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Development and analysis of finger millet flour-enriched pasta

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ABSTRACT

The extensively consuming market-based pasta products due to change in social stratification and income of individuals has led to many attempts of enhancement of it to improve the nutritional advantages. The present study was designed to developed nutrient-rich pasta by using finger millet flour. The developed products were analyzed for their nutritional quality, sensory characteristics, cooking quality and storability using standard procedures. It was observed that the nutritional quality of all developed enriched pastas is increased significantly ($p<0.05$) with increase in the level of supplementation of finger millet flour with refined wheat flour. In organoleptic evaluation, it was found that there was a significant ($p<0.05$) difference among the formulated pastas. Results indicated that FM_2 (refined wheat flour 85% with finger millet flour 15%) pastas were having higher nutritional value i.e. moisture (11.7%), ash (1.44%), crude protein (9.56%), crude fat (1.08%), crude fiber (0.74%), carbohydrate (75.92%), calcium (89.83 mg/100g), iron (2.70 mg/100g), zinc (1.27 mg/100g), magnesium (43.78 mg/100g), phosphorus (130.12 mg/100g) and potassium (122.33 mg/100g) and higher cooking quality i.e. optimum cooking time (8.39 min), maximum cooked weight (24.90 g/10) and minimum cooking loss (3.52 g/100g) and higher over all acceptability than the all the formulated pasta and control (100% refined wheat flour) pasta. Formulated pasta products were obtained in the acceptable category even after 60th days of keeping and stored in laminated pouch, which showed lower significant changes in colour.

Keywords: *Finger millet flour, refined wheat flour, nutritional quality, sensory quality, cooking quality, storability*

1. INTRODUCTION

Pastas are traditionally cereal based ready to cook food product, which are first introduced in Italy in 13th century. In India, portions of pasta are becoming more popular due to their convenience and palatability among children and adolescents. Now-a-days pasta products are occupying major proportion in breakfast, snacks and dinner preparation. [8] Grain one of the basic food groups in healthy diet from which pasta is made. Due to unique appearance, colour, texture and cooking quality pasta made up of durum wheat flour, semolina flour and all-purpose flour. Awareness and demand of delicious and nutritious food is increasing day by day. Now a days maintain optimum nutrition and good health are the most challenging and demanding. Due to the increased awareness about food components for health promotion, it is important to improve the nutritional quality of pasta by addition of healthy ingredients which are rich in fiber, protein, micro-nutrients, vitamins etc. Millets are used for different food formulations as it is rich in antioxidants, phytochemicals and other health nutrients. Finger millet or Ragi (Eleusine coracana) is known as a staple and healthy food which children old age people, woman and patients. [16,26] Finger millets give higher level of calcium, phytochemical and antioxidant properties which makes slowly digestible therefore, it helps to control blood glucose level efficiently in diabetic patients. [4,12,19,32] Hence, by addition of finger millet in the wheat flour for the preparation of pasta not only enhance the nutritional quality but also enhance the acceptable sensory properties of pasta.

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2. MATERIALS AND METHODS

2.1 Location of work done

The experiment was carried out in the Department of food and nutrition, College of Community Science, Odisha University of Agriculture and Technology, Bhubaneswar.

2.2 Raw materials

Refined wheat flour and other raw materials were purchased from local market and finer millet flour procured from AICRP on millets KVK, Berhampur, Odisha University of Agriculture and Technology.

2.3 Pasta preparation

By blending refined wheat flour with finger millet flour five types of composite flours were formulated for preparation of pasta as shown in the Table 2.1.

Table 2.1. Standardization of flours for preparation of pasta

Composite sample codes	Finger millet flour (%)	Refined wheat flour (%)
Control	0	100
FM_1	5	95
FM_2	15	85
FM_3	25	75
FM_4	35	65

Pasta was extruded using lab model pasta extruder (La Monferrina P6 pasta extruder, Italy). The standardized flour was added to the feed tank of the extruder to mixed thoroughly, till a uniform powder was obtained by the rotating action. Water taken was 30 ml per 100g dry ingredients and allowed to for 30 minutes so that no lumps remain, then the dough was passes through a single screw extruder fitted with adjustable die.

The pasta was allowed to cut into uniform length with a knife moving over the outer die surface. Pasta was dried in a tray at 60°C for 4 hours.

