millet and *jamun* seed powder offers a healthier food alternative at the market level, providing nutritional benefits to consumers, while at the industry level; it fosters innovation and meets the growing demand for nutrient-dense products.

Key words: *Jamun* seed powder, noodles, nutrients digestibility, pasta, Pear millet flour, sensory

Pasta and noodles are widely consumed staple foods, appreciated for their taste, convenience, and versatility in various cuisines worldwide (Adegunwa *et al.*, 2012). Traditionally, these products are made from wheat flour, which is a rich source of carbohydrates (Betoret *et al.*, 2011). However, in recent years, there has been a growing interest in exploring alternative grains and seeds to enhance the nutritional profile and functional properties of these popular food items. Pearl millet (*Pennisetum glaucum*) and *jamun* seeds (*Syzygium cumini*) are two such ingredients that have gained attention for their potential health benefits and unique flavor profiles. Pearl millet, known as "*Bajra*" in India, is a drought-tolerant and nutritionally dense grain (Singh, 2003). It is a significant dietary component in several regions, especially in South Asia and Africa. Pearl millet is rich in essential nutrients, including proteins, dietary fiber, vitamins, and minerals (Vaijapurkar *et al.,* 2015, Kaushik and Grewal, 2017). Moreover, it possesses antioxidant properties, gluten-free properties (Veena, 2004) contributing to its potential as a functional ingredient in food formulations. *Jamun* seeds, derived from the Indian black plum tree, are recognized for their medicinal properties in traditional medicine systems (Sidana *et al.*, 2017). They are a good source of nutrients such as vitamins, minerals (Raza *et al.*, 2015), phenolic compounds (Banu and Jyothi, 2016), flavonoids, and other bioactive compounds (Rahman and Baishnab, 2016) with antioxidant and anti-inflammatory properties. The inclusion of *jamun* seeds in food products has been suggested to confer health benefits and enhance product stability. Considering the nutritional and functional attributes of pearl millet and *jamun* seeds, incorporating them into pasta and noodles presents an opportunity to create innovative and healthier food options. The addition of these ingredients can potentially improve the protein content, fiber content, and antioxidant activity of the products, offering health-conscious consumers a viable alternative to conventional wheat-based pasta and noodles. This study aims to explore the feasibility of developing pearl millet and *jamun* seed-incorporated pasta and noodles and evaluate their organoleptic acceptability, nutrient content, and oxidative stability during storage. The findings from this research can provide valuable insights into the utilization of these underutilized grains and seeds in the development of value-added and nutritious pasta and noodles, contributing to the diversification of the food industry and promoting healthier food choices.

MATERIALS AND METHODS

Material and preparation: Pearl millet (HC 10 variety) was obtained from the Genetics and Plant Breeding Department of Chaudhary Charan Singh Haryana Agricultural University (HAU) in Hisar. To prepare the pearl millet, the grains were washed to remove dirt, soil, and foreign substances. Fresh *jamun* fruits were purchased from a local market in Hisar. They were washed, then the pulp was extracted and the seeds were separated. The seeds were dried in the shade for 24 hours at room temperature and then placed in a hot air oven at 55±5°C until their moisture level reached 3.90%. The dried *jamun* seeds were then ground into powder, sieved to remove any lumps, and stored under hygienic conditions for future use.

Ingredients used for preparation of raw pasta and noodles: Pearl millet flour, refined wheat flour, *jamun* seed powder, guar gum (0.50gm for pasta and 0.75 gm for noodles in all formulations), water (40 ml for pasta and 50 ml for noodles in all formulations).

Types of pasta

Control- Pearl millet flour (50g), Refined wheat flour (50g), *Jamun* seed powder (0g)

Type I- Pearl millet flour (45g), Refined wheat flour (45g), *Jamun* seed powder (10g)

Type II- Pearl millet flour (42.5g), Refined wheat flour (42.5g), *Jamun* seed powder (15g)

Type III- Pearl millet flour (40g), Refined wheat flour (40g), *Jamun* seed powder (20g)

Types of noodles

Control- Pearl millet flour (50g), Refined wheat flour (50g), *Jamun* seed powder (0g)

Type I- Pearl millet flour (47.5g), Refined wheat flour (47.5g), *Jamun* seed powder (5g)

Type II- Pearl millet flour (45g), Refined wheat flour (45g), *Jamun* seed powder (10g)

Type III- Pearl millet flour (42.5g), Refined wheat flour (42.5g), *Jamun* seed powder (15g)

Method

Pasta: Blended *jamun* seed powder, pearl millet, and refined wheat flour. Dissolved guar gum in warm water for 1 hour for gel consistency. Mixed flour, *jamun* powder, and guar gum gel to form a stiff dough. Extruded dough through an extruder. Dried pasta on trays at room temperature for 24 hours.

