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Development and Evaluation of Carrot Powder-Enriched Pasta for Improved Dietary Health

Lipsa Panda [a++*] and Chitrotpala Devidarshini [a#]

[a] *Department of Food and Nutrition, CCS, OUAT, Bhubaneswar, Odisha, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Author LP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author CD managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Pasta is gaining popularity in the diet of an individual specially among the young. Due to increased awareness about food components for health consciousness, it is important to enhance the nutritional quality of pasta. However, the present study was designed to developed nutrient rich pasta by using carrot powder and refined wheat flour. The developed products analyzed for their nutritional quality, sensory characteristics and storability using standard procedures. It was observed that the nutritional quality of all developed enriched pasta increased significantly ($p<0.05$) by increasing the level of supplementation of carrot powder with refined wheat flour. In sensory characteristics evaluation it was found that there was a significant ($p<0.05$) difference among the formulated pastas. Results indicated CP_4 (refined wheat flour 65% with carrot powder 35%) pasta

++ *Research Scholar;*
# *Assistant Professor;*
**Corresponding author: Email: pandalipsa444@gmail.com, pandalipsa444@gmail.com;*

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higher nutritional value i.e. moisture (8.72%), ash (2.26%), crude protein (11.85%), crude fat (1.39%), crude fiber (4.43%), carbohydrate (71.35%), calcium (84.32 mg/100g), iron (3.62 mg/100g), zinc (1.25 mg/100g), magnesium (71.56 mg/100g), phosphorus (114.17 mg/100g) and potassium (626.49 mg/100g) and CP_1 had higher overall acceptability than all the formulated pasta and control (100% refined wheat flour) pasta. Formulated pasta products were obtained in acceptable category even after 60th days of keeping and stored in laminated pouch which showed lower significant changes in color.

Keywords: Carrot powder; refined wheat flour; sensory evaluation; nutritional quality; storability.

1. INTRODUCTION

Pastas are traditionally cereal based ready to cook food product introduced by Italy in 13th century. In India pastas are becoming well liked due to their economic convenience and palatability among children and adolescents. Now-a-days pasta products are occupying major proportion in breakfast, snacks and dinner preparation (Gull et al. 2014; Kaur et al. 2017; Oke et al. 2023). Grain one of the basic food groups in healthy diet from which pasta is made. Pasta made of durum wheat flour, semolina flour and all-purpose flour due to their unique appearance, colour, texture and cooking quality (Adsule et al.1989; Verma et al. 2019). 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. Regular intake of plant-based foods i.e. fruits & vegetables has been associated with a lower risk of chronic disease (Azam et al. 2023). Dietary fiber is an important part of an individual's diet to maintain proper functioning of the body. Fruits and vegetables are progressively used in the food industry i.e. as ingredients in cookies, cake, bread, biscuits and more and more often in pasta (Wang et al.2022).

Carrot (*Daucus carota*) has gained attention over the years due to its richness in antioxidants and β-carotene (pro-vitamin-A) activity (Haq and Prasad 2017; Kambe et al. 2020). Among the processed vegetables, carrots are recognized as fair and good source of bioactive compound i.e., β-carotene which is act as precursor of retinol which is great for eyes. It is a good source of calcium pectate (pectin fiber), α-carotene, β-carotene, vitamins, minerals and dietary fiber (Chepkosgei et al. 2021; Kumar et al. 2015; Torronen et al. 1996). β-carotene which is present in carrot may inhibit the cancer and certain chronic diseases (Sharma et al. 2012). Addition of carrot into pasta contribute fair source of nutrients and helps to reduce the vitamin-A deficiencies and glycemic index. Hence, there is a good opportunity to utilize this healthy food ingredient for development of high-quality food products to meet the consumer demands.

Food products undergo several types of degradation during storage, distribution and consumption. Therefore, it is important to maintain the stability of the products during storage, transport and distribution. Studies on self-life of the products provides information to product manufactures enabling them to ensure that the consumer will a high-quality product for a significant time after production. Considering the previous mentioned information, the present exploration process was carried out with an aim to evaluate its nutritional compositions, organoleptic characteristics and storability.

2. MATERIALS AND METHODS

2.1 Raw Materials

Refined wheat flour and carrot roots were purchased from local market in Siripur, Bhubaneswar.

2.2 Carrot Powder Preparation

Carrot roots were cleaned, washed**,** cut to sliced, and raw carrots were oven dried at 120°C for 30 to 45 minutes then grounded in to fine powder by mixer grinder.