Fig. 1: Flow chart for preparation of products

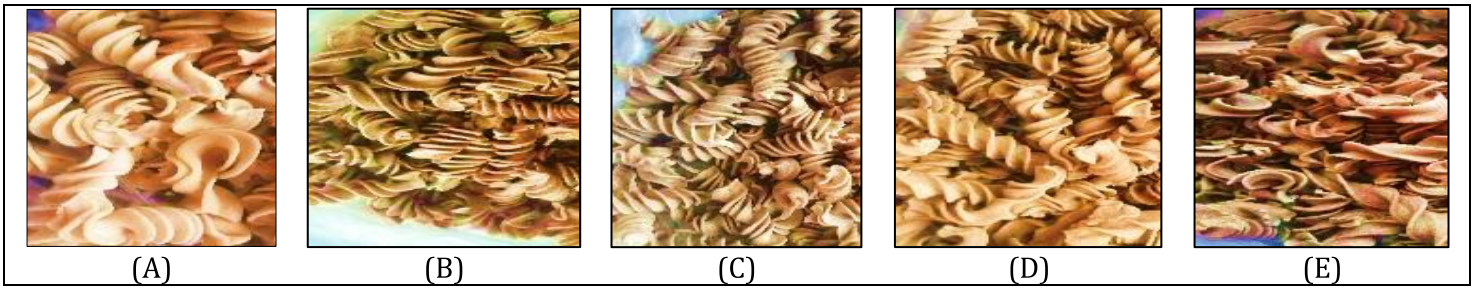

Fig.2. Developed products; (A) Control, (B) FM1, (C) FM2, (D) FM3, (E) Fm4

2.4 Methods of analysis

2.4.1 Determination of proximate composition

Moisture, ash, crude protein, crude fat, crude fiber contents of raw materials and refined wheat flour- finger millet flour pastas were analyzed using standard methods. Carbohydrate content was determined by difference. [2]

2.4.2 Determination of mineral composition

Calcium, iron, zinc, magnesium, phosphorus and potassium contents of raw materials and finger millet flour incorporated with refined wheat flour pastas were analyzed by employing the methodology of Jackson (1973). [9]

2.4.3 Cooking quality

The cooking quality of pasta was assessed for different parameter i.e. optimum cooking time, cooked weight, and cooking loss following the procedure given by AACC method (2000).[1]

2.4.4 Sensory evaluation

The developed products were prepared for sensory evaluation by cooking before testing and served hot to the panel members to evaluate for its sensory parameters like colour, flavour, texture and over all acceptability using 10 semi trained panel members with a nine-point hedonic scale.

2.4.5 Storability of developed pasta in different packaging materials

The developed pasta products of various blends were packed in polypropylene (PP) pouch and laminated pouches to study the sensory properties and storability. The packaging materials were sealed by using hand operated sealing machine and sample from different packaging materials were taken for study on 30th days intervals up to 90th days.

2.4.6 Statistical analysis

The nutritional compositions, sensory qualities and cooking qualities data were statistically analyzed by using analysis of variance (ANOVA) techniques and storability of pasta products by using Factorial Completely Randomized Design (FCRD) methods to see significant and non-significant differences among them.

3. RESULTS AND DISCUSSION

3.1 Nutritional composition of raw materials

The result on the proximate composition of the raw materials i.e., refined wheat flour, finger millet flour is shown in Table 3.1. It has been found that the moisture, ash, crude protein, crude fat, crude and carbohydrate contents of different raw materials are ranged from 11.87 to 10.92, 3.02 to 2.22, 10.62 to 8.67, 1.32 to 1.18, 3.62 to 0.62 and 73.75 to 72.55 percent, respectively. The maximum moisture, ash, crude protein and fat contents were observed in refined wheat flour, respectively and the maximum content of carbohydrate and crude fiber obtained in finger millet. All the raw materials differ significantly ($p<0.05$) in their proximate composition. Vaishnavi *et al.* (2018) also stated that ragi contains higher level of minerals like potassium and calcium. [29]

Table 3.1. Nutritional composition of raw materials (per 100g on dry mater basis)

