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ORIGINAL ARTICLE

Effect of maize based composite flour noodles on functional, sensory, nutritional and storage quality

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Abstract To explore the feasibility of utilization of maize flour in noodle preparation, eight different combinations (T_1 to T_8) with varied amount of maize flour (MF), refined wheat flour (RWF), rice flour (RF), wheat gluten (WG), soya protein isolate (SPI), kansui (Sodium Carbonates), potato starch (PS) were extruded to standardize good quality noodles. Among various combinations tested, the combination T_5 (50 %MF + 30 %RWF + 10 %SPI + 7 %RF + 3 %WG) was rated the best for appearance (8.3) colour (8.25) taste (8.5) elasticity (8.3) with an overall acceptability of 8.2 on a nine point hedonic rating sensory scale. There was no significant difference in normal noodle (NN) and Quality protein maize (QPM) noodle (QN) for T_5 with respect to sensory characteristics when compared to control noodle (CN) prepared out of refined wheat flour. The cooked yield was more for maize based noodle (234 g NN and 220 g QN) with lower cooking loss of 7.80 and 7.76 respectively for NN & QN. The nutritional composition of maize noodles revealed that addition of 10 % soya protein isolate had increased the protein content of noodles to the tune of 16.6 and 12.7 % in QN and NN respectively. The soluble (3.18NN, 3.76QN) and insoluble fiber (21.67NN, 21.87QN) contents of both NN & QN was significantly more compared to CN (0.15 and 9.3 g).There was non-significant increase in moisture and peroxide values up to 3 months of storage with high overall acceptable sensory scores (4.0, 4.1, & 4.2 respectively for NN, QN and CN but beyond third month of storage the increase was significant. However the noodles were within the acceptable range up to 6 months of storage with an overall acceptability score of 3.0, 3.4 and 3.2 for NN, QN and CN respectively on a five point hedonic scale.

Keywords Quality protein maize · Soya protein isolate · Extrusion · Water holding capacity

Research highlights Noodles were prepared with normal (NN), quality protein maize (QN) and compared the various characteristics. The cooked yield was more for maize based noodles.The nutritional composition of maize noodles revealed addition of 10 % soya protein isolate had increased the protein content of noodles to the tune of 16.6 and 12.7 % in QN and NN respectively. There is no difference in sensory, storage and cooking quality of normal and QPM based noodles, both were equally acceptable throughout the storage period of 6 months.

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The consumption of noodles and pasta has been increased due to easy availability, less cooking time with better sensory attributes. Number of convenience foods prepared out of wheat are available in the market and noodle is one such convenience food prepared through cold extrusion system which becomes hard and brittle after drying. These are very popular nowadays due to changing food habits of children and teenagers which created a good market for noodles in India and abroad. Commercial noodles available in the market are rich in carbohydrates, deficient in proteins, vitamins, dietary fiber and other vital nutrients. The consumption of foods enriched with proteins from plant sources has been increasing among vegetarian and health conscious people (Wu et al. 1987). Among the vegetarian sources, soy which contains around 40 % protein is rich in lysine while cereal protein is rich in sulphur containing amino acids especially methionine. Hence blending of these two in appropriate quantities will make up the individual deficiency. Many products of good quality could be produced with such combinations. Soy and its products have been used as chief source of protein for millions of people in the orient (eastern part of Asia) for centuries. The highly refined fraction of the soya is soy protein isolate which contains >90 % protein (N × 6.25) on moisture free basis (Endres 2001). Hence use of such soy fractions is beneficial for blending of lysine deficient cereals such as maize.

Despite of increased production of maize, its products are mainly used for animal or poultry feed and not so popular as human food, mainly because of lack of essential amino acids like lysine and tryptophan. Recently more attention has been given to produce maize for human consumption, as a result, QPM hybrids developed by breeders are boon to the nutritional security of animal as well as human beings. Maize with a modified amino acid profile with greater amounts of lysine and tryptophan than normal maize is known as "quality protein maize" (QPM) (Jorge et al. 2006). QPM has got special distinction among cereals due to presence of double the amount of essential amino acids viz, Lysine (4.92) and Tryptophan (1.20) which can be utilized for diversified purposes in food and nutritional security as infant food, health food, convenience food, specialty food and emergency nutrition. QPM looks and taste like normal maize with same or high yield and rich in quality of proteins (Jat et al. 2009). However the protein quality of normal grains can be improved by combining with good quality characteristics.

