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Development of spice mixture (Masala) for gluten free pasta and its shelf life study

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Abstract
Spirulina was incorporated to gluten free Quality Protein Maize (QPM) pasta at various levels (2, 4, 6, 8 and 10%) to standardise the level of incorporation. The suitable flour ratio among several combinations tested for gluten free pasta was determined to be QPM flour (Q) 60%, black gram flour (B) 30%, defatted soy flour (S) 8% and guar gum (G) 2% (Q60:B30:S8:G2) for QPM pasta and QPM flour (Q) 60%, black gram flour (B) 30%, Spirulina (Sp) 6%, defatted soy flour (S) 2% and guar gum (G) 2% (Q60:B30:S2:Sp6:G2) for spirulina pasta. Steaming the ingredients for one hour, mixing and kneading for 30 minutes followed by refrigeration (4 °C for 15 minutes) yielded a rupture free pasta. Spice mixture M5 containing salt (1.5 g), turmeric (1.5 g), coriander seeds (1.5 g), red chilli powder (1.2 g), corn flour (0.75 g), citric acid (0.3 g) and fenugreek seeds (0.1 g) at the rate of 10 g per 100 g of pasta was best accepted among different combinations tested (M1, M2, M3, M4 and M5). The sensory scores of gluten free (QPM and Spirulina pasta) and control pasta (100% whole wheat flour) was found to be within the acceptable range (> 7.5 sensory score) in both the packaging materials during six months of storage. The increase in moisture content of pasta irrespective of the type of packaging was noticed. The highest peroxide value was noticed in polyethylene terephthalate (PET) package which indicated that metalized polyester polyethylene (MPP) package had high oxygen barrier property than PET package. At the end of storage period, QPM pasta had slightly higher values for FFA followed by spirulina pasta.

Keywords: Standardization, Pasta masala, gluten free pasta and shelf life

Introduction

Consumption of gluten-free foods is the better option to treat celiac people to date. Gluten-containing grains such as wheat, barley and rye promote celiac disease (Sanguinetti *et al*., 2016) [18]. Gluten is required to make an elastic dough when combined with water in most bread and pasta products, hence its replacement is a high priority in celiac patient's diet (Sanguinetti *et al*., 2016) [18]. A large number of research publications on gluten-free foods, such as bread, bakery items, pasta and others, have been published by many workers till date (Bastos *et al*., 2016; Benhur *et al*., 2015; Bouasla *et al*., 2017; Detchewa *et al*., 2016; Bustos *et al*., 2015; Mirhosseini *et al*., 2015) [3, 4, 8, 10, 9, 14].

Pasta is a classic cereal-based foodstuff that is growing in popularity across the world due to its convenience, taste and nutritional value. Pasta is a good product to be enhanced with useful components of all sorts and sources due to its low cost, extended shelf life and consumed by people of all ages from all walks of life (Bustos *et al*., 2015) [9].

Consumption of pasta products on a regular basis in India is constantly expanding, this opens up the prospect of creating new sorts of development of pasta with functional ingredients like legumes or protein concentrates, vegetables like beetroot, carrot, green leafy vegetables and seaweed powders like spirulina. In order to fulfil the demand, pastas must be shelf-stable for a substantial amount of time. Not only enrichment of pasta with functional ingredients will not serve the purpose until and unless it is consumed by large number of consumers.

Spices, which are plant parts such as dried fruits, seeds, barks and roots are used in our Indian culinary preparations in many ways for the preparations of variety of foods. They primarily contribute to the flavour, aroma and colour of foods (Banach *et al*., 2012) [2]. Spices have long been used as food flavourings, seasonings and preservatives as well as medicinal ingredients throughout the world. They're known to be rich in phytochemicals, many of which have significant antioxidant capacities (AOCs) as well as additional anti-glycant, anti-inflammatory and anti-microbial properties. Spices are regarded trustworthy sources of natural antioxidants and possible bioactive substances in diets since they have a low calorie content and are inexpensive (Bi *et al*., 2015) [6].

It is critical to assess the shelf-life of developed pasta so that it does not lose its quality while storage. Any food product that reaches customers should have its shelf life assessed before it is released for commercial use (Bharath Kumar *et al*., 2018) [5]. Hence providing spice mixture along with pasta is very important as pasta cannot be eaten without the adjunct or spice gravy. Food products are kept in a variety of natural conditions as well as packed in many ways. Dry-packed products are frequently advised to be kept at room temperature. However, different parts of the world experience a huge variation of temperature and relative humidity resulting in water loss or increase in moisture content of products like pasta even when packed. During the storage period, pasta samples were generally kept at a temperature of 26-28 °C with a relative humidity of 60-65%.