Nutritional composition	Refined wheat four	Finger millet flour	CD (0.05)	P-Value
Moisture (%)	11.87^{a}±0.02	10.92^{b}±0.03	0.12	<0.01
Ash (%)	3.02^{b}±0.05	2.22^{c}±0.03	0.19	<0.01
Crude protein (%)	10.62^{c}±0.24	8.67^{d}±0.07	0.56	<0.01
Crude fat (%)	1.32^{b}±0.12	1.18^{b}±0.15	0.41	<0.01
Crude fiber (%)	0.62^{e}±0.11	3.26^{d}±0.10	0.31	<0.01
Carbohydrate (%)	72.55^{a}±0.17	73.75^{a}±0.19	2.35	<0.01
Calcium(mg/100g)	28.10^{e} ±0.09	341.20^{a} ±0.06	0.18	<0.01
Iron(mg/100g)	2.63^{d}±0.03	13.64^{b}±0.03	0.10	<0.01
Zinc(mg/100g)	2.53^{b}±0.02	2.26^{c} ±0.13	0.20	<0.01
Magnesium(mg/100g)	53.10^{e} ±0.03	107.11^{c} ±0.03	0.61	<0.01
Phosphorus(mg/100g)	124.61^{d}±0.01	263.10^{c} ±0.02	0.08	<0.01
Potassium (mg/100g)	139.32^{d}±0.04	38.11^{e} ±0.03	0..37	<0.01

Note: Values are mean ± SE of three independent replications. Means with same superscript (a,b,c,d,e) in the same column differ significantly (p > 0.05).

3.2 Nutritional composition of developed pasta

The data on proximate composition of finger millet flour and finger millet flour enriched developed pasta products are shown in Table 3.2. It has found that refined wheat flour developed pastas contained 11.84 % moisture, 1.04 % ash, 10.60 % crude protein, 0.67 % crude fat, 0.44 % crude fiber, 75.62 % carbohydrates which were also found to be significantly ($p<0.01$) FM_1, FM_2, FM_3, FM_4 composite flour developed pasta products. Moisture, ash, crude protein, crude fat, crude fiber and carbohydrate percentage of all four types of formulated composite flour-based pasta products ranged from 10.22 to 11.84, 1.04 to 1.84, 8.60 to 10.60, 0.67 to 1.16,

0.44 to 1.17 and 75.62 to 76.58 percent respectively. In FM_4 composite flour maximum ash, crude fat, crude fiber, and proximate compositions. In Table 2 refined wheat flour pasta contents calcium 14.97mg/100g, iron 1.39 mg/100g, zinc 1.08mg/100g, magnesium 39.85 mg/100g, phosphorus 104.20 mg/100g, potassium 113.08 mg/100g which was significantly ($p<0.01$) increased with increased in the level of incorporation of finger millet flour and varied from 51.82 to 138.78 mg/100g, 2.91 to 5.11 mg/100g, 1.12 to 2.41 mg/100g, 42.44 to 52.35 mg/100g, 118.21 to 147 .15 g/100g respectively. The higher mineral contents show in FM_4 composite flour developed pasta while lower mineral contents exhibited in FM_1 composite flour. FM_1, FM_2, FM_3, FM_4 composite flour developed pastas are differ significantly ($p<0.05$). Lande *et al.,* (2017), Verma *et al*., (2019) earlier recorded slimilar relation of finger millet incorporations with the proximal and mineral contents. [20,30]

Table 3.2. Nutritional composition of Finger Millet Flour enriched developed pasta (per 100 g, on a dry matter basis)

