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Suitability of wheat flour blends with malted and fermented cowpea flour for noodle making

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Abstract

The current trend is to develop composite flours based food products with enhanced nutritional as well as other superior quality traits adding variety to the food basket. Composite flour noodles were developed using blends of refined wheat flour with malted and fermented cowpea flour with replacement level of 10 and 20%. The native flours and their blends were analyzed for physicochemical, functional and pasting properties to assess their suitability for noodle making. The results of the proximate composition showed that malting and fermentation enhanced the protein content of the cowpea flour. Increasing the level of malted or fermented cowpea flour in the blend resulted in the increased protein content and water absorption capacity. The pasting properties of the refined wheat flour also got altered after supplementation with cowpea flour. The noodles were analyzed for cooking properties including cooking time, cooking loss and cooked weight. The textural attributes of the cooked noodles were determined using food texture analyzer. Composite flour noodles revealed less cooking time, less percent solid loss, low hardness, adhesiveness and cohesiveness but increased cooking yield. Presence of ingredients other than wheat flour could have caused discontinuity in the gluten network resulting in the faster moisture penetration and hence less optimum cooking time of noodles. Noodles with improved nutritional and acceptable cooking and textural quality attributes can be successfully developed using composite flours based upon refined wheat flour and malted cow pea flours.

Introduction

Noodles are considered as important food throughout the world, especially in Asian countries such as China, Korea, Malaysia, Philippines and Thailand (Akanbi *et al*., 2011). The popularity of noodles, particularly in Asian countries is increasing because of their simple preparation, desirable sensory attributes, long shelf life augmented with product diversity and nutritive value. As the world market is expanding, studies for the development and improvement of noodles qualities satisfying the consumer demands are of immense importance. Wheat flour is the main ingredient used in manufacturing of noodles and therefore, characteristics of wheat flour are important for noodle making. In recent years, the demand to use novel sources as substitute for wheat flour has increased and therefore, composite flours are considered advantageous in developing countries as it reduces the import of wheat flour and encourages the use of flours prepared from locally grown crops (Hasmadi *et al.*, 2014). Therefore, flours from alternative sources are being used as potential wheat flour substitutes for noodle making also adding variety and functionality to the product.

Cowpea *(Vigna unguiculata)*, commonly known as black-eyed pea, is an important legume of tropical and subtropical areas. It is rich in protein and essential amino acids especially lysine. Unlike other legumes such as soybeans and groundnuts, which are oil-protein seeds, cowpeas are starch-protein seeds offering a wider pattern of utilization than any other legumes. The high lysine content makes cowpea an excellent enhancer of protein quality and when blended with cereals, produces mixtures with complementary amino acid profiles improving the nutritional quality of the products (Fu *et al.*, 1996; Mensa-Wilmot *et al.*, 2001). Cowpea flour, which can simply be hydrated to make paste, offers a convenient alternative to other cereals flours like wheat, rice and maize etc up to a certain extent.

Despite its high protein content, cowpea has some limiting amino acids and some antinutritional factors like trypsin and chymotrypsin inhibitors responsible for reducing the digestibility of protein by inhibiting protease activity. Cowpea contains polyphenolic compounds, tannins, lectins, phytic acid and indigestible oligosaccharides. Among the oligosaccharides raffinose, stachyose, and verbascose are not utilized by monogastric animals including

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humans, who lack the specific α-galactosidase enzyme needed to digest them. So, the use of cowpea as a food source has not been utilized to its full potential. Wet processing including soaking, germination and fermentation leads to a reduction in phytic acid and thus improves bioavailability of minerals in cereals and legumes (Afify *et al*., 2011). Studies have shown that processes like germination (Sathe *et al*., 1983) and fermentation (Zamora and Fields, 1979) of cowpea do not only improve its digestibility, nutritional quality, flavor and functional properties but also reduce the various antinutritional factors. Germination has been shown to decrease the antnutritional factors like trypsin and chymotrypsin inhibitors and haemagglutinins (Fernandez and Berry, 1998; Uwaegbute *et al*., 2000). Malting has been reported to be one of the most effective and convenient ways for improvement of nutritional value of cereals and legumes (Gernah *et al*., 2011). Malting not only enhances the nutritional profile of the cereals or legumes, but it also induces activation of enzyme systems like amylases. Addition of amylase preparation from barley malt has been observed to produce softer texture in the raw as well as cooked samples of noodles (Cato *et al*., 2006). Fermentation of cereals and legumes improves amino acid composition, vitamins and protein contents besides lowering the levels of antinutrients such as trypsin inhibitor (Chavan *et al*., 1989). The maximum nutritional benefits can be achieved by complementing cereals with cowpea in the ratio of 45:15 (wt/wt), which yields amino acid scores closer to the FAO/WHO/UNU standard (Prinyawiwatkul *et al*., 1996). However, non-glutenous protein adjuncts when used at relatively high level induce changes in the water absorption, mixing tolerance and other physical properties of dough.