As previously said, many researchers have published the studies related to various types of pasta preparation techniques including gluten free pasta. However, so far not much work has been reported on standardisation of spice mixture or pasta masala which is very much crucial for acceptance by the consumers. In India, acceptability of bland pasta is very less, as addition of spice mixture or masala or any gravy kind of thing is always relished by Asian sub-continent people. Hence, the present study was taken up with an objective to develop the spice mixture (pasta masala) for gluten free pasta and its shelf life assessment.

Materials and Methods

Raw materials

Quality Protein Maize (QPM) grains, wheat, black gram, de fatted soy flour and spirulina powder were purchased in a single lot from a local store and refrigerated until used.

Standardization of gluten-free pasta and organoleptic analysis

Several combinations of QPM flour (Q), black gram flour (B), defatted soya flour (S) and spirulina powder (Sp) were tested in preliminary studies. QPM pasta and spirulina pasta were standardised as per Veena *et al*. 2022. While control pasta was prepared with 100% whole wheat flour. The perusal of Table 1 displays the trials conducted to standardize the method of preparation of gluten free pasta. Gluten-free pastas were extruded in different shaped dies, including shanku, ribbed tube (S shape) and twisted ribbons (Plate 2). Twenty-one semi-trained judges conducted an organoleptic study of cooked pasta with different levels of QPM and spirulina incorporation. Organoleptic characteristics such as appearance, color, texture, taste, flavor, stickiness, firmness and overall acceptability were rated on a nine-point hedonic scale of 1 to 9 with 9 being the highest value. The flour ratio and pasta making process was standardised as per Veena *et al*. 2022.

Standardization of spice mixture (Masala powder)

The spice mixture (Masala powder) normally used as adjunct while cooking of bland pasta, which plays an important role in acceptability of pasta on commercial scale. The suitable combination of spice mixture plays an important role in making the cooked pasta acceptable. To prepare the pasta masala, spices were dry roasted at 85 to 90 ℃ for 25 to 30 min, cooled to room temperature and mixed all the roasted spices in various combinations as per Table 2 (M1 to M5), including turmeric, coriander, cumin, mustard, fenugreek, cardamom, cloves, cinnamon, star anise, poppy seeds, rice, black gram dhal, bengal gram dhal and curry leaves and ground to a fine powder. In a determined quantity, added salt, red chilli powder, corn flour, sugar powder, citric acid and garlic powder to the finely ground spice mixture (Table 2). About 10 g of pasta masala was added during cooking, which was standardised among preliminary trails using 3, 5, 8, 9 and 10 grams of pasta masala.

Shelf life study of pasta

The best accepted pasta among various combinations [Control-100% whole wheat flour (C), QPM pasta-Q60:B30:S8:G2 (Q) and spirulina pasta- Q60:B30:S2:Sp6:G2 (S)] were selected for shelf life studies. The products were packed in polyethylene terephthalate (PET) and metalized polyester polyethylene (MPP) pouches and kept at ambient temperature (26-28 ℃) as per Shobha *et al*. (2021). Along with the pasta samples, a 10 g spice mixture was packed in aluminium silver pouch, heat sealed and added with the pasta samples at ambient temperature. The pasta samples along with spice mixture were evaluated for a period of six months with respect to biochemical (moisture, peroxide value and free fatty acid) and sensory attributes during storage (Shobha *et al*., 2014) [20].

Consumer acceptability of pasta

To assess the general acceptance of the products, the best accepted pasta (Control, QPM and spirulina pasta) cooked with standardised spice mixture (M5) were distributed to children, adults (male and female labours) of V.C Farm, Mandya and students of College of Agriculture, V.C Farm, Mandya, India. Consumers were given coded pasta products and a glass of water as well as a score card format in their native language and were asked to rate the pasta products for acceptability based on flavour, colour, ease of cooking at home, ready to purchase and overall product quality. Finally, total product ratings were used to calculate the acceptability of pasta (Like, dislike and neutral).

Statistical analysis

The R software (R studio) was used for the statistical interpretation of standardisation pasta masala and shelf life. Graphs are drawn using Python programming language (version 3.10.4, Python Software Foundation, https://www.python.org/). Several Python libraries were used and in particular, NumPy version 1.22.3, Matplotlib version 3.5.1 and Pandas version 1.4.1(Patsilinakos *et al*., 2018) [15]. While Origin software is used to draw the graphs of sensory evaluation of pasta masala.