Maize and its products can be utilized in many ways for the preparation of conventional as well as novel items. Lots of studies have been conducted by different workers such as Molina et al. (1982) who substituted the wheat flour by whole corn flour up to 75 % level in the preparation of semolina-corn-soy flour pasta. The use of germinated cajanus cajan seed flour to improve the nutritional value of pasta was studied by Torres et al. (2006). Similarly different maize flour incorporated products like maize based weaning food using peanut, maize and soyabean (Plahar et al. 2003), fortification of maize flour based diets with blends of cashew nuts meal, african locust bean meal and sesame oil meal (Ekpenyong et al. 2006) and preparation of wheat and quality protein maize based biscuits (Gupta and Singh 2005) were already popular.

In recent years number of studies on addition of different compounds to noodles are increasing by combining different cereal and pulses in order to overcome individual deficiencies which can be well achieved by composite flours. Composite flours refers to mixtures in which cereal flours, predominantly wheat flour are combined with other starch and protein sources including those derived from other cereals, roots, food legumes and oilseeds (Hulse 1974). In this direction various workers like Huda et al. (2000), Devaraju et al. (2006), Sudha and Leelavathi (2012) and Vijayakumar and Boopathy (2014) worked on preparation of noodles using composite flour mixes by blending with protein rich components such as fish surimi powders, finger millet composite flour, dehydrated green pea flour and amaranth seed flour for preparation of pasta.

However noodles and vermicelli from maize, other millets and sorghum blended with soya protein are still to appear in the market. A huge potential exists for these products, as it is value added and convenient product for the manufacturers and working women community as it adds variety to the consumers and such products can be used either as a savory, sweet or snack food.

Hence the objective of the present study was to assess the feasibility of maize flour incorporation in noodle preparation and its impact on sensory, nutritional and cooking quality.

Materials and methods

The maize grains of Quality protein maize hybrid (Shaktiman-4) and normal maize (NAH- 2049) were procured from AICR P, Dholi (Bihar) and V.C Farm, Mandya respectively and the grains were treated with 1 % lime solution washed and sundried till the moisture percentage reaches to around 9–10 %. The grains were dry milled in a mini SS dry grinder mill and passed through 60BS sieve to get a fine maize flour of 250 μm (MF). Refined wheat flour (RWF), rice flour (RF) and salt purchased from local market, while wheat gluten (WG), soya protein isolate (SPI), kansui (Sodium carbonates), potato starch (PS), pectin were procured from Ajay Trading Industries, Bengaluru.

Preparation of noodles

Based on the previous literature, noodles were prepared with different percentage of maize flour along with other ingredients as shown in Table 1 by keeping kansui (0.5 %) water (40 %) salt (3 %) and oil (5 ml) constant. The method of preparation was a modification of previous method described by Kruger et al. (1994). Flour mixtures were transferred to single screw dolly machine (La Monferrina, Italy, model p-3) and mix for 4–5 min. During mixing of flours in pasta making unit, a solution of 0.5 % kansui mixed with water was added to flour mixtures (T1 to T8). Water was added intermittently at the rate of 40 % for proper dough consistency. After 10–15 min, the dough was extruded using dies having perforation of 1.6 mm and the noodles were steamed on a boiling water bath for 8 min (102–105 °C). The steamed noodles were allowed to cool at room temperature (25 ± 3 °C) and were dried in a hot air oven at 50 °C for 5 h until the moisture percentage reaches 8 to

Table 1 Formulations with different levels of maize flour incorporation into the noodles

Ingredients (g)	Formulation (treatments)							
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
Maize flour	90	80	70	60	**50**	60	70	80
Refined wheat flour	10	20	20	20	**30**	28	28	–
Soy protein isolate	–	–	–	10	**10**	10	–	–
Rice flour	–	–	–	10	**7**	–	–	18
Potato starch	–	–	10	–	–	–	–	–
Wheat gluten	–	–	–	–	**3**	–	–	2
Pectin	–	–	–	–	–	2	2	–
Kansui	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Distilled water	40 ml	40 ml	40 ml	40 ml	**40 ml**	40 ml	40 ml	40 ml

Best accepted formula has been indicated in bold numbers

9 %. In order to select the best quality noodle among eight different combination of treatments (standardization purpose) the noodles (10 g) of treatments (T_1 to T_8) were reconstituted in boiling water (100 ml) with a known quantity of spice mix (5 g) and the coded samples were served for sensory evaluation by semi-trained panel members using nine point hedonic rating scale (Rathi et al. 2004). The judges were asked to evaluate the noodles based on colour, appearance, taste (aroma and mouth feel) elasticity and over all acceptability. Based on sensory evaluation results, T_5 (50 %MF + 30 %RWF + 10 %SPI + 7 % RF + 3 %WG) was rated as the best in terms of noodle quality (Fig. 1). Best noodle was selected to continue further experiments and analysis.