2.3 Preparation of Pasta

Five types of composite flours were formulated by incorporating carrot powder with refined wheat flour at different proportions as showed in Table 1. Pasta was extruded by using lab model pasta extruder (La Monferrina P6 pasta extruder, Italy).

The standardized flour was added to the feed tank of extruder to mixed thoroughly, till a uniform powder was obtained by 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 120°C for 4 hours.

Table 1. Standardization of flour for preparation of pasta

Composition sample code		
	Refined wheat flour (gram)	**Carrot powder (gram)**
Control	100	0
CP_1	95	5
CP_2	85	15
CP_3	75	25
CP_4	65	35

Fig. 1. Raw materials

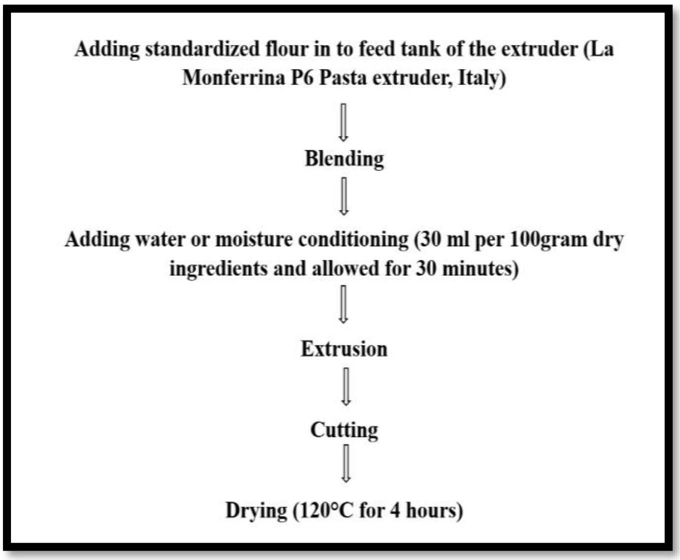

Fig. 2. Flowchart for preparation of pasta

Fig. 3. Developed pasta products according to various blend

2.4 Methods of Analysis

The proximate compositions i.e. moisture, ash, crude protein, crude fiber, carbohydrate contents and mineral compositions i.e. calcium, iron, zinc, magnesium, phosphorus and potassium contents of raw materials and developed pasta were analysed using standard methods by AOAC (2005) and as following methods.

Moisture: Accurately weighed sample was placed in a pre-weighted porcelain crucible and heated to 105 °C for 24 h to ascertain its moisture content. The crucible was taken out of the oven after drying, allowed to cool in the desiccators and carefully weighed (Islam et al., 2019). Following equation was used to determine the moisture content of each sample:

$$\text{Moisture (\%)} = \frac{\text{weight of sample after drying (g)}}{\text{Weight of sample before drying (g)}} \times 100$$

Ash: A known-weighed sample was placed in a pre-weighted porcelain and pre-heated to 100°C on a gas burner to prevent the loss of the sample into a muffle furnace at high temperatures. The crucibles were then heated for 6 h at 550 °C in a muffle furnace (Chowdhury et al. 2023). After completely burning the samples, the crucibles were kept out, allowed to cool off for a couple of minutes, and then placed in a desiccator to cool off completely. Finally, the crucibles containing ash were weighed and carefully recorded. The ash content of each sample was calculated by following equation

$$\text{Ash (\%)} = \frac{\text{Weight of Ash (g)}}{\text{Weight of sample (g)}} \times 100$$

Crude Protein: Crude protein in the sample was carried out based on Kjeldahl methods. This includes digestion followed by distillation and followed by titration by using the KEL PLUS Automatic Nitrogen Estimation System.The crude protein content of the sample was estimated by the following formula:

$$\text{Crude protein (\%)} = \frac{14.01 \times (\text{ml titrant} - \text{ml blank}) \times \text{Normality}(0.025) \times 6.25}{\text{Weight of sample (g)} \times 1000} \times 100$$

Crude Fat: Determination of crude fat in the sample was carried out based on A.O.A.C. (2000) by using the automatic SOCS plus solvent extraction system. Fat percentage was calculated by following equation:

$$\text{Fat (\%)} = \frac{\text{weight of beaker with fat (g)} - \text{Weight of empty beaker(g)}}{\text{Weight of sample (g)}} \times 100$$