Ingredients and method: Ingredients for all types of pasta were in equal proportions: pasta (25g), capsicum (10g), carrot (10g), mushrooms (10g), and white sauce (as required). For 25 gm of pasta, the white sauce preparations required ingredients such as butter (7g), refined wheat flour (15g), milk (40ml), black pepper powder, oregano, chilli flakes, and salt (¼tsp). **Sauce preparation:** In a pan, melted butter and let it reach a liquid state. Gradually added refined flour and stirred continuously for about 2-3 minutes. Poured milk into the pan and mixed thoroughly to create a smooth paste. Enhanced the flavor by adding black pepper powder, oregano, chilli flakes, and salt. To prepare the pasta firstly heated water in a pan, added oil and salt. Cooked pasta in the boiling water until tender but still firm. Drained the pasta and blot dried it on filter paper to remove excess water. Blanched vegetables separately in boiling water. Added the blanched vegetables to the white sauce and stirred for 2-3 minutes. Added the pre-boiled pasta to the sauce and mixed gently. Cooked for an additional 2-3 minutes, stirring occasionally, and served (Plate 1).

Noodles: Sieved pearl millet flour and *jamun* seed powder. Prepared guar gum gel by adding a measured quantity of warm water and keeping it aside for 15

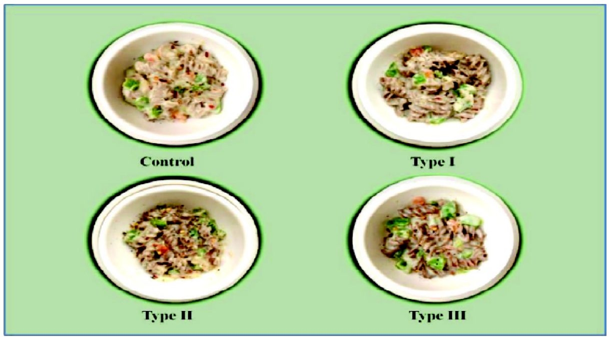

Plate 1: Types of Pasta

minutes. Manually mixed the flour with guar gum gel to form a stiff dough, let it rest for 30 minutes. Extruded dough into sheets. Cut sheets into noodles and air-dried overnight on trays. I**ngredients and method:** Ingredients for all types of noodles were in equal proportion: Noodles (50g), onion (15g), tomato (10g), cabbage (15g), capsicum (10g), oil (45ml), salt (1 tsp), black pepper (¼tsp), soy sauce (¼tsp), tomato sauce (1 ½tbsp), and green chilli sauce(½tsp). For cooking noodles, firstly boiled water and added oil, salt, and noodles to the pan. When the noodles were tender, drained the water and placed them on paper to remove excess moisture. Then, heated oil and sautéed all chopped vegetables until they softened. Seasoned the vegetables with salt and black pepper, then added the boiled noodles and lastly added some soy sauce, tomato sauce, and chili sauce. Mixed it well and served it (Plate 2).

Sensory evaluation

A panel of 10 judges used a 9-point scale to evaluate the taste and other sensory qualities of pasta and noodles (Peryam *et al.,* 1957). The judges panel was not professionally trained, but well experienced in conducting the sensory evaluations. Additionally, the highly acceptable pasta and noodles were evaluated for their nutritional content.

Nutritional assessment

To determine the chemical composition of the samples, standard methods outlined by the AOAC (2000) were employed. Moisture content was measured by drying a 5gm sample in a pre-weighed petri dish in a hot air oven at 100°C for 6 hours. The weight loss due to drying was used to calculate moisture content.

Moisture content (%) = $(W_2 - W_3) / (W_2 - W_1) \times 100$
Where: - W_1 is the weight of the empty petri dish (grams) - W_2 is the weight of the petri dish with sample before drying (grams) - W_3 is the weight of the petri dish with dried sample (grams)
To measure crude protein content, MicroKjeldahl method (established by AOAC in 2000) was used with an Automatic KEL PLUS CLASSIC–DX apparatus. A 0.2gram sample was heated in 10 ml of sulfuric acid and a catalyst mixture until the solution became colorless. The samples were then distilled using a distillation unit containing 40% NaOH, 4% boric acid, and an indicator. The distilled sample was titrated with 0.1N HCl until the color became slightly pinkish. Nitrogen Content Calculation:
Nitrogen % = (Sample titration - Blank titration) × (Normality of HCl) × 14) / (Sample weight × 1000) × 100
Crude Protein Calculation: 6.25 (conversion factor) × Nitrogen %

To measure crude fat content, a standardized AOAC (2000) method was employed. The extraction apparatus (Automatic SOCS plus) used petroleum ether (auto solvent) as the extraction solvent. Two grams of sample were placed in thimbles and extracted for 1:30 hours using petroleum ether. The extract was collected in pre-weighed beakers, which were dried in a hot air oven at 100°C overnight and cooled in desiccators to obtain a constant weight. The fat percentage was calculated as $[(W_2 - W_1)/W] \times 100$.
Where, W is the sample weight (gm), W_1 is the empty beaker weight (gm), and W_2 is the beaker with fat weight (gm)