Sensory evaluation

To know the difference between QN, NN and CN the sensory characteristics of cooked noodles were evaluated on a five point hedonic scale (Ranganna 1986).

Cooking characters

To evaluate the cooking quality, 10 g of noodles were cooked in 100 ml of water and recorded the time taken for cooking (min). After complete cooking, cooked noodles were weighed and recorded in grams. For cooking loss (%) noodles were drained for 5 min and volume of collected gruel was measured and stirred well and 20 ml of the gruel was pipetted into a petri plate and evaporated into dryness over a water bath. Then the

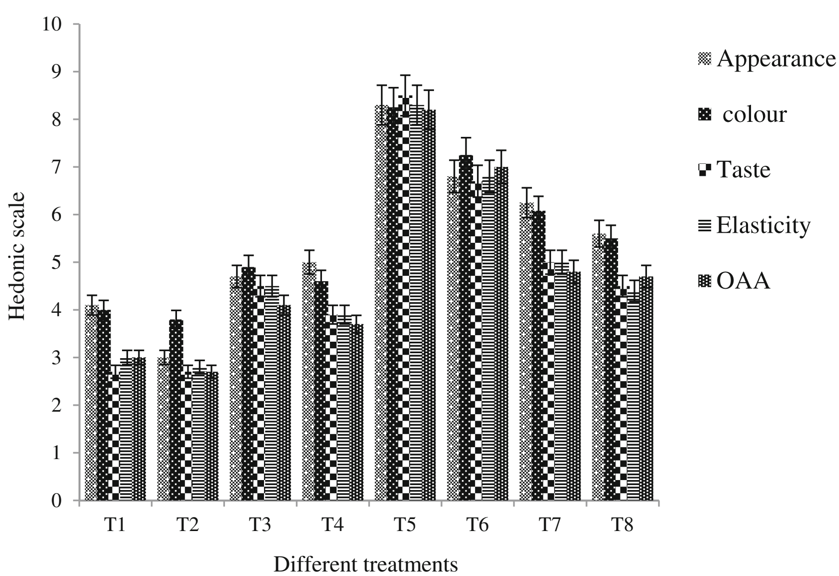

Fig. 1 Mean sensory scores of different treatments with variable amount of maize flour. T_1 -90 % MF + 10 % RWF, T_2 -80 % MF + 20 % RWF, T3-70 % MF + 20 % RWF + 10 % PS, T4 -60 % MF + 20 % RWF + 10 % SPI + 20 % WG, T_5-50 % MF + 30 % RWF + 10 % SPI + 7 % RF + 3%WG, T_6 - 60 % MF + 28 % RWF + 10 % SPI + 2 % pectin, T_7 -70 % MF + 28%RWF + 2 % pectin, T_8-80 % MF + 18 % RF + 2 % WG: Score pattern: 9-Liked extremely, 8-Liked very much, 7-Liked moderately, 6-Liked slightly, 5-Neither liked nor disliked, 4-Disliked slightly, 3-Disliked moderately, 2-Disliked very much, 1-Disliked extremely, *OAA* over all acceptability

petri plate was transferred to a hot air oven maintained at 105 ± 2 °C and dried to constant mass. Each analysis was repeated for four times. The cooking yield (%) was calculated according to ISI (1993) by the equation:

$$\text{Cooking yield } (\%) = \frac{\text{Weight of the noodles after cooking}}{\text{Weight of the noodles before cooking}} \times 100$$

Water uptake ratio was estimated as per the method of Buck et al. (1987) and bulk density by Okaka and Potter (1977). Water holding capacity (WHC) of the dry noodle was calculated according to Deshpande and Poshadri (2011), where in approximately 5 g of fine ground sample was weighed and allowed to rehydrate over night in excess of water (7:1), after draining it was reweighed and WHC was calculated as

$$\text{WHC} = \frac{\text{Weight of wet noodle powder} - \text{weight of dry noodle powder}}{\text{Weight of dry noodle powder}} \times 100$$

Analysis of nutritional composition

Proximate and calcium content was estimated according to standard procedure of AOAC (1995) and iron by Wong's method. Water soluble vitamins like thiamine, riboflavin, niacin, pyridoxine and folic acid contents were estimated according to Ekinci and Kadakal (2005). Total dietary fibre (soluble and insoluble) was analysed according to the method of Asp and Johansson (1981) while zinc was estimated by calorimetric dithizone method (FSSAI 2012).