Crude Fiber: Determination of crude fiber in the sample was carried out based on Alam et al. (2021) method. The fiber content was calculated by following equation:

$$\text{Crude fiber (\%)} = = \frac{\text{Loss of weight (g)}}{\text{Weight of sample (g)}} \times 100$$

Carbohydrate content: Carbohydrate content in the pasta sample was estimated by the difference according to Cao et al. (2020). The percentage of protein, fat, fiber, ash and moisture was subtracted from 100 to give the percentage of carbohydrate of sample as following equation

Carbohydrate (%) = Total weight – Weight of (Moisture + Ash +Fat + Protein)

Minerals content: The sample was treated for acid digestion for estimation of mineral content by applying the method of Jackson (1973). Then Perkin Elmer Avio™ 200 dual view instrument equipped with Syngistix™ software for inductively coupled plasma optical emission spectrometry (ICP-OES), was used to measure the elemental concentrations of the resultant sample solutions.

The developed pastas were packed in polypropylene (PP) pouch and laminated pouch 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.

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

The nutritional composition & sensory qualities data were statistically analysed by using analysis of variance (ANOVA) techniques and storability of pasta products by using Factorial Completely Randomized Design (FCRD) methods to see the significant and non-significant difference among them.

3. RESULTS AND DISCUSSION

3.1 Nutritional Composition of Raw Materials

Result in the Table 2 indicated that refined wheat flour contained 11.87% moisture, 3.02% ash, 10.62% crude protein, 1.32% crude fat, 0.62% crude fiber and 72.55% carbohydrates. Shree et al. (2018) also reported comparable results of proximal contents for moisture%, fat%, protein%, carbohydrate%, fiber% and ash% i.e. 10.86, 1.56, 11.6, 71.38 and 1.67 respectively. The mineral contents of refined wheat flours as described in Table 1 were calcium (28.10 mg/100g), iron (2.63mg/100g), zinc (1.44mg/100g), magnesium (53.10 mg/100g), phosphorus (124.61mg/100g) and potassium (139.32mg/100g) which was obtained almost similar findings with Gopalan et al. (1982). The nutritional compositions of carrot powder moisture, ash, crude protein, crude fat, crude fiber and carbohydrate percentage were 9.04%, 3.24%, 4.48%, 0.68%, 18.62% and 63.94% respectively (Table1) and mineral compositions were calcium(209.13mg/100g), iron (4.95mg/100g), zinc (2.53mg/100g), magnesium (117.30mg/100g), phosphorus (344.61mg/100g), and potassium (556.26mg/100g) were depicted in Table1. Jalgaonkar et al. (2017) explores comparable similar findings for proximal and mineral contents with the present study.

3.2 Nutritional Composition of Developed Pasta

The pasta products prepared by formulating carrot powder with refined wheat flour were subjected to proximate compositions analysis and result observed were presented in the Table 3. The results reported that with increased amount of carrot powder up to 35% there was increased in contents of ash (1.04 to 2.26%), crude fat (1.19 to 1.39%), crude fiber (1.98 to 4.43%) and crude protein (10.71 to 11.85%) whereas carbohydrate (75.51 to 71.35%) and moisture (8.95 to 8.72%) content was inverse relation to carrot powder incorporation. The increase in mineral contents calcium (43.51 to 84.32mg/100g), iron (2.02 to 3.62mg/100g), zinc (1.12 to 1.25mg/100g), magnesium (44.85 to 71.56mg/100g) and potassium (172.51 to 626.49mg/100g) is directly related to increasing level of carrot powder substitutions. Nwachukwu et al (2020); Omachi and Yusufu (2017); Stephen et al. (2019) earlier recorded similar relation of carrot powder supplementation with the proximal and mineral contents.

Table 2. Nutritional composition of raw materials (per 100g on dry mater basis)

Nutritional composition	Refined wheat four	Carrot powder	CD at 5%
Moisture (%)	11.87^{a} ±0.02	9.04^{b} ±0.06	0.15
Ash (%)	3.02^{b} ±0.05	3.24^{a} ±0.08	0.21
Crude protein (%)	10.62^{c} ±0.24	4.48^{a} ±0.13	0.59
Crude fat (%)	1.32^{a} ±0.12	3.24^{a} ±0.19	0.33
Crude fiber (%)	0.62^{b} ±0.11	18.62^{a} ±0.07	0.37
Carbohydrate (%)	72.55^{a} ±0.17	63.94^{b} ±0.15	0.63
Calcium (mg/100g)	28.10^{b} ±0.09	209.13^{a} ±0.03	5.95
Iron (mg/100g)	2.63^{b} ±0.03	4.95^{a} ±0.06	0.14
Zinc (mg/100g)	1.44^{b} ±0.01	2.53^{a} ±0.02	0.05
Magnesium (mg/100g)	53.10^{b} ±0.03	117.30^{b} ±0.04	0.10
Phosphorus (mg/100g)	124.61^{b} ±0.01	344.61^{a} ±0.04	0.92
Potassium (mg/100g)	139.32^{a} ±0.04	2544.39^{a} ±0.04	0.12