To determine the ash content, the AOAC (2000) method was used. A two-gram sample was placed in a pre-weighed crucible and charred. The crucible was then heated in a muffle furnace at 550-650°C for six hours, or until the weight remained constant. The crucible was then removed from the furnace, cooled in desiccators, and weighed. The ash content was calculated using the following formula: Ash (%) = $[(W_2 - W_3) / (W_2 - W_1)] \times 100$

Where: W_1 is the weight of the empty silica crucible in grams, W_2 is the weight of the sample plus the weight of the crucible before ashing in grams, W_3 is the weight of the sample plus the weight of the crucible after ashing in grams

To determine the crude fiber content, the AOAC (2000) method was employed. A defatted sample (extracted with petroleum ether) was digested for 30 minutes under reflux with 1.25% H_2SO_4 followed by 1.25% NaOH. The solution was then washed with distilled water (twice), alcohol (twice), and acetone (three times). After washing, the sample was dried at 100°C and then ashed in a furnace (muffle) at 550°C for 1 hour. The fiber content was calculated as the difference in weight between the sample before and after ignition, expressed as a percentage of the initial sample weight. Crude Fiber Content (%) = $[(W_2 - W_3) / W_1] \times 100$

W_1: Weight of the sample (grams) * W_2: Weight (gm) of the insoluble matter (crucible weight + insoluble matter - crucible weight), W_3: Weight (gm) of the ash (crucible + ash - weight of crucible)

Lindsey and Norwell's (1969) technique was used to analyze total minerals using an atomic absorption spectrophotometer (PERKIN-ELMER, USA). Samples were digested with a mixture of hydrochloric acid ($HClO_4$) and nitric acid (HNO_3) (1:5 volume/volume), and left overnight. Samples were heated until clear, with visible white precipitation on the surface of the flask. The samples were filtered using a Whatman (42) filter and rinsed with distilled water. Volume was adjusted to 50 ml with double-distilled water for mineral content estimation. Readings were taken using a spectrophotometer, flame photometer, and titration. Calculation:

Total Mineral Content (mg/100g) = [Reading (concentration µg/ml) × Volume (ml)] / [Sample Weight (gm) × 1000] × 100

In vitro protein digestibility was assessed by using the modified method of Mertz *et al.* (1983). A sample weighing 250 mg was put into a centrifuge tube with 20 ml of pepsin reagent. The tube was closed and shaken in an incubator kept at 37°C for 3 hours. It was then cooled and 5 ml of 50% TCA was added. The contents were centrifuged for 10 minutes at 10,000 rpm at room temperature and then filtered. 10 ml of the filtrate was dried in an oven and digested using the Microkjeldahl method (AOAC, 2000) to determine protein content. Protein digestibility was calculated using the formula: Protein digestibility (%) = (Digested protein / Sample protein) x 100

Singh *et al.* (1982) method was used to evaluate the *in vitro* digestibility of starch. One milliliter of 0.2 M phosphate buffer (pH 6.9) containing fifty milligrams of defatted sample was mixed with 0.5 milliliter of pancreatic amylase, and the test tubes were sometimes shaken while the mixture was incubated at 37°C for two hours. Following incubation, a boiling water bath was used to rapidly add two milliliters of dinitrosalicyclic reagent and then heated it for five minutes. After cooling, distilled water was added to make the solution to 25 ml, and the absorbance was measured at 550 nm. Simultaneously, a blank was performed by incubating the material without the enzyme. The enzyme solution was added after the addition of the dinitrosalicyclic reagent. The results were given as mg of maltose released per g of sample. A standard maltose solution containing 0.5–4.0 mg of maltose was used to produce the standard curve.

Davies and Reid's (1979) approach was used to determine the amount of phytic acid present in the sample. A sample weighing 500 gm was extracted with 20 ml 0.5M HNO_3 for 3 hours through continuous shaking. The extract sample was filtered through Whatman No.1 filter paper. Filtrate was used for phytic acid estimation. Combined 1 ml HNO_3 extract with 1.4 ml water and added 1 ml ferric ammonium sulphate solution. Boiled for 20 minutes and cooled, then 5 ml iso-amyl alcohol was added. Mixed vigorously followed by adding 0.1 ml ammonium thiocyanate solution. Centrifuged at 3000 rpm for 10 minutes. Color intensity read at 465 nm against iso-amyl alcohol blank after 15 minutes. Standard curve was plotted using 0.4-1.0 ml standard phytate solution containing 80-200 mg phytic acid.

Singh and Jambunathan (1981) method was used to extract the polyphenols. The defatted sample (500 mg) was refluxed with 50 ml of 1% HCl in methanol for 4 hours. Concentrated extract's volume was adjusted to 25 ml with methanolic-HCl. Then, 1.5 ml test solution was further diluted to 8.5 ml with water. Added 0.5 ml Folin-Denis reagent and shaken. After 3 min, added 1 ml saturated sodium carbonate, again it was shaken. The absorbance read at 725 nm after 1 hour time. If the consistency seemed cloudy, it was centrifuged before the reading. Standard curve was plotted using 0.2-1.0 ml working tannic standard solution (20-100 µg tannic acid).