Storage study

Samples packed in Low-density polyethylene pouches (200 gauge) were drawn periodically (0–6 months) for assessing the moisture, peroxide value (AACC 1990) and sensory quality.

Statistical analysis

Statistical analysis was carried out using analysis of variance (ANOVA) by taking mean of 12 semi trained judges for various sensory parameters. Data obtained from each treatment was subjected to analysis of variance as described by Steel et al. (1997).

Results and discussion

Among the different types of maize flour incorporated noodles (T_1 to T_8) treatment, T_5 (50 % MF + 30 %RWF + 10 %SPI + 7 %RF + 3 %WG) differed significantly with respect to sensory characters such as colour (8.25), appearance (8.30), taste (aroma and mouth feel) (8.50) and elasticity (8.30) with an overall acceptability score of 8.20 on a nine point hedonic rating scale compared to other treatments (Fig. 1). Since maize flour is gluten free different combinations of other ingredients helped in the formation of rupture free structures and improved the quality characteristics. Among the different combinations tested, T_5 noodles were firm without any stickiness; elasticity and mouth feel were excellent. As the level of maize flour increases (T_1, T_2, T_3, T_6, T_7, & T_8) the noodles exhibited a starchy mouth coating along with raw taste. Similar kind of study conducted by Vijayakumar et al. (2010) on quality evaluation of noodles indicated that as the level of millet flour incorporation increases, starchy mouth coating appears in prepared noodle. In the present study noodles with 50 % maize flour incorporation did exhibit a mild starchy mouth coating. High amount of maize flour incorporation (T_1, T_2, T_3, T_6, T_7, & T_8) increases the roughness of cooked noodles, indicating that amount of grainy particles and bumps on the noodle surface, so also starchy mouth feeling was increased with increase in level of maize flour. Hence the treatment T_5 (50 % MF + 30 %RWF + 10 %SPI + 7 %RF + 3 %WG) prepared with a combination of other ingredients along with maize flour was highly acceptable because of the presence of wheat gluten which has an added advantage not only helps in easy extrusion but also gives a smooth and fissure free texture to the noodles. Erdman and Fordyce (1989) reported that addition of gluten as a source of protein had acceptable quality. Apart from this soya flour used to produce noodles had added advantage since their fibres have been shown to lower blood cholesterol and alter the distribution of plasma lipid fractions. Addition of 3 % gluten increased the cutting stress, and at 1.5 to 3 % vital gluten, the shear values increased from 53 to 64 g as reported by Kim et al. (1989). Similar kind of surimi powder added yellow noodles were prepared with addition of other ingredients like kansui (1 %) and salt (2 %) was reported by Chin et al. (2012). Even the addition of additives at the rate of 0.5 % of the ingredient weight was reported by Purnima et al. (2012) for the production of pasta. Addition of combination of ingredients to increase the quality of vermicelli was reported by Prabhasankar et al. (2007).

The standardized procedure for preparation of noodle is depicted in Flow chart 1. Comparison of sensory characteristics among three different noodles (NN, QN & CN) for the standardized combination T_5 is depicted in Table 2. The CN was highly acceptable in overall acceptability score of 4.40 at the same time, there was no significant difference between NN and QN in terms of appearance, colour, texture, flavor, taste and overall acceptability (OAA) indicating that 50 % maize flour added noodle (T_5) was acceptable irrespective of QPM or normal maize and were exhibited non-significant differences in sensory qualities with an overall acceptability score of 3.40 and 3.30 respectively.

Cooking qualities

Cooked noodle must be firm, elastic, resilient and non sticky for maximum consumer acceptance. Cooking characteristics of noodles is depicted in Table 3. The CN took less time to cook (8.8 min) compared to NN (10.5 min) and QN (10.6 min). The cooking yield was defined as the percentage of noodle weight after cooking to the weight of raw noodles; hence it represented the ability of the noodles to absorb water from the cooking medium. A higher value for the cooking yield and lower cooking loss typically represents good quality alkaline noodles. The yield of noodles after cooking was more for NN (234 g) and QN (220 g) compared to CN (201 g). This is due to unique property of the maize flour to hold more water than other cereal flour, so also the relative hydration rate, swelling capacity is more for maize noodles. Hence the