Many studies have been performed on the development of composite flour noodles with the incorporation of garbonzo bean flour (Lee *et al*., 1998), defatted peanut flour (Chompreeda *et al*., 1987), soy flour (Singh *et al*., 1989; Lateef *et al*., 2004), pumpkin powder (Lee *et al*., 2002), raw and cooked pea flour or pea protein concentrate (Nielsen *et al*., 1980), sweet potato flour (Collins and Pangloli, 1997; Reungmaneepaitoon, 2009; Yadav *et al*., 2014), defatted wheat germ (Ge *et al*., 2001), rye flour (Kruger *et al*., 1998), millets flour (Devraju *et al*., 2008; Vijaykumar *et al*., 2010) and water chestnut flour (Yadav *et al*., 2014). Noodles prepared from 70% wheat flour and 30% malted ragi flour combination had higher values of protein, fiber and minerals (Kulkarni *et al*., 2012). Husniati and Anastasia (2013) reported the improved quality of cooked noodles prepared from wheat and fermented cassava flours with a ratio of 80:20. Since, the literature does not witness the application of malted and fermented cowpea flour for noodle making, the present study was undertaken to supplement the refined wheat flour with malted and fermented cowpea flour to improve its nutritional quality, and to study the effect of supplementation on the cooking and textural properties of noodles.

Materials and Methods

Procurement of raw material

Cowpea seeds, refined wheat flour and salt were purchased from local market of Rohtak (Haryana). Cowpea flour was prepared in the laboratory flour mill (Milcent, India). All chemicals and reagents used in the study were of analytical grade.

Malting of cowpea seeds

For malting, all seeds were pretreated with 200 ppm of 5.25% sodium hypochlorite to control microbial growth. Seeds were germinated at 30°C for 24 h, the time needed to reduce flatulence-producing oligosaccharides and minimize rootlet development. Sprouted seeds were dried in hot air oven at 50°C for 12-20 h to reduce the moisture content up to 10% (wb). Seed coats were separated from sprouted cowpea seeds manually by gently rubbing the seeds between palms and fingers and then removing away by a fan. Dried malted seeds were stored at 4°C until ground to flour for further applications.

Fermented cowpea flour preparation

Fermented cowpea flour was produced by subjecting the cowpea seeds to natural lactic acid fermentation as described by Hallen *et al.* (2004). Cowpea seeds were washed, dried and ground in a laboratory flour mill (Milcent, India) and passed through a 1 mm mesh screen. The flour was then mixed with water (1:4, w/w) slurry was left to ferment in an incubator at 25ºC for four days until the pH of the slurry reached to 5.5. The fermented slurry was dried at 50ºC and ground to get fermented cowpea flour.

Physico-chemical and functional properties of flours

Refined wheat flour (RWF), raw cowpea flour (RCF), malted cowpea flour (MCF) and fermented cowpea flour were evaluated for their proximate composition i.e. moisture, protein, ash, fat and fiber using standard methods (AOAC, 1995). Water and oil absorption capacities were determined using method of Sosulski *et al.* (1976). Water or oil absorption capacity was determined as water or oil absorbed by the flour sample and the results were expressed as g/g of sample. The bulk density was determined according to the method as described by Okaka and Potter (1977). The bulk density was calculated as weight per unit volume of sample. The least gelation concentration was determined using method of Coffman and Garcia (1977) with some modifications. The flour dispersions with concentrations of 2 to 30% with an interval of 2% were prepared and the least gelation concentration was determined as that concentration when the sample from inverted tube did not slip. The method of Okaka and Potter (1977) with some modifications was used for determining the swelling capacity. Water solubility index was determined from the amount of dried solids obtained after drying the supernatant and was expressed as g/g of sample. The swelling power and solubility were determined using the standard formulations and the results were expressed as g/g of dry flour.