Results and Discussion

Standardization of nutritionally enriched gluten free pasta

a) Standardization of flour and spirulina ratio

The greater acceptability of QPM flour incorporation was found to be 80% among 50, 60, 70, 80 and 100%. Acceptability level up to 10% was noted with spirulina incorporation levels of 5, 10 and 15% (Plate 1). Different combinations of gluten-free pasta standardisation are depicted in the study of Veena *et al*. 2022, where in the suitable flour ratio for gluten free pasta extrusion among several combinations was determined to be QPM flour (Q) 60%, black gram flour (B) 30%, defatted soy flour (S) 8% and guar gum (G) 2% for QPM pasta (Q60:B30:S8:G2) and QPM flour

(Q) 60%, black gram flour (B) 30%, Spirulina (Sp) 6%, defatted soy flour (S) 2% and guar gum (G) 2% for spirulina pasta (Q60:B30:S2:Sp6:G2).

b) Standardization of method of pasta preparation
Sensory evaluation of preliminary trailed pasta (Table 1) revealed that raw flavour and stickiness in cooked pasta (Trials T1 to T4). Hence, further experiment was conducted by steaming (one hour at 100 °C) and refrigeration (4 °C for 15 min.) are used to allow the starch molecules to hydrate, resulting in less raw flavour and stickiness in the cooked pasta (T5). Even the results of Larrosa *et al*. (2013) revealed similar finding during the manufacturing of gluten-free pasta based on maize-starch and corn flour. The mixing and kneading period of pasta before extrusion was standardised between 10, 15, 20, 25 and 30 minutes and it was discovered that 30 minutes of mixing and kneading was optimum for getting desired shaped pasta (Table 1). The results of Table 1 revealed that steaming the ingredients for one hour, mixing and kneading for 30 minutes followed by refrigeration (4 °C for 15 minutes) yielded a rupture free pasta.

c) Standardization of dies
Gluten free pasta samples were extruded in three different dies such as *shanku*, *twisted ribbon* and *ribbed tube* (S shape). Pastas extruded with shanku and twisted ribbon dies lost their structure while cooking due to leaching of starch. Even after cooking, these pasta samples exhibited a raw flavour and stickiness. This might be because of the reason that pastas made from shanku and twisted ribbon required more dough to extrude in those forms leading to less hydration of starch resulting in to raw flavour and more cooking loss. When compared to above two pasta shapes, ribbed tube (S shape) pastas held their shape throughout cooking and were non sticky with acceptable cooked flavour. As a result, the ribbed tube (S shape) die was chosen for further experiments.

d) Standardisation of optimum spice mixture (Masala):
The persual of Table 2 revealed that important spices which contributed significantly for the organoleptic quality were salt, turmeric, coriander seeds, red chilli powder, corn flour and fenugreek. Hence, these spices in varied quantity (M1 to M5) were standardised (Table 2) and served for sensory evaluation. The spice combination M5 had better overall acceptability score (8.5) compared to rest of the samples (M1 to M4). Sensory panel of ten judges evaluated five distinct masala combinations (M1 to M5) for pasta masala required to be added while cooking (Table 2). Among five types of masala, one pasta masala recipe was chosen based on the opinion of the taste panel (M5). Persual of Table 2 depicts the standardised masala recipe that must be added during cooking of pasta. The mean organoleptic scores of pasta masala for the characteristics of appearance, colour, odour, flavour, taste, texture and overall acceptability are depicted in Fig. 1. The control was commercial pasta masala purchased from market had the highest score for all the sensory attributes. Variation M5 was determined to be the most liked pasta masala, whereas, M1 received lowest marks for all sensory attributes. The difference in sensory scores and masala recipes was proven to be statistically significant at 5% level. Sensory panel are well versed with the appearance and flavour of the conventional pasta masala recipe, as a result, standardising the pasta masala in the current study was quite challenging. Except for M1, which had slightly deeper yellow colour due to high turmeric content (2.52±0.01), rest of all the masala samples were similar in colour compared to control. Lower overall acceptability score (7.0) showed that colour parameter was not in the acceptable range for M1. For the pasta products, textural quality was described as soft, extremely soft, firm, liquid, semi solid and thick in the score card. Because of the significant amount ($p<0.01$) of corn flour (1.51±0.01), the majority of panel members felt that M1's textural quality was thick and hard, whereas M5's textural quality was soft and semisolid which was ideal for pasta consistency (0.75±0.1). The taste component of M1 and M2 indicated spicy and slight bitter tastes respectively as they had more red chilli powder (2.51±0.01) and fenugreek (0.25±0.002) compared to other masala samples. Due to significant amount of citric acid in M3 (0.51±0.01) it was sour. The spice mixture M5 had a taste score of 8.5 which was closer to control (8.8), hence it was well received by the panellists. There is no published work on evaluation of spice mixture or masala powder of pasta to compare our results.