QPM Maize
↓ After cleaning
Soak 500g grains in 1% lime water for 5 minutes
↓
Give heat treatment at simmering temperature for 30 minutes
↓
Remove the vessel and leave it for overnight. Wash 3 – 4 times to remove lime
↓
Dry in sunlight
(Moisture level should be 9-10 %)
↓
Cleaned Quality Protein Maize grains/ NAH-2049
↓
Milled and sieved (Std sieve no 60)
↓
Weigh 50 g Maize flour, 30 g Wheat flour, 10 g Soya protein isolate,
7 g Rice flour, 3g Wheat gluten 5 ml oil, 0.5g kansui and 3 g salt
↓
Mixed with 40 ml water
↓
Kneaded in pasta making machine (P-3) for 15 min
↓
Extruded in noodles dye of 1.6mm thickness, (single screw extruder Dolly P-3)
Steam cooked for 8 min
↓
Dried at 50°C for 5 hr

Flow chart 1 Lime treatment of QPM maize grain & preparation of noodles

Table 2 Difference in sensory scores of normal and QPM noodles compare to control

Sensory characteristics	Sample			Statistical analysis		
	CN	NN	QN	F-Value	SEm±	CD @5 %
Appearance	4.60	3.50	3.40	16.40	0.23	0.48
Color	4.10	3.40	3.20	4.67	0.31	0.63
Texture	4.00	3.70	2.60	13.97	0.28	0.57
Flavor	3.70	3.00	3.80	4.38	0.29	0.60
Taste	4.50	3.80	3.00	15.06	0.27	0.56
OAA	4.40	3.40	3.30	14.48	0.23	0.46

Significant @5 %, *n* = 12, 1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Excellent

CN control noodle; *NN* normal noodle; QN-QPM noodle

cooking time and the water uptake were high compared to control**.** The cooking yield was defined as the percentage of noodle weight after cooking to the weight after the raw noodles. Hence it represented the ability of the noodles to absorb water from the cooking medium. A higher value for cooking loss typically represents good quality alkaline noodles. Similar kind of variation in cooking yield of different levels of surumi powder added noodles was reported by Chin et al. (2012). Addition of ingredients such as gluten at 2 and 4 % increased the cooked weight and decreased the cooking loss as per Sudha and Leelavathi (2012).

The cooking loss represented the particles that diffused out from the noodles into the cooking medium during cooking. The cooking loss property reflects the surface characteristics of the noodles according to Shiau and Yeh (2001). Higher the cooking loss, is the stickier the noodle surface, hence cooking loss is undesirable because of high starch content in the cooking medium and that the noodles had a low cooking tolerance (Chakraborty et al. 2003). On the other hand according to Wu et al. (1987) it should not exceed 10 % of the dry weight. The cooking loss in the present study was within the range in all the samples (6.3, 7.8 and 7.76 respectively for CN, NN & QN). The reduced cooking loss in the present study might be due to the combination of other ingredients used to formulate the product. Values for cooking loss in the range of 5.6 to 9.1 for different other ingredients added pasta products was reported by Purnima et al. (2012). Reduced cooking loss with the addition of different other ingredients like GMS, kansui and gluten was also reported by Kaur et al. (2004), Defloor et al. (1991) and Kim et al. (1989).

The water uptake ratio was more for maize based noodles viz, NN (1.26), QN (1.24) while it was comparatively less for CN (1.16). Study conducted by Lagasse et al. (2006) relates this decreased water uptake to shorter cooking time. Similar trend was observed with CN which exhibited a lesser water uptake ratio of 1.16 g/g with shorter cooking time (8.8 min)

Table 3 Cooking characteristics of noodles

Noodle type	Cooking time (min)	Cooked yield (%)	Cooking loss (%)	Water uptake ratio (g)	WHC (%)	BD (g/ml)
NN	10.5 ± 0.5	234.1 ± 1.52	7.80 ± 0.07	1.26 ± 0.05	418.6 ± 0.57	0.58 ± 0.30
QN	10.6 ± 0.5	220.3 ± 1.02	7.76 ± 0.04	1.24 ± 0.04	420.8 ± 0.76	0.55 ± 0.32
CN	8.8 ± 0.8	201.1 ± 1.25	6.3 ± 0.02	1.16 ± 0.15	380.4 ± 0.45	0.42 ± 0.02

CN control noodle; *NN* normal noodle; *QN* QPM noodle; *BD* bulk density; *WHC* water holding capacity

Values are mean ± SD of three observations

while the water holding capacity was maximum for maize based noodles (418 and 420 respectively for NN and QN) compared to CN (380).This could be due to the higher level of cereal starch and crude fiber in maize samples. Similar observation was made by Zaneta et al. (2006) for maize based noodles. The water holding capacity of extruded snacks prepared from varied proportion of foxtail millet based composite flour was in the range of 440, 420 and 400 respectively for 70, 60 and 50 % foxtail added products (Deshpande and Poshadri 2011). Further authors relate that to the higher level of cereal starch and crude fiber in composite flours. It is also evident from the research of Shirani and Ganesharanee (2009) where in highest moisture retention was found in the extruded product prepared from composite flour which was mainly because of increase in protein content due to maximum utilization of pulses in composite flour.