Polyphenols (mg/100gm) = $M \times V \times 100 / W \times V_1 \times 1000$ Where, M = Concentration of extract elute obtained from graph, V = Volume made of extract (ml), W = Weight (g) of sample, V_1 = Volume of extract aliquot taken (ml)

The shelf life of pasta and noodles was assessed by monitoring their sensory quality, acidity of fats, and oxidation levels over a three-month storage period following established guidelines (AOAC, 2000).

Fat acidity- Ten grams of the sample was extracted with petroleum ether using the Soxhlet apparatus. The solvent from extract was then evaporated on a steam bath. The residue was dissolved in 50 ml benzene-alcohol-phenolphthalein solution and titrated with standard potassium hydroxide (1g/L) to orange-pink color. Blank titration was performed with 50 ml benzene-alcohol-phenolphthalein, the obtained value was subtracted from sample titration value. Fat acidity was calculated as mg of potassium hydroxide needed to neutralize free fatty acids per 100g of sample. Fat acidity = 10 × (T-B) Where, T = ml of KOH required to titrate sample extract, B = ml KOH required to titrate blank

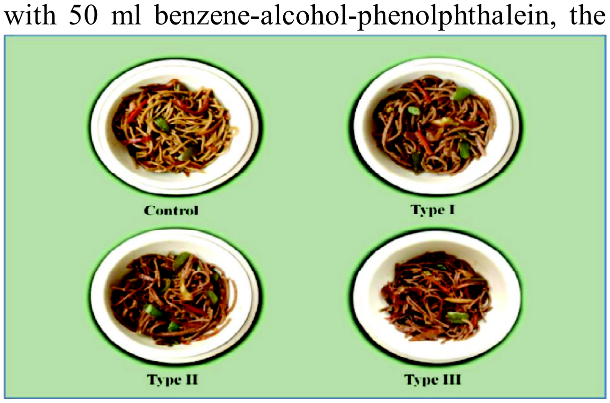

Plate 2: Types of Noodles

Peroxide value - One gram of fat sample was placed in a conical flask. Added 10 ml of acetic acid-chloroform mixture to the sample, swirled to dissolve. Added 0.5 ml saturated potassium iodide and left for 1-2 minutes with occasional shaking. Then added 20 ml distilled water. It was slowly titrated against 0.01 N sodium thiosulfate until yellow color nearly vanished. After that, added 1 ml starch solution and continued the titration with vigorous shaking until blue color was disappeared from the layer of chloroform. Blank was treated in a similar manner. Peroxide value was calculated accordingly.

Peroxide value (meq peroxide/1000g) = (S-B) × N ×1000 / weight of sample
Where, B = Volume (ml) of $Na_2S_2O_3$ used for titration of blank, S = Volume (ml) of $Na_2S_2O_3$ used for titration of sample. N = Normality of $Na_2S_2O_3$ solution

Statistical analysis

The quality data was evaluated using statistical analysis. This analysis included calculating the mean, standard error, and conducting an ANOVA test as described in the standard method by Sheoran and Pannu (1999). The hypothesis being tested was whether incorporating *jamun* seed powder into pearl millet flour for pasta and noodle products would affect their nutritional and sensory properties. Null Hypothesis (H0): There will be no difference in the sensory and nutritional qualities of pasta and noodles made with *jamun* seed powder compared to those prepared without *jamun* seed powder. Alternative Hypothesis (Ha): There will be a difference in the sensory and nutritional qualities of pasta and noodles made with *jamun* seed powder: One-tailed test (Ha: 0 > 0): The sensory and nutritional qualities of pasta and noodles with *jamun* seed powder will be better than the control. Two-tailed test (Ha: 0 #0): The sensory and nutritional qualities of pasta and noodles with *jamun* seed powder will differ from the control.

RESULTS AND DISCUSSION

Sensory analysis

The results (Table 1) indicated that the incorporation of *jamun* seed powder into pearl millet-based pasta and noodles had variable effects on sensory acceptability. The control pasta received the highest mean scores for color (8.00±0.30), appearance (7.70±0.30), aroma (7.60±0.22), texture (7.40±0.27), taste (7.80±0.33), and overall acceptability (7.70±0.25). Type I, II, and III pasta showed no significant difference in appearance, aroma, or texture whereas significant differences were observed in color, taste, and overall acceptability mean scores. Notably, Type I, Type II, and Type III pasta formulations exhibited a decrease in 'overall acceptability' compared to the control, with each falling into the category of being 'liked moderately'. The control noodles showed higher mean scores for color (7.60±0.14), appearance (7.60±0.14), aroma (7.45±0.15), texture (7.45±0.15), taste (7.30±0.15), and overall acceptability (7.48±0.13). The overall acceptability of noodles significantly declined from 7.48 (liked moderately) in control to 5.28 (neither liked nor disliked) in Type III noodles made by incorporating 15 % *jamun* seed powder as indicated by scores obtained. The reduction in overall acceptability with increasing *jamun* seed content might be attributed to the unique taste and flavor of *jamun* seeds, which could be less preferred by consumers accustomed to the taste of traditional pasta and noodles. Similar results for overall acceptability (8.08 to 6.62) were reported by *Gull et al.,* (2017) for control pasta and noodles, pasta prepared with pearl millets and semolina with different ratios. The sensorial mean score of the present results were in accordance with Deshmukh and Parmar (2021) who developed noodles with pearl millet with different treatments having an overall acceptability mean score ranging from 7.4 to 6.62. Thorat and Khemnar (2014) found that cookies with up to 40% jamun seed powder were satisfactory organoleptically. Savita *et al.* (2023) found similar sensory results in biscuits, *chapatti, dalia,* and *upma* developed with a 20% incorporation of pearl millet and *jamun* seed powder.