Shelf life study of the best accepted pasta
View of Fig. 2 depicts the sensory changes of pasta samples during six months storage period. For sensory evaluation, the sensory panel was served with pasta along with 10 g of spice mixture (M5). The overall acceptability (OAA) of gluten free (QPM and spirulina pasta) as well as control pasta was found to be within acceptable range (>7.5 sensory score) in both the packaging materials (MPP and PET). However, at the end of storage period, pasta stored in MPP retained significantly higher sensory scores compared to PET package ($p<0.05$). The increase in moisture content of pasta irrespective of the type of packaging was noticed (Fig. 3a). However, it was non-significant ($p>0.05$) between different pasta samples. The oxidation parameters peroxide and free fatty acid value were observed to rise in the gluten-free pasta sample as the storage period increased (Fig. 3b and 3c). When the storage period had reached the sixth month, a significant rise in the peroxide and free fatty acid values was seen ($p>0.05$). The perusal of Fig.3b indicated that among two types of packages, the highest peroxide value was noticed in PET package which indicated that MPP package had high oxygen barrier property than PET package. From fourth month significant increase in peroxide value and free fatty acid value was noticed due to increased absorption of moisture. Manthey *et al*. 2008 [13], Kaur *et al*. 2012 [11], Yadav *et al*. 2014 [25] and Shobha *et al*. 2015 [21] also reported an increasing trend for peroxide and FFA during storage. During sixth month of storage the peroxide value of gluten free pasta (Q and S) in two types of packaging material was significantly high (9.3 for MPP, 9.5 meq/kg fat for PET and 9.1 for MPP, 9.7 meq/kg fat for PET respectively) as compared to control (8.8 for MPP, 9.5 meq/kg fat for PET) and the values for the same were within the BIS limits (<10meq/kg fat). During sixth month of storage, the free fatty acid (FFA) content of control (0.64 for MPP & 0.73% of oleic acid for PET), QPM (0.72 for MPP & 0.85% of oleic acid for PET) and spirulina pasta (0.7 for MPP & 0.83% of oleic acid for PET) increased with increase in storage period (Fig.3c). The sensory values remained within the acceptable range (> 7.5 score) because of which the taste, flavour and acceptability of pasta did not significantly affect ($p>0.05$). At the end of storage period, QPM pasta had slightly higher values for FFA followed by spirulina pasta

which is due to the fact that maize contained high amount of fat (4.0-4.5 g/100 g) than wheat flour (2.0-2.5 g/100 g). The bacterial population of three types of pasta was found to be nil in fresh samples in both the types of packages (Data not shown). However, after one month there was a gradual increase in bacterial count up to six months of storage period. It was also observed that during storage period, the bacterial count of MPP packed sample was found to be very less compared to PET. Further, no fungal population was discovered in any of the pasta types until fifth month of storage. However, during sixth month few fungal colonies were noticed in PET package. The test for coliform revealed that no colonies reported in both the packages over six-month storage period. The presence of *E. coli* in foods is unfavourable because it implies sanitary issues, contamination or insufficient heat treatment (Takhellambam *et al*., 2016) [23]. As a result, the microbial examination of pasta revealed that the low moisture level of pasta (<10%), the method used for processing, preparation, storage and use of most sanitary practises were all led to the production of microbiologically safe product in the current study.

Consumer acceptability

Consumer acceptance is the most important connection in product development. In market-oriented organizations, meeting customer needs is a top concern and consumer acceptance of a food product is considered as a trigger for repeat purchases and therefore as a component that will contribute to the firm's long-term success (Resano *et al*., 2010) [16]. The findings of the Table 3 indicated the consumer acceptability scores of control, QPM and spirulina pasta. The control pasta was enjoyed by 96% of the consumers (children, adults and students) followed by spirulina (82%) and QPM pasta (74%). Control and spirulina pasta were well received by consumers including children, adults and students indicating the potential for commercialization of these healthy gluten-free pasta products suited for consumption of all age group people.

Table 1: Preliminary trials to standardize the method for preparation of gluten free pasta

Attributes	T1	T2	T3	T4	T5 (Accepted)
Ingredients (Q, S, B,Sp,G)					✓
Steaming for half an hour	×		×	×	×
Steaming for one hour	×	×			✓
Mixing and kneading time (min)	10	15	20	25	30
Refrigeration at 4 °C for 10 min	×	×	×		×
Refrigeration at 4 °C for 15 min	×	×	×	×	✓
	Extrusion				

T: Preliminary trials (T1 to T5), Q: QPM flour, B: blackgram flour, S: defatted soy flour,G: guar gum, Sp: spirulina powder

Table 2: Standardization of Spice mixture (Pasta Masala Powder) for 100 g of pasta

Item	Quantity (gm)				
Ingredients	**M1**	**M2**	**M3**	**M4**	**M5 (Accepted)**
Salt (Sl)	0.31	0.75	1.0	1.2	1.5
Turmeric (Tm)	2.5	1.0	1.0	1.2	1.5
Coriander seeds(Cr)	0.5	1.0	1.0	1.2	1.5
Red chilli powder (Rc)	2.5	1.5	1.0	1.2	1.25
Corn flour (Cf)	1.5	1.0	0.5	0.7	0.75
Sugar powder	0.17	0.5	0.6	0.7	0.75
Cumin seeds	0.5	1.0	0.5	0.6	0.6
Garlic powder	0.2	0.5	0.5	0.5	0.5
Citric acid (Ct)	0.15	0.2	0.5	0.3	0.3
Mustard seeds	0.15	0.10	0.10	0.12	0.12
Fenugreek seeds (Fg)	0.25	0.25	0.15	0.10	0.12
Cardamom	0.10	0.10	0.12	0.12	0.12
Cloves	0.10	0.10	0.12	0.12	0.12
Cinnamon	0.08	0.25	0.20	0.15	0.12
Star anise	0.15	0.15	0.12	0.12	0.12
Poppy seeds	0.07	0.09	0.10	0.12	0.12
Rice	0.10	0.10	0.12	0.12	0.12
Black gram dhal	0.10	0.18	0.15	0.13	0.12
Bengal gram dhal	0.15	0.18	0.15	0.13	0.12
Curry leaves	0.10	0.18	0.15	0.15	0.12
Total	9.68	9.13	8.08	8.98	9.97