Nutritional composition

Nutritional composition of the noodles is depicted in Table 4. Significant difference was found in nutritional composition of three types of noodles. The protein content of QN was 16.65 g compared to NN (12.7 g) that was significantly higher than control noodle (10.99 g). Similar line of work on rice noodle preparation from BPT5204, a popular variety of Andra Pradesh as reported by Anitha and Rajyalakshmi (2012). Dietary fiber plays a multifaceted role in preventing a number of disorders through their influence in the gastrointestinal tract which includes both soluble and insoluble fibre. Insoluble fibre shortens bowel transit time, increases fecal bulk and renders feces softer. Soluble dietary fibre delays gastric emptying, slows glucose absorption, lowers serum cholesterol level and helps to reduce the risk of heart attack (Dreher 2001). Both soluble (3.18, 3.76) and insoluble fibre (21.67, 21.87) content of NN and QN respectively and were significantly more compared to control, obviously because they were prepared out of refined wheat flour.

Storage study

The appearance, colour, texture, taste and flavor are the important characteristics for acceptability and also these are the good indicators for physiochemical changes during storage. Perusal of Fig. 2 showed that the maximum OAA scores were observed up to 3 months (4.0, 4.1, & 4.2 respectively) of storage, beyond this sensory scores were affected significantly with respect to colour (3.2, 3.4 and 3.8 respectively for NN, QN and CN) which ultimately affects the appearance scores. During 6 months of storage, OAA of maize (NN&QN) as well as CN were well within acceptable range. Even the observation made by Payumo et al. (1969) on the organoleptic test of coco noodles prepared from wheat, coco and mung bean flour in the ratio of 50:30:10 and the noodles were acceptable over a storage period of 6 months. On the other hand work on spaghetti reported by Duskiewicz et al. (1988) indicates no significant difference between spaghetti containing concentrates and flour for mouth feel at zero time (month) and after 6 months of storage time, further external appearance and general acceptability after 3 months found to be unchanged.

At the end of storage period even though products fall in acceptable category due to oxidative changes within the

Table 4 Nutritional composition of standardized noodles

Nutrients	NN	QN	CN
Moisture (%)	8.10 ± 0.01^b	8.00 ± 0.01^c	8.20 ± 0.05^a
Proteins (g)	12.7 ± 0.11^b	16.65 ± 0.03^a	10.99 ± 0.11^c
Fat (g)	3.76 ± 0.08^b	4.28 ± 0.02^a	3.59 ± 0.09^c
Carbohydrates (g)	77.98 ± 0.02^c	84.04 ± 0.25^a	82.4 ± 0.25^b
Soluble fibre (g)	3.18 ± 0.02^b	3.76 ± 0.02^a	0.15 ± 0.03^c
Insoluble fibre (g)	21.67 ± 0.05^b	21.87 ± 0.02^a	9.3 ± 0.25^c
Zinc (mg)	22.77 ± 0.10^c	27.7 ± 0.1^b	37.0 ± 0.2^a
Iron (mg)	10.9 ± 0.10^c	18.6 ± 0.16^b	29.2 ± 0.2^a
Calcium (mg)	52.9 ± 0.02^b	51.7 ± 0.43^c	53.6 ± 0.15^a
Magnesium (mg)	45.41 ± 0.08^a	38.15 ± 0.05^b	20.75 ± 0.05^c
Thiamine (mg)	11.38 ± 0.04^c	17.78 ± 0.09^b	23.7 ± 0.1^a
Riboflavin (mg)	0.02 ± 0.02^a	0.02 ± 0.02^a	0.02 ± 0.01^a
Niacin (mg)	0.02 ± 0.02^c	1.72 ± 0.08^a	0.67 ± 0.05^a
Pyridoxine (mg)	71.99 ± 0.07^b	70.07 ± 0.01^c	139.4 ± 0.4^a
Folic acid (mg)	0.02 ± 0.02^a	0.02 ± 0.02^a	0.02 ± 0.02^a

NN normal noodle; *QN* QPM noodle; *CN* control noodle

Values are means ± SD of three observations. Data followed by different letters are significantly different at $P < 0.05$ and the same letter were not significantly different ($P = 0.05$)