Nutritional analysis

The results (Table 2) indicated that the incorporation of *jamun* seed powder into pearl millet-based pasta and noodles had variable effects on nutritional profile. The moisture content decreased slightly in Type I pasta (58.13%) and noodles (53.76%) developed with *jamun* seed powder (Type I), compared to regular pasta (61.63%) and noodles (54.66%). However, these differences were not statistically significant (Table 2). Control noodles and pasta had crude protein ranging from 9.66% to 10.13%, while Type I had 8.76% to 9.89%. Type I noodles had less protein than control noodles, but there was no significant difference in protein between Type I and control pasta. The amount of fat in controls and Type I pasta and noodles did not differ significantly from one another. Fat content ranged from 7.80 to 11.91% and 7.80 to 11.83 % in control and Type I products. The ash content was significantly increased in *jamun* seed powder incorporated (type I) pasta and noodles compared to their controls. Pasta and noodles of Type I had ash contents of 1.24% and 1.01%, which were significantly greater than those of their controls. The crude fiber content of Type I pasta and noodles were in the range of 2.22 to 2.47 % which was slightly higher than the control's range of 2.15 to 2.38 percent. A significant difference was observed in calcium content between control and Type I treatments for both pasta and noodles. Type I pasta and noodles contained 50.62 to 68.05 mg/100g of calcium, while control samples ranged from 35.03 to 52.46 mg/100g. The amount of phosphorus (188.70 to 176.14 mg/100g) significantly decreased in Type I pasta and noodles compared to their controls (198.86 to 195.80 mg/100g). There was a non-significant difference in the iron level between the control and Type I noodles, while there was a significant difference between the controls (4.45 mg/100gm) and Type I (4.80 mg/100gm) pasta. Zinc levels in Type I noodles and pasta varied from 2.25 to 2.45 mg/100g, whereas controls had between 1.92 and 2.06 mg/100g. The zinc concentration of the control and Type I pasta and noodles differed significantly. There was no statistically significant difference observed between the control and Type I pasta and noodles for magnesium content. *In vitro* protein digestibility for pasta and noodles in the control sample was 63.07 and 60.72 percent, respectively. However, in Type I pasta and noodles the protein digestibility was 58.59 and 58.66 percent. A non-significant difference was observed in noodles for protein digestibility while *jamun* seed powder incorporated in pasta significantly decreased protein digestibility. A non-significant difference was observed for starch digestibility in pasta and noodles. Controls and Type I pasta and noodles had starch digestibility ranging from 30.31 to 31.09 mg maltose released/g and 30.64 to 32.25 mg maltose released/g, respectively. The phytic acid content in control pasta was 341.33 mg/100g, while Type I pasta showed a lower phytic acid content of 328.56 mg/100g. The significant difference was observed within the pasta, whereas non-significant differences occurred in noodles. In Type I treatments, the polyphenol content ranged from 246.24 to 252.73 mg/100g, while in controls for pasta and noodles, it ranged from 236.20 to 240.90 mg/100g. The polyphenol content significantly increased in pasta incorporated with *jamun* seed powder, whereas in noodles, there was a non-significant difference. Deshmukh and Parmar (2021) reported that noodles prepared with pearl millet have nutrients such as 8.2% moisture, 2.2% ash, 1.43% fat, crude protein 10.69%. The blend of 70% wheat semolina and 30% pearl millet yielded improved results, increasing protein, zinc, and iron content in the pasta (Jalgaonkar and Jha 2016). Similar patterns were seen by Marufa *et al.* (2019) in cakes using 30% *jamun* seed powder: ash content increased while moisture, protein, and fat levels dropped. Savita *et al.* (2023) developed biscuits and Indian breakfast items (chapati*, dalia, upma*) with *jamun* seed powder, assessing their nutritional profile. Nutritional composition such as crude fiber, calcium, iron, zinc, polyphenols content increased while the amounts of protein, fat, phosphorus, and phytic acid significantly decreased when 10% *jamun* seed powder was added. The current research observed similar patterns in nutrient changes, indicating increases or decreases in line with the findings from the previous study (Savita *et al.,* 2023).