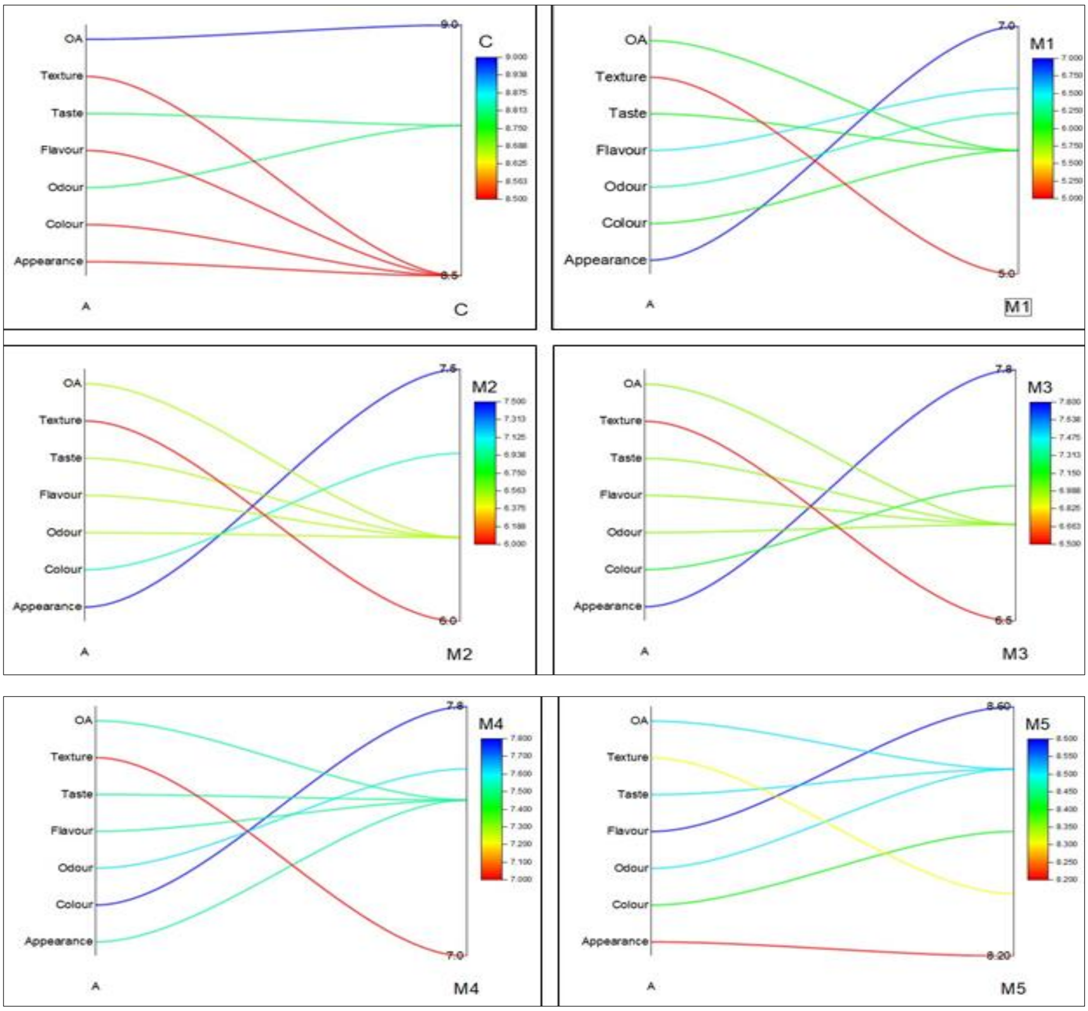
Important ingredient variations of pasta spice mixture (Masala powder)							
Spice variations	**Sl±SD (g)**	**Tm±SD (g)**	**Cr±SD (g)**	**Rc±SD (g)**	**Cf±SD (g)**	**Ct±SD (g)**	**Fg±SD (g)**
M1	0.31±0.008^{e}	2.52±0.01^{a***}	0.51±0.01^{d}	2.51±0.01^{a***}	1.51±0.01^{a***}	0.15±0.001^{d}	0.25±0.001^{a***}
M2	0.76±0.01^{d}	1.0±0.008^{d}	1.0±0.008^{c}	1.51±0.01^{b}	1.01±0.01^{b}	0.21±0.01^{c}	0.25±0.002^{a}
M3	1.01±0.01^{c}	1.01±0.01^{d}	1.01±0.01^{c}	1.01±0.01^{e}	0.51±0.01^{d}	0.51±0.01^{a***}	0.15±0.001^{b}
M4	1.22±0.01^{b}	1.22±0.01^{c}	1.22±0.01^{b}	1.22±0.01^{d}	0.71±0.01^{c}	0.31±0.01^{b}	0.12±0.01^{c}
M5	1.51±0.01^{a***}	1.51±0.01^{b}	1.51±0.01^{a***}	1.25±0.001^{c}	0.75±0.1^{c}	0.32±0.01^{b}	0.12±0.002^{c}
F-value	6905.4***	11952***	4704.9***	13690***	288.54***	776.56***	431.78***
S.Em±	0.0052	0.0053	0.0049	0.0044	0.021	0.0045	0.0029
CD at 5%	0.016	0.016	0.015	0.014	0.067	0.014	0.009