Pasting properties

A rapid visco-analyzer (RVA) (Tech Master, Perten, Australia) was used to study the pasting properties of flours. 3.0 g flour sample (14% mb) was mixed with distilled water to make a total weight of 28 g in RVA sample canister. A programmed heating and cooling cycle was used at constant shear rate, where the sample was held at 50ºC for 1 min, heated to 95ºC in 3.42 min, held at 95ºC for 2.70 min, cooled to 50ºC in 5.88 min. Peak viscosity (PV), time to reach PV (Ptime), temperature at PV (Ptemp.), hot paste viscosity (HPV), and cool paste viscosity or the viscosity at the end of the hold time at 50ºC (CPV) were recorded.

Preparation of composite flour noodles

Composite flour noodles were prepared using blends of refined wheat flour with malted cowpea and fermented cowpea flours at replacement levels of 10 and 20%. Refined wheat flour noodles were considered as control. The standardized formulation for the noodles had the ingredients as 200 g flour, 3 g salt and 75 ml water. The dough was mixed for 5 min in the dough making section of the noodle making machine (La Monferrina, Italy). The dough was sheeted with noodle press by maintaining a gap of 2.5 mm. The dough sheet was folded and rolled three times each through successively decreasing roller gaps of 2.04 mm, 1.65 mm, and 1.10 mm. Finally, dough sheet was cut into 2.0 mm wide noodles with a roller cuter, air dried at room temperature (27°C) for 12 h and then stored at room temperature in polythene bags for further use.

Cooking characteristics of the noodles

For determining cooking time, noodles (10 g) were cooked in 200 ml of boiling distilled water taken in a 250 ml beaker until disappearance of white core as judged by pressing between two glass slides. The cooked weight of noodles was determined as described by Galvez and Resurreccion (1992) with minor modifications. Noodles (10 g) were first soaked in 300 ml water for 5 min and then cooked in water bath for 5 min. The beaker was covered with aluminum foil to minimize the loss of water due to evaporation. The cooked noodles were drained for about 2 min, rinsed with distilled water in a buchner funnel and cooked weight was determined by weighing wet mass of noodles and the percent cooking yield was determined. For determining cooking loss, the cooked noodles were drained and rinsed with distilled water (50 ml) in a buchner funnel. The gruel solid loss was determined by evaporating to dryness the cooking and rinse water in a pre-weighed petri-plate in an oven at 110^{o}C for about 12 h (Galvez and Resurreccion, 1992). The residue was weighed after cooling in a desiccator to determine gruel solid loss.

Textural properties of cooked noodles

The cooked noodles were evaluated for their textural properties within 5 min after cooking using a TA-XT2 Texture analyzer (Stable Micro systems, Haslemeres,UK). Five strands of cooked noodles were placed parallel on a flat metal plate and compressed crosswise twice to 70% of their original height using a 35 mm probe at a speed of 1 mm/s. From force time curves of the TPA, hardness, springiness, cohesiveness, and adhesiveness were determined according to the description of Park and Baik (2004).

Sensory analysis of cooked noodles

The sensory evaluation of cooked noodles was carried out in order to get consumer response for overall acceptability of the noodles. Freshly cooked noodles were evaluated by a panel of 10 semi-trained judges for different sensory attributes including slipperiness, tooth packing (stickiness), firmness, appearance and total acceptability. The members were not professional sensory analysts but they were made acquainted with sensory parameters to be used for sensory analysis. The members were asked not to eat spicy and pungent foods before the analysis. Sensory evaluation of the cooked starch noodles was performed on a nine point hedonic scale (1 = very undesirable; 2 = undesirable; 3 = moderately undesirable; 4 = slightly undesirable; 5 = neither undesirable nor undesirable; 6 = slightly desirable;

Table 1. Proximate composition of flour samples

Flour sample	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fiber (%)	Carbohydrate
RWF	12.13±0.23	13.0±0.21	0.90±0.13	1.78±0.23	0.62±0.03	84.6
RCP	9.50±0.05	24.13±0.42	2.94±0.06	2.31±0.09	0.97±0.01	72.6
MCF	4.21±0.08	26.0±1.02	2.48±0.53	0.97±0.15	0.54±0.06	72.5
FCF	3.35±0.13	28.00±0.63	2.30±0.23	0.99±0.33	0.53±0.00	70.5

Where, RWF = Refined wheat flour, RCP = Raw cowpea flour, MCF = malted cowpea flour, FCF = Fermented cowpea flour
The values are mean± S.D. of three independent determinations

7 = moderately desirable; 8 = desirable; 9 = very desirable).