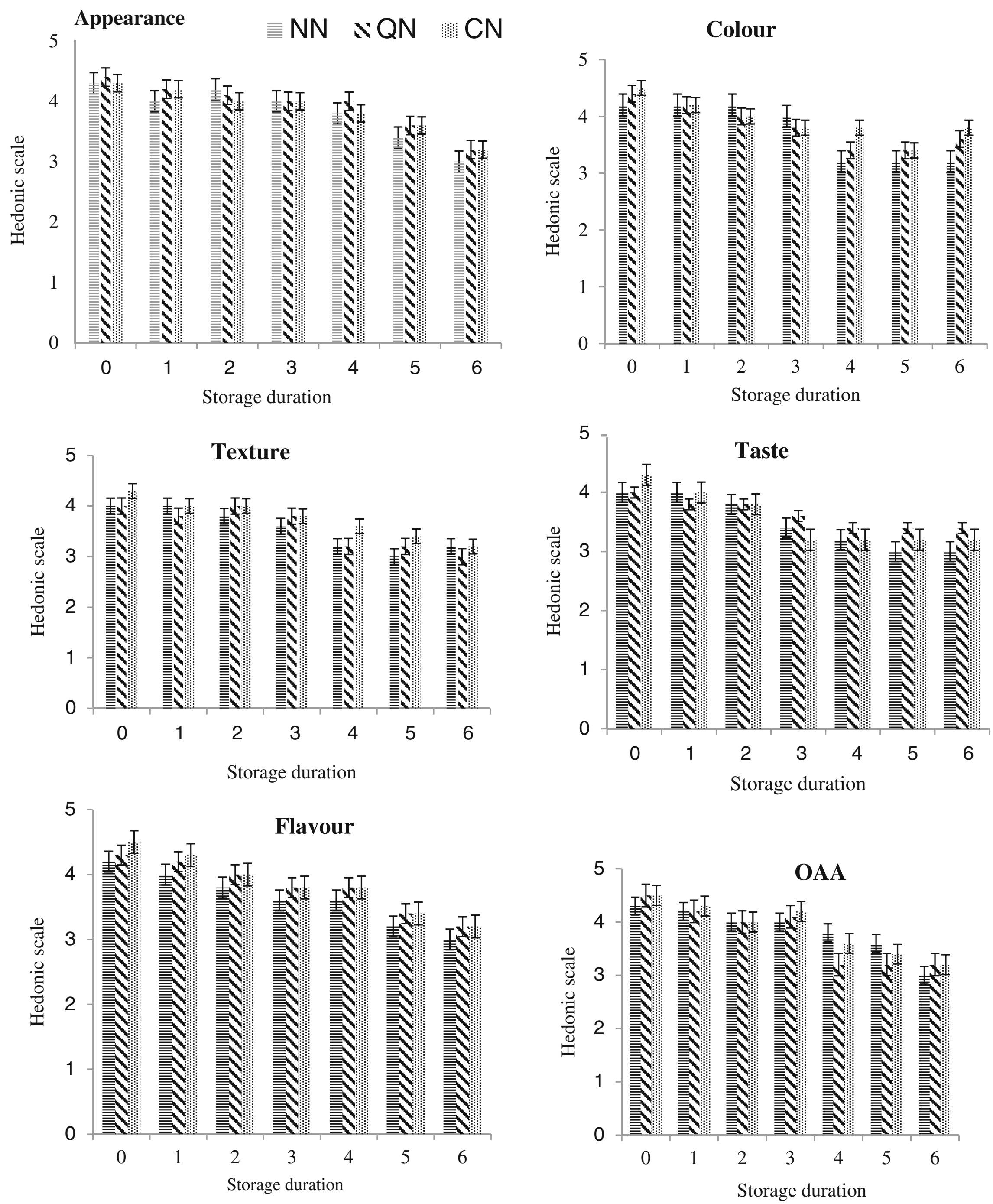

Fig. 2 Mean sensory scores of noodles during storage. *NN* normal noodle; *QN* QPM noodle; *CN* control noodle; *OAA* over all acceptability, Score pattern: 1-Poor, 2-Fair, 3-Good, 4-Very good, 5-Excellent; 0 to 6-Storage duration

packages, there was significant change in the colour (3.2, 3.6, and 3.8 respectively for NN, QN and CN) and taste (3.0, 3.4 and 3.2 respectively for NN, QN and CN) of the products which ultimately affects other sensory parameters. The biochemical changes during storage (Fig. 3a) showed that irrespective of samples, there is a significant increase in the moisture content of all samples from zero time (8.20, 8.10 and 8.0 %) to 6 months (10.10, 9.98, and 9.68 %) of storage period. Similar trend of increase in moisture content of value added vermicelli was from 7.7 to 8.0 % over a period of two months as reported by Midha and Mogra (2007).