Note: *Values are mean ± SE of three independent replications. Mean with different superscript in the same row differ significantly (p>0.05).*

Table 3. Nutritional composition of carrot powder enriched developed pasta products (per 100g, on dry matter basis)

Nutritional composition	Control	CP_1	CP_2	CP_3	CP_4	CD at 5%
Moisture (%)	$11.84^{a} \pm 0.03$	$8.95^{b} \pm 0.02$	$8.94^{c} \pm 0.02$	$8.84^{d} \pm 0.03$	$8.72^{e} \pm 0.03$	0.07
Ash (%)	$1.04^{d} \pm 0.03$	$1.07^{b} \pm 0.11$	$1.19^{b} \pm 0.09$	$1.34^{b} \pm 0.15$	$2.26^{a} \pm 0.09$	0.32
Crude protein (%)	$10.60^{a} \pm 0.14$	$10.71^{de} \pm 0.34$	$11.03^{cd} \pm 0.21$	$11.41^{bc} \pm 0.12$	$11.85^{a} \pm 0.09$	0.73
Crude fat (%)	$0.67^{b} \pm 0.08$	$1.19^{a} \pm 0.0.7$	$1.28^{a} \pm 0.7$	$1.30^{a} \pm 0.19$	$1.39^{a} \pm 0.12$	0.34
Crude fiber (%)	$0.44^{b} \pm 0.06$	$1.98^{c} \pm 0.10$	$2.15^{b} \pm 0.05$	$3.29^{b} \pm 0.18$	$4.43^{a} \pm 0.13$	0.62
Carbohydrate (%)	$75.62^{b} \pm 0.17$	$75.51^{a} \pm 0.15$	$75.41^{a} \pm 0.31$	$73.82^{b} \pm 0.05$	$71.35^{c} \pm 0.27$	0.72
Calcium (mg/100g)	$14.97^{e} \pm 0.30$	$43.51^{d} \pm 0.37$	$59.67^{c} \pm 0.18$	$75.59^{b} \pm 0.21$	$84.32^{a} \pm 0.12$	0.79
Iron (mg/100g)	$1.39^{d} \pm 0.03$	$2.02^{d} \pm 0.02$	$2.17^{c} \pm 0.03$	$2.89^{b} \pm 0.04$	$3.62^{a} \pm 0.04$	0.11
Zinc (mg/100g)	$1.08^{c} \pm 0.01$	$1.12^{ab} \pm 0.02$	$1.14^{ab} \pm 0.03$	$1.20^{ab} \pm 0.04$	$1.25^{a} \pm 0.07$	0.12
Magnesium (mg/100g)	$39.85^{e} \pm 0.02$	$44.85^{d} \pm 0.40$	$56.24^{c} \pm 0.07$	$60.55^{b} \pm 0.24$	$71.56^{a} \pm 0.30$	0.70
Phosphorus (mg/100g)	$104.20^{e} \pm 0.03$	$108.61^{d} \pm 0.03$	$113.07^{c} \pm 0.04$	$113.32^{b} \pm 0.03$	$114.17^{a} \pm 0.04$	0.19
Potassium (mg/100g)	$113.08^{e} \pm 0.04$	$172.51^{d} \pm 0.04$	$268.39^{c} \pm 0.02$	$426.68^{b} \pm 0.03$	$626.49^{a} \pm 0.03$	0.10

Note: *Values are mean ± SE of three independent replications. Mean with different superscript in the same row differ significantly (p>0.05).*
Control- RWF: CP (100:0) *CP_1- RWF: CP (95:5)* *CP_2- RWF: CP (85:15)* *CP_3- RWF: CP (75:25)*
CP_4- RWF: CP (65:35) *RWF- Refined wheat flour CP- Carrot powder*