Statistical analysis

The data were analyzed statistically in a completely randomized design (CRD) using one factor analysis of variance (ANOVA) with the help of OPSTAT version OPSTAT1.exe. (Hisar, India).

Results and Discussion

Proximate composition of flours

The chemical composition of flours prepared from refined wheat, raw cowpea, malted cowpea and fermented cowpea is as shown in Table 1. As evident from the results, the protein content of cowpea was almost double when compared to wheat. The malting and fermentation had a slightly increasing effect on the protein content of cowpea flour. A similar increase in the protein content of germinated/malted cereals and legumes has been reported by the earlier researchers also (Kulkarni *et al*., 2012; Kavitha and Parimalavalli, 2014). This increase in crude protein content during malting could be because of synthesis of enzyme proteins or a compositional change following the degradation of other constituents during germination (Bau *et al*., 1997). Ash content of cowpea was found to be significantly much higher than wheat ($p<0.05$). Ash content is considered as an important factor in the assessment of minerals present in flours. The fiber content of raw cowpea flour was significantly higher than refined wheat flour and it decreased to considerable extents in malted and fermented cowpea flours. Changes in fiber content may be attributed to the fact that part of the seed fiber may be solubilized enzymatically during seed germination (El Maki *et al.*, 1999). Alemu (2009) observed that sorghum crude fiber decreased after fermentation. The carbohydrate content as determined by difference method was the highest in RCF whereas the carbohydrate content of raw and processed cowpea flours was reasonably similar.

Functional properties of flour blends

The functional properties of refined wheat flour and its blends with MCF and FCF are as shown in Table 2. The water absorption capacity (WAC) of different blends differed significantly ($P<0.05$) and it ranged from 1.45 to 2.45 g/g. The highest WAC was reported in blend containing 20% fermented flour and lowest was observed in refined wheat flour. WAC represents the ability of a product to associate with water under condition where water is limited (Singh, 2001). Protein has both hydrophilic and hydrophobic properties and can interact with water in foods. Low water absorption capacity is related to low polar amino acids in flour (Harijono *et al*., 2013). Therefore, the higher WAC of flour blends could be attributed to their higher protein content in comparison to wheat flour. The difference in WAC might also be due to the quantity of damaged and undamaged starch present with in flour. Water absorption capacity is important in the development of ready to eat foods and a high water absorption capacity may assure product cohesiveness (Ogunlakin *et al*., 2012). The values for oil absorption capacity (OAC) were in the order C > B > D > E > A and it ranged from 1.63 to 2.45 g/g. The OAC of all the flour blends was higher than refined wheat flour. The high OAC could suggest the presence of hydrophobic groups on the surface of protein molecules (Subagio, 2006). The OAC of flour helps to improve mouth feel and flavor retention (Kinsella, 1976). Higher oil absorption capacity of flour blends increases the palatability of the noodles. The bulk density of different flours varied from 0.75 to 0.78 g/ml, highest bulk density was observed in blend prepared with 20% fermented cowpea flour and lowest was observed in blend prepared in 10% malted

Table 2. Functional properties of different flour samples

Treatment	WAC (g/g)	OAC (g/g)	BD (g/g)	LGC (%)	Solubility (g/g)	SC (ml)
A	1.45±0.23	1.63±0.02	0.77±0.01	24	0.06±0.00	16.9±1.2
B	2.27±0.04	2.43±0.03	0.75±0.01	20	0.10±0.01	16.0±0.8
C	2.41±0.08	2.45±0.06	0.77±0.01	20	0.16±0.01	16.4±0.9
D	2.28±0.04	2.37±0.01	0.77±0.07	20	0.07±0.00	17.7±1.1
E	2.45±0.03	2.32±0.03	0.78±0.04	20	0.10±0.03	18.3±0.8
CD	0.36	0.11	N.S.	-	N.S.	0.02