M1: Masala trial 1; M2: Masala trial 2; M3: Masala trial 3; M4: Masala trial 4 and M5: Masala trial 5, Sl: salt, Tm: Turmeric, Cr: Coriander seeds, Rc: Red chilli powder, Cf: Corn flour, Ct: Citric acid, Fg: Fenugreek seeds, ***significant at 1 % ($p<0.01$) and SD standard deviation for five determinations and data followed by different letters (a-c) within the same column indicate

Table 3: Consumer acceptability of gluten free pasta (N=100)

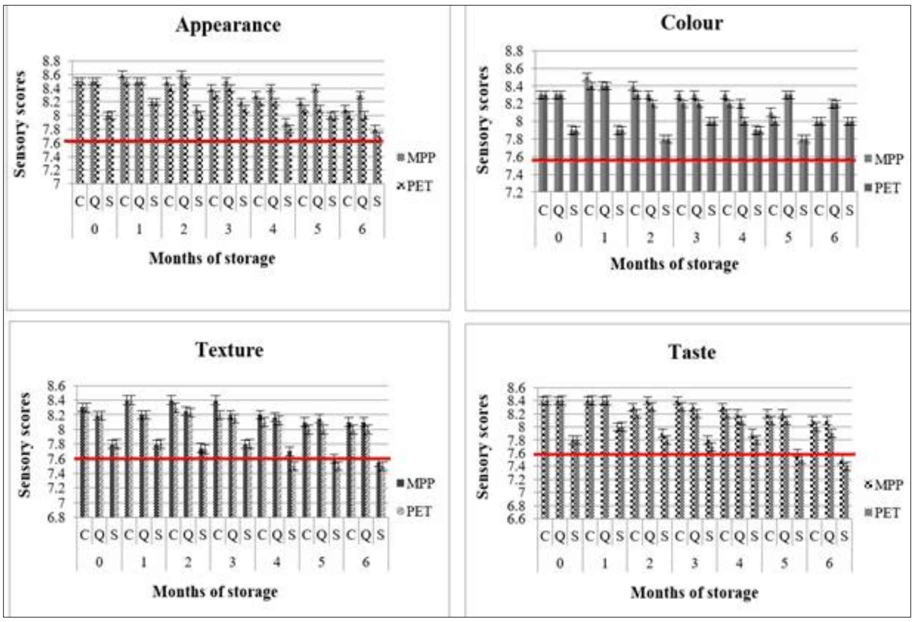
Gluten free pasta types	Like (%)	Dislike (%)	Neither like nor dislike (%)
Control (C-100:W)	96	-	4
QPM pasta (Q- Q60:B30:S8:G:2)	74	6	20
Spirulina pasta (S- Q60:B30:S2:Sp6:G:2)	82	8	10

W: whole wheat flour, Q: QPM flour, B: blackgram flour, S: defatted soy flour, G: guar gum, Sp: spirulina powder, QPM: quality protein maize.