Peroxide values usually used as an indicator of deterioration of fats as oxidation takes place, the double bond in the unsaturated fatty acids is broken down to produce secondary oxidation products which in turn causes rancidity. Samples had initial peroxide values 0.70, 0.63, and 0.61 m eq/kg fat

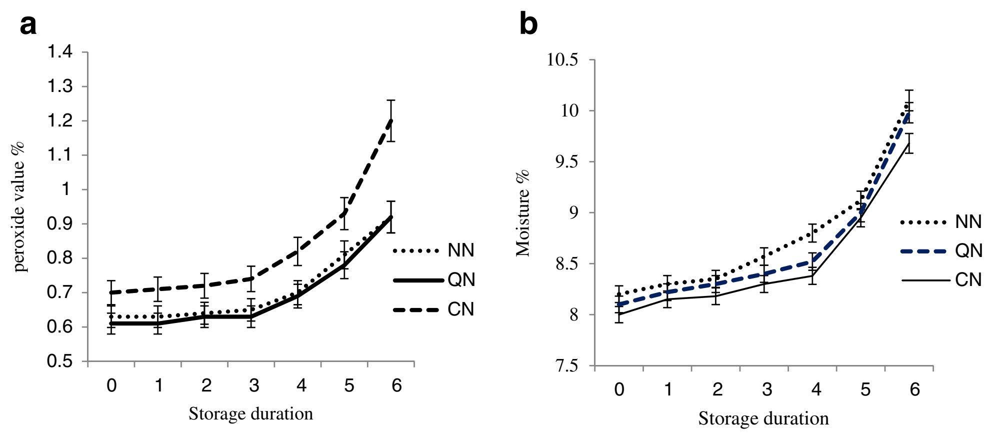

Fig. 3 Effect of storage on the biochemical changes of noodles. **a** Moisture changes during storage of noodles. **b** Peroxide value changes during storage of noodles. *NN* normal noodle, *QN* QPM noodle, *CN* control noodle; 0 to 6- Storage duration

respectively of CN, NN and QN (Fig. 3b). There was a non significant increase in peroxide value of NN (0.64) and QN (0.63) up to 3 months of storage, which is supported by the work conducted on peroxide value of quality protein maize flour during storage was stable up to 3 months in LDPE covers as reported by Shobha et al. (2012). After 3 months of storage, significant increase in peroxide value was observed due to increased absorption of moisture however the increase was within the limits for rancidity. Kwaku et al. (2004) reported a peroxide value of 1.64 for cowpea ground nut miso like product while Kirk and Sawyer (1991) reports for a noticeable rancidity the peroxide value of 20-40 meq/kg as the range at which rancidity begins. The low peroxide value in all the three noodle samples suggests a desirable low degree of lipid oxidation. In the present study maize as well as control noodles exhibited a peroxide values well within the BIS limits (<10 meq/kg fat).

Conclusion

Present study has indicated that maize flour can be substituted up to 50 % level along with other ingredients for the production of good quality noodle with natural yellow colour. Addition of other ingredients such as gluten; kansui in combination with maize flour improved the quality characteristics. Combination of T_5 (50 % MF + 30 %RWF + 10 %SPI + 7 %RF + 3 %WG) was rated best for colour, appearance, taste, elasticity and over all acceptability compared to rest of combinations (T_1 T_2 T_3 T_4 T_6 T_7 & T_8) tested. There was no difference in sensory quality of normal or QPM noodle indicating that both are equally acceptable. The cooked yield was more for maize noodles (234 g NN, 220 g QN) with lower cooking loss of 7.80 and 7.76 respectively for NN & QN. Addition of 10 % soya protein isolate had increased the protein content of noodles to the tune of 16.6 and 12.7 % in QN and NN respectively. The soluble (3.18, 3.76) and insoluble fibre (21.67, 21.87) contents of both NN and QN was good compared to CN (0.15 and 9.3 g). Even though there was a significant increase in moisture, peroxide value of noodles after 3 months of storage but were in the acceptable range up to 6 months in sensory characters. The storage stability of noodles was good mainly because of low moisture content. There was no significant difference in sensory, storage and cooking quality of normal and QPM based noodles both were equally acceptable. Further attention is needed on reduction of cooking time of maize based noodles.

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