Storage study

The results (Table 3) indicate that the incorporation of *jamun* seeds had variable effects on the sensory scores of pasta and noodles during storage durations of 0 to 90 days. Changes in sensory scores were observed over time, indicating fluctuations in sensory perception. The color and appearance mean score declined significantly from 'liked very much' to 'liked moderately' during storage (90th day) in control noodles and pasta. Type I pasta's appearance remained 'liked moderately' throughout storage.

Table 1: Mean scores for sensory acceptability of pearl millet based pasta and noodles incorporated with *jamun* seed powder

Product	Color	Appearance	Aroma	Texture	Taste	Overall acceptability
			Mean score			
			Pasta			
Control	8.00±0.30	7.70±0.30	7.60±0.22	7.40±0.27	7.80±0.33	7.70±0.25
Type I	7.40±0.31	7.40±0.31	7.50±0.22	7.10±0.35	7.60±0.34	7.40±0.27
Type II	6.85±0.21	6.85±0.21	7.35±0.15	6.95±0.28	6.85±0.26	7.03±0.15
Type III	6.75±0.23	6.75±0.27	7.35±0.15	6.85±0.30	6.35±0.32	6.81±0.19
C.D.($P \leq 0.05$)	0.76	NS	NS	NS	0.90	0.63
			Noodles			
Control	7.60±0.14	7.60±0.14	7.45±0.15	7.45±0.15	7.30±0.15	7.48±0.13
Type I	7.10±0.19	7.10±0.19	6.85±0.18	6.85±0.18	6.70±0.13	6.92±0.16
Type II	6.80±0.29	6.60±0.26	5.70±0.15	5.60±0.16	5.40±0.22	6.02±0.13
Type III	5.60±0.22	5.60±0.22	5.30±0.15	5.20±0.20	4.70±0.21	5.28±0.15
C.D.($P \leq 0.05$)	0.63	0.60	0.46	0.50	0.53	0.42

Values are mean ± SE of ten independent determinations, NS= Non-significant

Table 2: Nutrients profiling of pearl millet based pasta and noodles incorporated with *jamun* seed powder

	Pasta			Noodles		
Nutrients	Control	Type I	t value	Control	Type I	t value
			Proximate compositions (% dry matter basis)			
Moisture*	61.63±0.80	58.13±1.72	3.18^{NS}	54.66±1.41	53.76±1.10	0.86^{NS}
Crude protein	10.13±0.50	9.89±0.38	0.65^{NS}	9.66±0.32	8.76±0.44	2.86*
Fat	11.91±0.06	11.83±0.06	1.45^{NS}	9.11±0.07	8.98±0.10	1.75^{NS}
Crude FiberAsh	2.34±0.05	2.47±0.10	1.96^{NS}	2.15±0.06	2.22±0.06	1.37^{NS}
	0.81±0.02	1.24±0.04	15.63**	0.81±0.03	1.01±0.01	9.97**
			Total minerals (mg/100gm on dry matter basis)			
CalciumIron	52.46±2.10	68.05±2.06	9.17**	50.78±2.25	58.53±2.85	3.69*
Iron	4.45±0.13	4.84±0.12	3.66*	4.35±0.12	4.32±0.06	0.32^{NS}
Zinc	1.92±0.04	2.45±0.12	6.84**	1.97±0.03	2.25±0.04	9.00**
Magnesium	105.30±2.09	105.28±4.07	0.00^{NS}	88.42±4.48	89.20±2.81	0.25^{NS}
Phosphorus	195.80±3.71	176.14±4.99	5.47**	198.86±2.17	188.70±3.95	3.90*
			In-vitro studies			
Protein digestibility (%)	63.07±0.19	58.59±1.85	4.16*	60.72±2.16	58.66±1.92	1.23^{NS}
Starch digestibility	30.99±0.55	31.71±0.92	1.15^{NS}	30.31±1.39	30.64±0.87	0.34^{NS}
Phytic acid (mg/100gm)	341.33±0.73	328.56±3.90	5.56*	342.06±0.80	335.62±4.88	2.25^{NS}
Polyphenols (mg/100gm)	236.20±3.45	248.70±3.85	4.18*	240.90±0.30	246.24±2.62	3.50^{NS}

Note: * - significant (P<0.05), **- significant (P<0.01), NS - non significant, Values are mean ± SE of three independent determinations, Starch digestibility expressed (mg maltose released/gm)

Table 3: Changes in sensorial scores during storage of pearl millet based pasta and noodles incorporated with *jamun* seed powder