Table 4. Effect of storage on carrot powder enriched developed pasta

Organoleptic Parameters	Packaging	Storage duration (In days)	Control	CP_1	CP_2	CP_3	CP_4
Appearance		0^{th}	8.40±0.16	7.80±0.13	6.80±0.20	5.90±0.23	5.80±0.20
	PP	30^{th}	7.90±0.18	7.70±0.15	6.40±0.22	5.60±0.22	5.30±0.21
		60^{th}	7.80±0.13	7.30±0.15	6.10±0.23	6.30±0.30	5.00±0.30
		90^{th}	7.50±0.22	6.70±0.15	5.80±0.26	5.10±0.28	4.90±0.31
	Laminated Pouch	30^{th}	8.00±0.15	7.40±0.20	6.40±0.21	5.30±0.25	5.30±0.26
		60^{th}	7.80±0.13	7.20±0.20	5.90±0.31	5.20±0.20	5.10±0.28
		90^{th}	7.60±0.22	7.10±0.18	5.60±0.31	5.20±0.28	5.00±0.28
P-value	Composition level (A)= <0.01 Storage period (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	7.20±0.20	7.50±0.22	7.20±0.13	7.20±0.13
	PP	30^{th}	8.20±0.13	7.00±0.21	7.10±0.18	7.00±0.21	6.70±0.21
		60^{th}	7.50±0.17	6.70±0.15	6.60±0.16	6.50±0.17	6.10±0.28
		90^{th}	5.80±0.15	6.10±0.31	5.90±0.28	5.80±0.33	5.50±0.33
	Laminated Pouch	30^{th}	7.70±0.21	6.80±0.20	6.90±0.28	6.90±0.18	6.60±0.16
		60^{th}	7.50±0.22	6.30±0.21	6.10±0.23	6.30±0.30	5.90±0.23
		90^{th}	7.20±0.25	5.90±0.31	5.60±0.34	5.90±0.23	5.70±0.21
P-value	Composition level (A)= <0.01 Storage period (B)= <0.01 Packaging (C)= NS A×B=NS A×C=NS B×C=0.01 A×B×C=NS						
Texture		0^{th}	8.50±0.17	6.50±0.27	7.50±0.22	7.20±0.13	7.30±0.15
	PP	30^{th}	8.10±0.18	6.10±0.23	6.80±0.25	6.70±0.21	6.90±0.28
		60^{th}	7.70±0.22	5.70±0.30	6.30±0.37	6.20±0.20	6.10±0.28
		90^{th}	6.80±0.25	5.50±0.34	5.60±0.27	5.90±0.23	5.80±0.36
	Laminated Pouch	30^{th}	8.20±0.20	6.10±0.18	6.70±0.30	6.60±0.16	6.80±0.20
		60^{th}	7.80±0.20	5.60±0.22	6.20±0.13	6.10±0.25	6.20±0.25
		90^{th}	6.50±0.34	5.30±0.30	5.60±0.16	6.00±0.26	5.90±0.23
P-value	Composition level (A)= <0.01 Storage period (B)= <0.01 Packaging (C)= NS A×B=NS A×C=NS B×C=NS A×B×C=NS						
Colour		0^{th}	8.70±0.15	8.30±0.21	7.70±0.15	6.80±0.20	6.50±0.17
	PP	30^{th}	8.30±0.15	7.90±0.18	7.20±0.13	6.60±0.22	6.30±0.26
		60^{th}	7.80±0.20	7.60±0.22	6.80±0.20	6.30±0.26	6.10±0.23
		90^{th}	7.10±035	7.20±02.0	6.60±0.16	6.10±0.28	5.80±0.20

	Laminated Pouch	30th	8.20±0.20	7.80±0.25	7.10±0.18	6.70±0.21	6.40±0.31
		60th	7.90±0.18	7.60±0.16	6.70±0.15	6.30±0.21	6.20±0.20
		90th	6.90±0.23	7.30±0.15	6.50±0.27	6.30±0.21	6.10±0.23
P-value	Composition level (A)= <0.01 Storage period (B)= <0.01 Packaging (C)= NS A×B=0.02 A×C=NS B×C=NS A×B×C=NS						
Overall acceptability		0th	8.40±0.16	7.90±0.10	7.40±0.16	7.30±0.15	6.90±0.10
	PP	30th	8.00±0.16	7.60±0.16	7.10±0.16	6.90±0.19	6.60±0.26
		60th	7.70±0.15	7.30±0.15	6.90±0.23	6.70±0.15	6.20±0.25
		90th	7.10±0.35	6.80±0.25	6.50±0.22	6.30±0.23	5.90±0.15
	Laminated Pouch	30th	7.90±0.31	7.60±0.16	7.20±0.20	6.90±0.18	6.70±0.21
		60th	7.60±0.27	7.10±0.23	6.70±0.21	6.80±0.13	6.40±0.16
		90th	6.90±0.31	6.60±0.27	6.30±0.21	6.50±0.17	6.00±0.30
P-value	Composition level (A)= <0.01 Storage period (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*