Nutritional composition	Control	FM_1	FM_2	FM_3	FM_4	CD (0.05)	P-Value
Moisture (%)	11.84^{a}±0.03	11.48^{b}±0.09	11.17^{c}±0.07	10.85^{d}±0.03	10.22^{e}±0.05	0.19	<0.01
Ash (%)	1.04^{d}±0.03	1.32^{c}±0.03	1.44^{b}±0.02	1.52^{b}±0.01	1.84^{a}±0.02	0.08	<0.01
Crude protein (%)	10.60^{a}±0.14	10.10^{a}±0.11	9.65^{b}±0.25	8.92^{c}±0.16	8.60^{c}±0.15	0.54	<0.01
Crude fat (%)	0.67^{b}±0.08	0.85^{ab}±0.15	1.08^{a}±0.19	1.13^{a}±0.15	1.16^{a}±0.10	0.36	0.04
Crude fiber (%)	0.44^{b}±0.06	0.55^{b}±0.07	0.74^{b}±0.09	1.40^{a}±0.03	1.71^{a}±0.20	0.33	<0.01
Carbohydrate (%)	75.62^{b}±0.17	75.69^{b}±0.36	75.92^{b}±0.04	76.17^{ab}±0.08	76.58^{a}±0.14	0.59	0.02
Calcium(mg/100g)	14.97^{e} ±0.30	51.82^{d}±0.33	89.83^{c} ±0.62	120.75^{b}±0.26	138.78^{a} ±0.07	1.14	<0.01
Iron(mg/100g)	1.39^{d}±0.03	2.91^{d}±0.05	2.70^{c}±0.04	4.32^{b}±0.02	5.11^{a} ±0.03	0.10	<0.01
Zinc(mg/100g)	1.08^{c}±0.01	1.12^{c} ±0.04	1.27^{b}±0.06	1.39^{ab}±0.03	2.41^{a} ±0.04	0.12	<0.01
Magnesium(mg/100g)	39.85^{e}±0.02	42.44^{d}±0.35	43.78^{c}±0.16	47.59^{b}±0.17	52.35^{a} ±0.14	0.63	<0.01
Phosphorus(mg/100g)	104.20^{e}±0.03	118.21^{d}±0.06	130.12^{c}±0.05	139.28^{b}±0.03	147.15^{a} ±0.03	0.13	<0.01
Potassium(mg/100g)	113.08^{e}±0.04	119.19^{d}±0.03	122.33^{c}±0.03	123.62^{b}±0.35	128.80^{a} ±0.68	1.08	<0.01

Note:Values are mean ± SE of three independent replications. Means with same superscript (a, b, c, d, e) in the same column differ significantly ($p < 0.05$)

3.3 Effect of finger millet incorporation on cooking quality of pasta

The cooking quality of the developed pastas were depicted in Table 3.3. It was observed that finer millet incorporated noodles were found significantly lower cooking time i.e. 9.45 min, 8.39 min, 7.16 min, 6.27 min for FM_1, FM_2, FM_3 and FM_4, respectively in comparison to the control (11.40 min). Cooked weight of finger millet blend pasta FM_1 (26.77 g/10g), FM_2(24.90 g/10g), FM_3 (22.53 g/10g) and FM_4 (20.60 g/10g) found to be decreased with increased in the level of supplementation of finger millet flour. Control contained 28.27 g/10g cooked weight which was maximum among all the developed products. The cooking loss was increased with increased in the finger millet incorporation with the value ranges from 2.77 g/100g to 7.46 g/10g respectively. control pasta obtained minimum cooking loss i.e. 1.96 g/100g. All the four supplemented pasta products differ significantly ($p<0.05$). Similar results were also observed by Kulkarni *et al*., (2010), Ritika *et al.,* (2016), Kudake *et al*., (2017). [16,18,23] Faster moisture penetration and discontinued gluten network in other ingredient except refined wheat flour were the causes for lower optimum cooking time.

Table 3.3. Effect of finger millet incorporation on cooking quality of pasta

Developed products	Optimum cooking time (minutes)	Cooked weight (g/10g)	Cooking loss (g/100g)
Control	11.40^{a} ± 0.43	28.27^{a} ± 0.24	1.96^{a} ± 0.12
FM_1	9.18^{b} ± 0.44	26.77^{b} ± 0.18	2.77^{b} ± 0.63
FM_2	8.39^{b} ± 0.38	24.90^{c} ± 0.44	3.52^{cd} ± 0.04
FM_3	7.16^{c} ± 0.03	22.53^{d} ± 0.08	4.53^{cd} ± 0.08
FM_4	6.27^{d} ± 0.08	20.60^{e} ± 0.29	7.46^{d} ± 0.33
CD (0.05)	0.83	0.78	0.90
P-Value	<0.01	<0.01	<0.01

Note: Values are mean ± SE of three independent replications. Means with the same superscript (a, b, c, d, e) in the same column differ significantly ($p < 0.05$)

3.4 Sensory evaluation of developed pasta

Fig.3. exhibits the sensory acceptability of finger millet flour formulated pasta by the panelists. With the increased amount of finger millet supplementation up to 35%, there was decrease in appearance, taste, texture, colour, overall acceptability which varied from 7.30 to 6.10, 7.80 to 7.30, 8.10 to 7.10, 8.10 to 6.90, 8.20 to 7.50 respectively. The FM_2 Pasta made from 85% refined wheat flour and 15% finger millet flour were more acceptable among the all four types of finger millet formulated pasta products along with control. Lande *et al*., (2017), Kulkarni *et al*., (2012) also suggested similar sensory score. [17,20]