The values except LGC are mean ± SD of three independent determinations ($p < 0.05$).
Where, A= RWF, B = 10% MCF + 90% RWF, C = 20% MCF + 80% RWF, D = 10% FCF + 90% RWF, E = 20% FCF + 80% RWF.
WAC = Water absorption capacity, OAC = Oil absorption capacity, BD = Bulk density, LGC = Least gelation capacity, SC = Swelling capacity.

cowpea flour. Significantly higher bulk density was reported for the fermented Artocarpus altilis pulp flour when compared to its unfermented counterpart (Appiah *et al*., 2011). A hollow and puffy sel roti product with low bulk density was obtained from the flour having finer particle size. The flour comprising of coarse particles produced dense product with very less or no puffiness (Subba and Katawal, 2013). Thus bulk density of flours could affect the compactness/texture of the noodles. The degree of coarseness of the flour particles can be measured by its bulk density. Bulk density has been found to be a function of flour wettability (Solsuki, 1962). Bulk density is an indication of the porosity of a product which influences packages design and could be used to determine the type of packaging material required (Akubor and Obiegbuna, 1999). It is also important in infant feeding where less bulk density is desirable (Iwe and Onalope, 2001).

Swelling capacity determined the extent to which a flour sample increased in volume over the initial volume when soaked in water. The swelling capacity (SC) of different flours ranged from 16.9 to 18 ml being highest for the blend containing 20% fermented cowpea flour. The solubility index ranged from 6 to 10% and the highest solubility index was observed in blend containing 20% fermented cowpea flour and lowest was observed in refined wheat flour. Swelling power is an indication of the water absorption index of granules during heating (Loos *et al*., 1981). The variation in the swelling power indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water (Kafilat, 2010). In case of starch noodles, the restricted swelling behavior of starches for noodle making is a desirable trait as restricted swelling stabilizes starch against shearing action during cooking in water (Galvez & Resurreccion, 1992). The least gelation concentration (LGC) indicated the index of gelation capacity. The LGC of all the flour blends was same and it was lower than refined wheat flour. The variation in the gelling properties of flours was attributed to the relative ratio of protein, carbohydrates and lipids that make up the flours and interaction between such components (Sathe *et al*., 1982).

Pasting properties of flours

The pasting characteristics of refined wheat flour and its blends with malted and fermented cowpea flours are given in Table 3. Peak viscosity (PV) and hot paste viscosity (HPV) of different flour sample varied from 107 to 190 RVU and 73.8 to 117.3 RVU respectively. The PV and HPV of all the blends were observed to be lower than the respective values for refined wheat flour with minimum value in case of blend containing 20% fermented cowpea flour. Incorporation of malted and fermented cowpea flours in to refined wheat flour decreased the peak viscosity of flour blends as also reported by Collado and Corke (1996). Peak viscosity is an indicator of ease with which the starch granules are disintegrated and often correlated with final product quality. HPV was observed to be highest for refined wheat flour whereas blend containing 20% fermented cowpea flour exhibited the lowest HPV. High HPV generally represents low cooking loss and superior

Table 3. Pasting properties of different flour samples

Flour sample	Peak viscosity (RVU)	Hot paste viscosity (RVU)	Breakdown (RVU)	Cold paste viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting Temp. (°C)
A	190.8	117.3	73.5	266.08	148.75	5.53	81.4
B	181.3	111.2	70.08	268.00	156.75	5.53	83.1
C	189.5	116.1	73.33	266.25	150.08	5.40	80.7
D	152.5	103.4	51.41	249.00	147.83	5.66	87.3
E	107.8	73.8	34.00	183.83	110.00	5.33	87.2