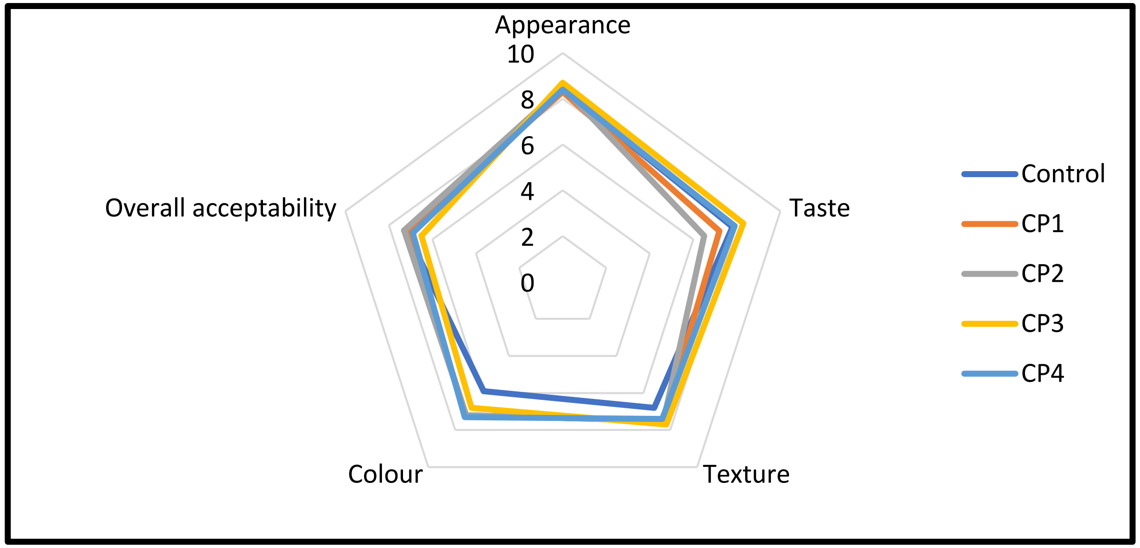

Fig. 4. Mean organoleptic acceptability of carrot powder enriched developed pasta products

3.3 Sensory Evaluation of Developed Pasta

Results related to the organoleptic characteristics of pastas incorporated with carrot powder are shown in the Fig. 4 indicated that increasing the concentrations of carrot powder up to 35% there was decline in the sensory attributes appearance, taste, texture, colour and overall acceptability from 7.80 to 5.80, 7.50 to 7.20, 7.50 to 6.50 and 7.90 to 6.90 (declined from category of like moderately to neither like nor dislike) CP_1 Pasta made from 95% refined wheat flour and 5% carrot powder were more acceptable than other three treatments along with refined wheat flour pasta(control). Sule et al (2019); Turksoy and Ozkaya (2011) reported the similar results.

3.4 Effect of storage on Carrot Powder Enriched Developed Pasta Products

The data depicted from Table 4 explained that all the sensory qualities of carrot powder formulated pasta along with control decreased significantly with increased in the storage intervals at 0^{th}, 30^{th}, 60^{th} and 90^{th} days. From the present study it was found that carrot powder incorporated developed pasta products were acceptable up to 60^{th} days of storage periods without any significant change in sensory acceptability. It was found that sensory attribute taste and colour changed were higher in PP pouch than laminated pouch. Similar results revealed by Nousheen (2013); Samta and Jood (2018) with the present exploration process.

4. SUMMARY AND 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 14.97 mg/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 carrot powder in refined wheat flour. The maximum nutritional contents were observed in CP_4 and minimum contents in CP_1 composite flour developed pasta. Pasta made from 95 percent refined wheat flour with 5 percent carrot powder (CP_1) was within acceptable range in term of overall acceptability by the penal members. CP_1 composite flour pasta depicted desirable nutritional quality and sensory characteristics. All the sensory characteristics of carrot powder formulated pasta along with control decreased significantly with increased in the storage intervals at 0^{th}, 30^{th}, 60^{th} and 90^{th} days. From the present study it was observed that the carrot powder incorporated developed pasta products 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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