C: Control; M1: Masala trial 1; M2: Masala trial 2; M3: Masala trial 3; M4: Masala trial 4 and M5: Masala trial 5

Fig 1: Sensory evaluation of different types of spice mixture (Pasta masala powder) (M1 to M5)



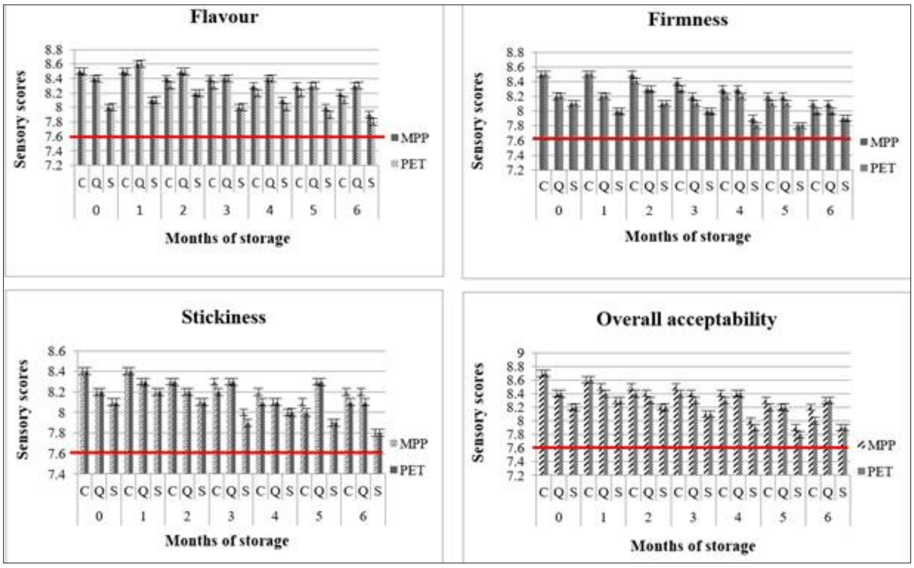
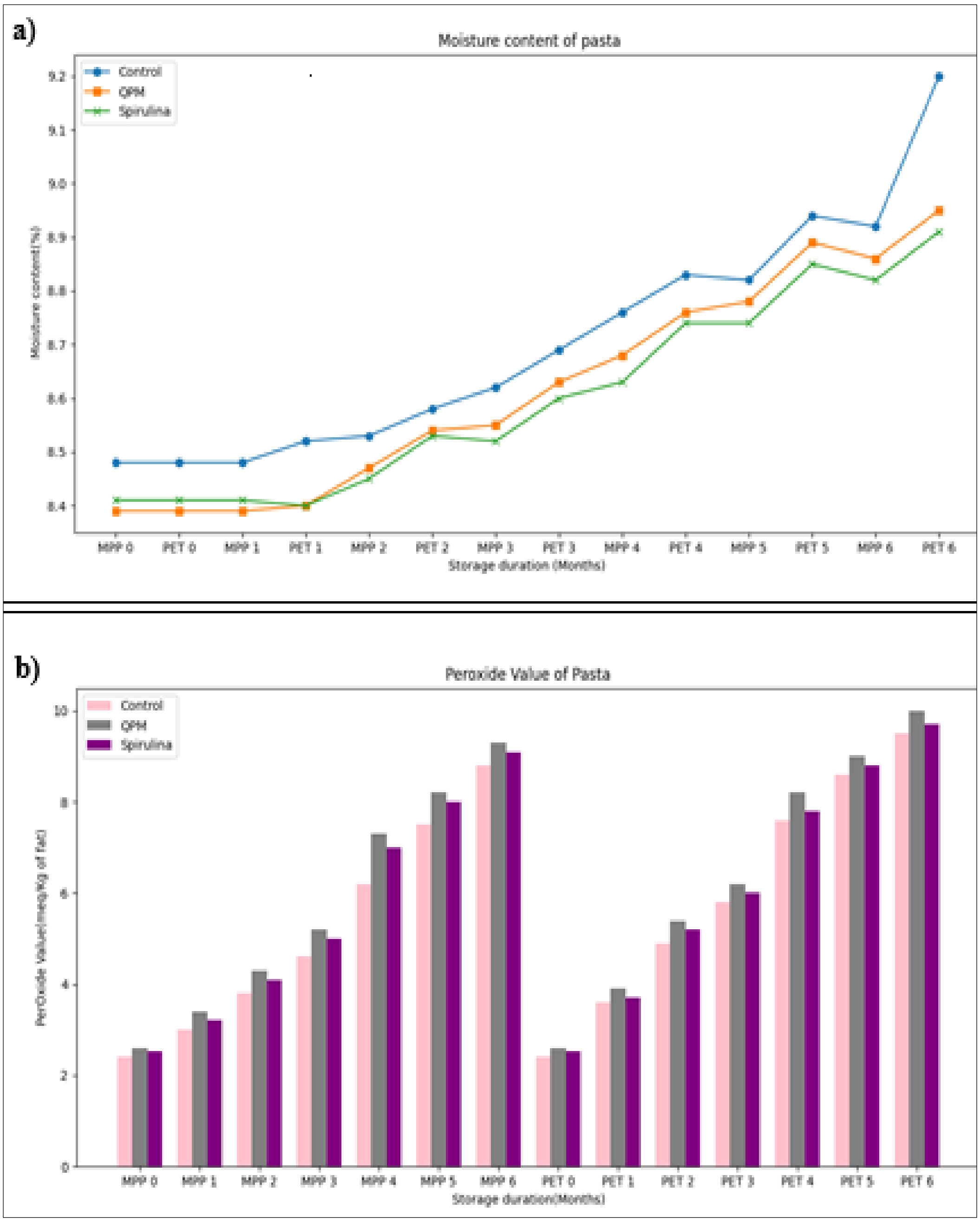