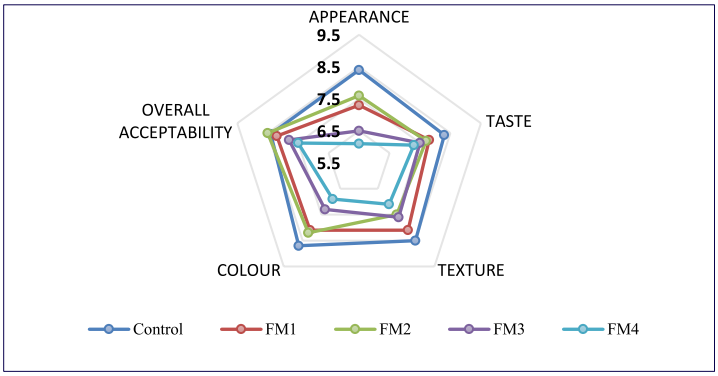

Fig.3. Mean organoleptic acceptability of finger millet flour enriched developed products

3.5 Effect of storage on finger millet flour enriched developed pasta

The data depicted in Table 3.4. explained that all the sensory qualities of finger millet flour formulated pasta along with control decreased significantly with increased in storage intervals at 0^{th}, 30^{th}, 60^{th} and 90^{th} days. From the present study it was found that the finger millet incorporated developed pasta products were acceptable up to 60^{th} days of storage period with out any significant change in sensory attributes. There was no significant change found in finger millet flour incorporated pasta stored in two different packaging materials. Kaur *et al*. (2017); Jalgaonkar *et al*. (2017) revealed earlier similar results with the present study. [10,14]