		Pasta			Noodles		
Days	Variable	Control	Type I	t-value	Control	Type I	t-value
0	Color	8.00±0.94^{a}	7.40±0.96^{a}	1.40^{NS}	8.20±0.42^{a}	7.60±0.51^{a}	2.84*
30		7.80±0.63^{ab}	7.05±0.59^{a}	2.72**	7.85±0.52^{ab}	7.35±0.57^{ab}	2.01*
60		7.30±0.48^{bc}	7.20±0.42^{a}	0.49^{NS}	7.55±0.43^{ab}	7.15±0.47^{ab}	1.95^{NS}
90		7.15±0.57^{c}	7.15±0.57^{a}	0.00^{NS}	7.25±0.35^{b}	6.90±0.21^{b}	2.68**
0	Appearance	7.70±0.94^{ab}	7.40±0.96^{a}	0.70^{NS}	7.70±0.67^{a}	7.40±0.51^{a}	1.11*
30		8.10±0.56^{a}	7.10±0.56^{a}	3.93**	7.60±0.45^{a}	7.10±0.56^{b}	2.16*
60		7.50±0.52^{ab}	7.40±0.51^{a}	0.42^{NS}	7.40±0.45^{ab}	7.05±0.2^{b}	2.04*
90		7.30±0.67^{b}	7.10±0.31^{a}	0.84^{NS}	7.00±0.62^{b}	6.80±0.53^{b}	0.76^{NS}
0	Aroma	7.60±0.69^{a}	7.50±0.70^{a}	0.31^{NS}	7.00±0.47^{a}	6.80±0.42^{a}	1.00*
30		7.20±0.42^{a}	6.90±0.31^{b}	1.80^{NS}	6.90±0.51^{a}	6.70±0.63^{a}	0.77^{NS}
60		6.40±0.51^{b}	6.30±0.67^{c}	0.37^{NS}	6.50±0.66^{b}	6.40±0.45^{ab}	0.39^{NS}
90		6.30±0.48^{b}	6.20±0.63^{c}	0.39^{NS}	6.10±0.84^{c}	6.10±0.51^{b}	0.00^{NS}
0	Texture	7.40±0.84^{a}	7.10±1.10^{a}	0.68^{NS}	7.60±0.51^{a}	7.30±0.67^{a}	1.11*
30		7.30±0.48^{a}	7.70±0.48^{a}	1.85^{NS}	7.40±0.51^{a}	7.15±0.47^{ab}	1.12^{NS}
60		5.60±0.51^{b}	5.50±0.52^{b}	0.42^{NS}	6.90±0.56^{b}	6.85±0.57^{b}	0.19^{NS}
90		5.50±0.52^{b}	5.55±0.55^{b}	0.20^{NS}	6.60±0.51^{b}	6.65±0.47^{b}	0.22^{NS}
0	Taste	7.80±1.03^{a}	7.60±1.07^{a}	0.42^{NS}	7.30±0.48^{a}	6.60±0.51^{a}	3.13**
30		7.80±0.63^{a}	7.00±0.66^{a}	2.75**	7.10±0.56^{ab}	6.50±0.47^{a}	2.57**
60		5.70±0.48^{b}	5.40±0.51^{b}	1.34^{NS}	6.80±0.42^{bc}	6.30±0.42^{ab}	2.65**
90		5.60±0.69^{b}	5.30±0.34^{b}	1.21^{NS}	6.60±0.51^{c}	6.00±0.62^{b}	2.34*
0	Overall	7.70±0.80^{a}	7.40±0.84^{a}	0.81^{NS}	7.56±0.24^{a}	7.14±0.38^{a}	2.88**
30	acceptability	7.64±0.32^{a}	7.15±0.27^{a}	3.62**	7.37±0.35^{a}	6.96±0.36^{a}	2.55*
60		6.50±0.27^{b}	6.36±0.33^{b}	1.02^{NS}	7.03±0.23^{b}	6.75±0.17^{ab}	3.03**
90		6.37±0.29^{b}	6.26±0.22^{b}	0.95^{NS}	6.71±0.37^{c}	6.49±0.20^{b}	1.63^{NS}

Values are mean ± SE of ten independent determinations, Note I: The t-value indicates the difference between control and Type I treatment at different intervals, Note II: * - significant (P<0.05), **- significant (P<0.01), NS - non significant
Note III: Means varying different superscripts in a row differs significantly (p<0.05)

Table 4: Fat acidity and peroxide value of pearl millet based *jamun* seeds powder incorporated pasta and noodles (dry matter basis) during storage

		Pasta			Noodles		
Days	Variable	Control	Type I	t-value	Control	Type I	t-value
0	Fat acidity (mg KOH/100g)	24.60±0.16 ^{d}	23.12±0.22 ^{d}	9.07**	25.69±0.95 ^{d}	24.53±0.30 ^{d}	1.99^{NS}
30		42.62±0.03 ^{c}	40.59±0.43 ^{c}	8.14**	44.28±0.21 ^{c}	41.32±0.37 ^{c}	11.89**
60		67.84±0.71 ^{b}	64.20±0.17 ^{b}	8.57**	69.22±0.20 ^{b}	65.35±0.20 ^{b}	22.72**
90		79.42±0.42 ^{a}	75.56±0.49 ^{a}	10.31**	80.32±0.40 ^{a}	77.27±1.06 ^{a}	4.65*
0	Peroxide value (meq/1000g of fat)	3.87±0.02 ^{d}	3.72±0.01 ^{d}	11.50**	3.96±0.02^{d}	3.81±0.01 ^{d}	11.61**
30		4.37±0.00 ^{c}	4.27±0.01 ^{c}	10.96*	4.36±0.02 ^{c}	4.13±0.03 ^{c}	10.36**
60		8.24±0.03 ^{b}	8.15±0.05 ^{b}	2.52^{NS}	7.21±0.01 ^{b}	7.07±0.01 ^{b}	10.95**
90		10.90±0.01 ^{a}	10.80±0.01 ^{a}	8.66*	10.86±0.05 ^{a}	10.42±0.04 ^{a}	10.71*