Fig 2: Sensory evaluation of best accepted gluten free pasta during storage



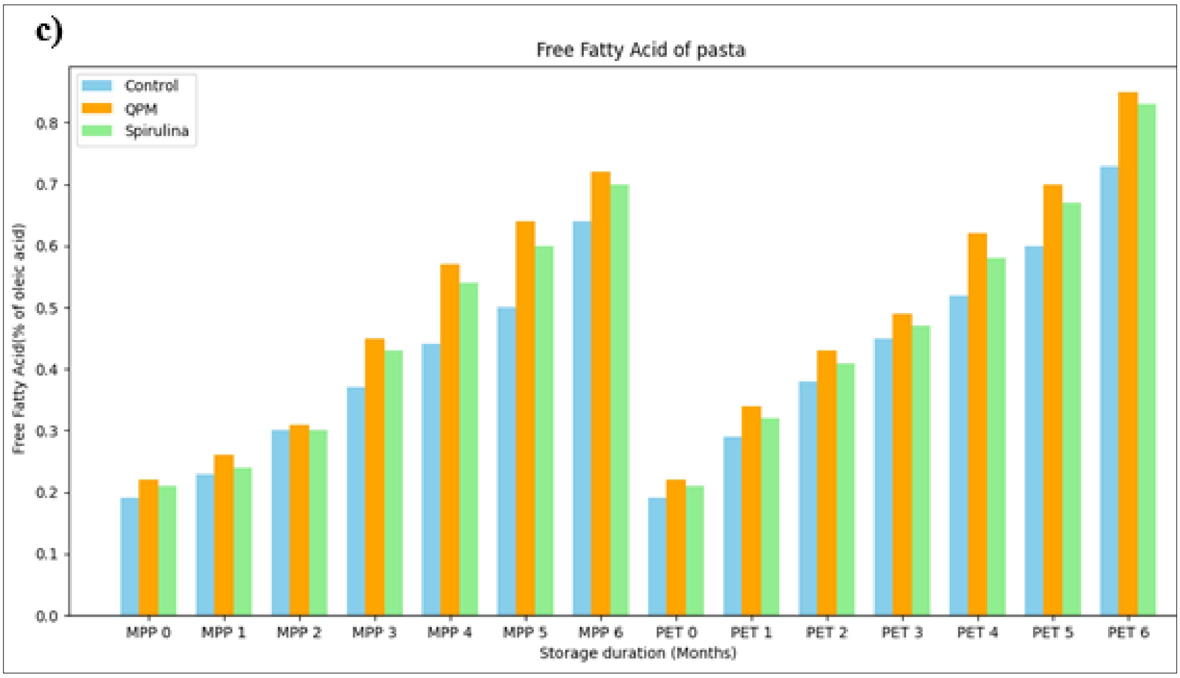


Fig 3: Shelf life study of the best accepted pasta a) Moisture, b) peroxide value and c) free fatty acid value of pasta during storage

Plate 1: Pastas prepared using 5, 10 & 15% of spirulina powder and different types of dies.

Plate 2: Different dies, a) Ribbed tube (S shape) b) Twisted ribbon c) Shanku

Plate 3: Consumer acceptability of gluten free pasta

Conclusion

The result of the study indicated that acceptable shelf stable value added gluten free pasta can be developed from quality protein maize (QPM) with spirulina incorporation. Spice mixture or masala powder (M5) containing salt (1.5 g), turmeric (1.5 g), coriander seeds (1.5 g), red chilli powder (1.2 g), corn flour (0.75 g), citric acid (0.3 g) and fenugreek seeds (0.1 g) at the rate of 10 g per 100 g of pasta was acceptable among different combinations tested (M1, M2, M3, M4 and M5). Moreover, the sensory scores of gluten free as well as control pasta was found to be within acceptable range (>7.5 sensory score) in both the packaging materials (MPP & PET) during six months of storage. However, higher values for peroxide, free fatty acid and moisture content was noticed in PET package compared to MPP. Hence, study revealed that MPP packaging material was found to be suitable for safe storage of QPM pasta (Q), spirulina enriched QPM pasta (S) along with 10 g of spice mixture per 100 g and can be stored for a period of six months under ambient conditions.

Authors' contributions

Veena U. K: Responsible for conceiving the idea, carried out the work and wrote the manuscript.

Shobha D: Supervised the work and revising the manuscript critically for important intellectual content.

Ethical Statements

Conflict of Interest: The authors declare that they do not have any conflict of interest.

Ethical Review: This study does not involve any human or animal testing. Not applicable to this study.

Informed Consent: Not applicable

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