Table 3.4 Effect of storage on finger millet flour enriched developed pasta

Organoleptic Parameters	Packaging	Storage duration (Indays)	Control	FM_1	FM_2	FM_3	FM_4
Appearance		0^{th}	8.40±0.16	7.30±0.15	7.60±0.16	6.50±0.31	6.10±0.23
	PP	30^{th}	7.90±0.18	7.10±0.18	7.20±0.13	6.20±0.20	5.90±0.23
		60^{th}	7.80±0.13	6.90±0.23	7.00±0.15	5.90±0.23	5.70±0.26
		90^{th}	7.50±0.22	6.50±0.22	6.50±0.17	5.70±0.30	5.40±0.31
	LaminatedPouch	30^{th}	8.00±0.15	7.00±0.21	7.30±0.18	6.20±0.23	6.00±0.20
		60^{th}	7.80±0.13	6.70±0.21	7.00±0.13	5.90±0.16	5.60±0.31
		90^{th}	7.60±0.22	6.10±0.23	6.60±0.22	5.60±0.22	5.50±0.21
P-value	Composition level(A)=<0.01 Storageperiod (B)=<0.01 Packaging(C)=NS A×B=NS A×C=NS B×C=NS A×B×C=NS						
Taste		0^{th}	8.30±0.21	7.80±0.20	7.70±0.21	7.50±0.17	7.30±0.15
	PP	30^{th}	8.20±0.13	7.30±0.15	7.60±0.22	7.30±0.26	7.20±0.20
		60^{th}	7.50±0.17	7.20±0.20	7.80±0.20	6.80±0.20	6.70±0.21
		90^{th}	5.80±0.15	6.70±0.22	6.50±0.16	6.30±0.15	5.90±0.13
	LaminatedPouch	30^{th}	7.70±0.21	7.10±0.23	7.40±0.22	7.10±0.23	7.10±0.18
		60^{th}	7.50±0.22	6.90±0.23	6.80±0.20	6.50±0.17	6.50±0.17
		90^{th}	7.20±0.25	6.50±0.16	6.40±0.22	6.40±0.31	6.10±0.29
P-value	Composition level(A)=<0.01 Storageperiod (B)=<0.01 Packaging(C)=NS A×B=NS A×C=NS B×C=NS A×B×C=NS						
Texture		0^{th}	8.50±0.17	8.10±0.23	7.50±0.22	7.60±0.16	7.10±0.10
	PP	30^{th}	8.10±0.18	7.80±0.13	7.30±0.15	7.30±0.21	6.80±0.20
		60^{th}	7.70±0.22	7.50±0.18	7.10±0.17	6.90±0.23	6.70±0.15
		90^{th}	6.80±0.25	6.90±0.28	6.70±0.26	6.60±0.27	6.4±0.16
	Laminated Pouch	30^{th}	8.20±0.20	7.70±0.15	7.40±0.16	7.90±0.22	6.90±0.23
		60^{th}	7.80±0.20	7.20±0.29	6.50±0.17	6.80±0.25	6.60±0.31
		90^{th}	6.50±0.34	6.70±0.21	6.70±0.26	6.60±0.27	6.50±0.22
P- Value	Compositionlevel(A)=<0.01 Storageperiod (B)=<0.01 Packaging(C)=NS A×B=0.02 A×C=NS B×C=NS A×B×C=NS						
Colour		0^{th}	8.70±0.15	8.10±0.10	8.20±0.13	7.30±0.21	6.90±0.10
	PP	30^{th}	8.30±0.15	7.70±0.15	7.90±0.28	6.80±0.25	6.70±0.21
		60^{th}	7.80±0.20	7.20±0.25	7.50±0.22	6.60±0.16	6.50±0.22
		90^{th}	7.10±035	6.70±0.21	6.90±0.18	7.30±0.17	6.30±0.26
	Laminated Pouch	30^{th}	8.20±0.20	7.50±0.17	7.7-±0.21	6.80±0.16	6.70±0.26
		60^{th}	7.90±0.18	7.10±0.23	7.30±0.21	6.60±0.17	6.40±0.22
		90^{th}	6.90±0.23	6.60±0.16	6.70±0.15	6.30±0.21	6.20±0.25
P-Value	Compositionlevel(A)=<0.01 Storageperiod (B)=<0.01 Packaging(C)=NS A×B=0.01 A×C=NS B×C=NS A×B×C=NS						
Overall Acceptability		0^{th}	8.40±0.16	8.20±0.25	8.50±0.17	7.80±0.20	7.50±0.22
	PP	30^{th}	8.00±0.16	7.80±0.22	7.90±0.16	7.10±0.19	7.10±0.11
		60^{th}	7.70±0.15	7.50±0.22	7.40±0.22	6.70±0.15	6.80±0.20
		90^{th}	7.10±0.35	6.80±0.25	6.70±015	6.50±0.27	6.40±0.27
	Laminated Pouch	30^{th}	7.90±0.31	7.70±021	7.70±0.15	6.90±0.23	6.80±0.13
		60^{th}	7.60±0.27	7.40±0.16	7.30±0.21	6.60±0.16	6.60±0.23
		90^{th}	6.90±0.31	6.60±0.16	6.60±0.22	6.40±0.16	6.30±0.26
P-Value	Compositionlevel(A)=<0.01 Storageperiod (B)=<0.01 Packaging(C)=NS A×B=NS A×C=NS B×C=NS A×B×C=NS						

Note: Values are mean ± SE of three independent replications. NS- Non significance

4. CONCLUSION

It was observed that pasta developed from refined wheat flour contents moisture 11.84%, ash 1.04 %, crude protein 10.60%, crude fat 0.67%, crude fiber 0.44% and carbohydrate 75.62% and mineral contents calcium 14.97mg/100g, iron 1.39 mg/100g, zinc 1.08mg/100g, magnesium 39.85 mg/100g, phosphorus 104.20 mg/100g and potassium 113.08 mg/100g which were significantly ($p<0.05$) increased with increased in the level (5%, 15%, 25% and 35%) of substitutions of finger millet flour in refined wheat flour the highest proximal and mineral contents were obtained in FM_4 composite flour developed pasta and lowest content were obtained in FM_1 and where as pasta FM_2 made up of refined wheat flour and finger millet flour (85:15) was more acceptable by panelists and higher nutritional quality than control. FM_1 and FM_2 obtained the maximum cooking quality among all the developed products for the improvement of nutritional status of young consumers. All the sensory characteristics of finger millet flour formulated pasta along with control decreased significantly with an increased in the storage intervals at 0^{th}, 30^{th}, 60^{th} and 90^{th} days. From the present study it was found that the finger millet incorporated developed pastas were acceptable up to 60^{th} days of storage periods without any significant change in sensory acceptability. Hence, this nutrient enriched pasta can be a good source of diet for vulnerable groups.

FUTURE SCOPE OF STUDY

The current investigation accelerate to analyze the change in nutritional content of pasta during storage period.

CONFLICT OF INTEREST

Authors declare that there are no conflicts of interest.

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