Values are mean ± SE of three independent determinations, Note I: The t-value indicates the difference between control and Type I treatment at different intervals, Note II: * - significant (P<0.05), **- significant (P<0.01), NS - non significant, Note III: Means varying different superscripts in a row differs significantly (p<0.05)

Aroma scores decreased significantly from 'liked moderately' to 'liked slightly'. Texture and taste scores also significantly decreased. Overall acceptability significantly decreased from 7.56 to 6.71. Similarly, in Type I noodles the color, appearance, aroma, texture, and taste scores all significantly decreased over time. Overall acceptability also significantly decreased from 7.14 to 6.49. Aroma acceptability decreased from 'liked very much' to 'liked slightly' in both control and Type I pasta. Texture scores decreased over time in both types of pasta. Taste acceptability decreased from 'liked very much' to 'liked slightly' in control pasta and from 'liked very much' to 'neither liked nor disliked' in Type I pasta. Overall acceptability decreased from 'liked very much' to 'liked moderately' in control pasta and from 'liked moderately' to 'like slightly' in Type I pasta. There was no significant difference in fat acidity and peroxide value compared to the control and Type I noodles and pasta at the o day. The fat acidity of Type I pasta significantly decreased compared to the control from day 30 (42.62 to 40.59 mg KOH/100g) to till day 90 (79.42 to 75.56 mg KOH/100g). Similarly, the fat acidity significantly decreased in type I noodles as compared to control noodles during the storage period. Over 30, 60, and 90 days, Type I pasta showed a significant decrease in peroxide value compared to the control, while Type I noodles only exhibited significant decreases after 60 and 90 days. The results indicate that the incorporation of *jamun* seeds in pearl millet-based pasta and noodles influenced their fat acidity and peroxide value during storage. The decrease in fat acidity and peroxide value in Type I pasta and noodles suggests that *jamun* seeds may have antioxidative properties, which can inhibit the oxidation of fats during storage. This effect is beneficial as it can help maintain the quality and extend the shelf life of the products. Jalgaonkar *et al.* (2017) reported a change during storage (6 months) of pasta developed with pearl millets, the peroxide value varied from 2.10 to 5.79 meq.Kg^{-1} of oil and fat acidity value varied from 20.54 to 37.77 mg/100gm. Pearl millet has anti-nutrients; lowering nutrient bioavailability and storage requires managing bitterness, and rancidity (Nantanga *et al.,* 2008). Polyphenolic pigments cause a grey color in pearl millet grain, impacting sensory traits (Rathi *et al.,* 2004). Enzymatic breakdown increased pasta's fatty acids and peroxide value over time (Chaiyasit *et al.,* 2007; Yadav *et al.,* 2014; Kaur *et al.,* 2012). However, acceptability remained, as lipases were inactive during cooking, and water content was low. Vegetable paste raised peroxide value within limits (Yadav *et al.,* 2014). Light exposure sped oxidation in durum wheat spaghetti (Verardo *et al.,* 2009). Fat acidity rose during storage, connected to moisture and lipolysis (Nantanga *et al.,* 2008). Fat acidity is linked with bitterness. Yadav *et al.* (2014) presented a slight decrease in pasta acceptability during 90-day storage without major sensory changes. Kaur *et al.* (2012) suggested that cereal bran pasta was acceptable for up to 4 months. Pinarli *et al.* (2004) showed that 1-year storage didn't affect taste panel evaluation. Savita *et al.* (2023) stated that the incorporation of *jamun* seed powder in pearl millet for the development of biscuits increased the shelf life of stored products.

CONCLUSION

Incorporating *jamun* seed powder in pasta and noodles formulations resulted in notable improvements in various nutritional aspects. The fat content decreased, while ash, crude fiber, calcium, zinc, and polyphenols content increased, indicating a shift towards a more nutrient-rich profile. Additionally, protein digestibility was enhanced. During the storage study, lower fat acidity and peroxide values were observed compared to the control, suggesting improved stability and freshness retention. In conclusion, the incorporation of *jamun* seed powder presents a promising avenue for enhancing the nutritional quality and stability of pasta and noodles. The observed changes in nutrient content signify potential health benefits for consumers. Moreover, the improved protein digestibility further adds to the nutritional value of the products. Overall, the changes in organoleptic scores varying between pasta and noodles with *jamun* seed incorporation during storage highlight the potential influence of the extrusion process and formulation on the sensory attributes of the final products. These findings underscore the potential of innovative formulations to meet consumer demand for healthier food options while maintaining sensory appeal and product stability. These inventive extruded food items can meet the growing need for wholesome yet enticing food options in the market as customers are becoming more health conscious.

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