Where, A= RWF, B = 10% MCF + 90% RWF, C = 20% MCF + 80% RWF, D = 10% FCF + 90% RWF, E = 20% FCF + 80% RWF

eating qualities in noodles (Yadav *et al*., 2011). The breakdown which is a measure of structural disintegration of starch during cooking was observed to be highest (73.5 RVU) in refined wheat flour and lowest (34 RVU) in blend containing 20% fermented cowpea flour. According to Higley *et al.* (2003), higher breakdown levels could be associated with the greater degree of collapse of swollen starch granules (low viscosity), corresponding to a greater release of solubilized starch with re-association capability during the cooling phase. The difference in breakdown is related to difference in the rigidity of swollen granules. Setback, which is a measure of retrogradation tendency of the starch, was observed to be highest for blend containing 10% malted cowpea flour and lowest was observed for blend containing 20% fermented cowpea flour. Decreased pasting qualities of germinated flours from barley (Hansen *et al.,* 1989), wheat (Gopaldas *et al.*, 1988), sorghum (Mosha and Svanberg 1983), finger millet, and green gram (Brandtzaeg *et al*., 1981) were reported. The effects of germination on the functional properties of these flours were attributed to amylolytic and proteolytic enzyme activity. It has also been suggested that type C viscoamylograph characterized by the absence of peak and viscosity remaining constant or increasing during continued heating is ideal for good quality noodles (Lii and Chang, 1981).

Cooking and textural quality characteristics of noodles

Noodles quality could be estimated from cooking attributes such as cooking time, cooking yield and cooking loss. The cooking and textural quality characteristics of noodles are presented in Table 4. The cooking time of the noodles prepared from various blends was observed to be lower than that of control sample. A good quality noodle should have short cooking time with little loss of solids in the cooking water. The noodles prepared from refined wheat flour had highest cooking time (6.66 min) whereas the noodles prepared from 20% fermented flour showed the lowest cooking time (3.66 min). Ingredients other than wheat flour such as fermented cowpea flour causes discontinuity in gluten network (Manthey *et al*., 2004; Izydorczyk *et al*., 2004) resulting in faster moisture penetration and therefore leading to lower optimum cooking time. Difference in cooking time of noodles can be attributed to the difference in the gelatinization temperature of respective flours. The cooking loss is the amount of dry matter leached in to the cooking water of optimally cooked noodles. The cooking loss ranged from 0.90 to 1.53% being the highest for noodles prepared with supplementation of 20% fermented cowpea flour whereas it was the lowest for noodles prepared with 10% malted cowpea flour. An increase in the cooking loss with the noodle containing malted and fermented cowpea flour might have been due to weakening of the protein network by the presence of malted and fermented flour. Cooking loss is an indicator of noodles' resistance to cooking (Nagao, 1996), so low levels are preferable. High cooking loss is undesirable because it represents high solubility of starch, resulting in turbid cooking water, low cooking tolerance and sticky mouthfeel (Jin *et al*., 1994). However, the cooking yield of all the noodles prepared from various blends was observed to be higher than of control sample and highest cooking yield was observed in noodles prepared from 20% fermented cowpea flour. The high cooking yield could be attributed to the higher water absorption capacity of the respective flour blends.

The main characteristics that determine the consumer acceptance of cooked noodles are based on

Table 4. Cooking quality characteristics and textural properties of different types of noodles

Treatment	Cooking time (min)	Cooking yield (%)	Cooking loss (%)	Hardness(g)	Adhesiveness (g.sec)	Cohesiveness	Gumminess	Resilience
A	6.6±0.3	120.7	1.32±0.04	268.69±18.66	-522.83±112.52	0.39±0.01	105.72±11.12	0.69±0.01
B	6.0±0.0	135.2	0.93±0.07	265.48±18.04	-147.77±43.91	0.39±0.06	106.70±20.08	0.47±0.03
C	6.0±0.0	142.5	1.05±0.04	209.79±14.88	-291.85±31.09	0.23±0.04	53.96±22.01	0.65±0.07
D	6.0±0.0	154.1	1.62±0.13	255.65±27.99	-356.69±23.04	0.38±0.01	98.64±12.94	0.75±0.03
E	5.6±0.3	160.3	1.53±0.22	101.80±16.25	-77.89±13.81	0.44±0.02	45.33±9.01	0.55±0.07

Where, A= RWF noodle, B = 10% MCF + 90% RWF noodle, C = 20% MCF + 80% RWF noodle, D = 10% FCF + 90% RWF noodle, E = 20% FCF + 80% RWF noodle
The values are mean± S.D of three independent determinations

Table 5. Sensory quality characteristics of cooked noodles

Noodle sample	Slipperiness	Firmness	Tooth packing (stickiness)	Appearance	Total acceptability
A	6.0±1.5	7.3±1.6	6.4±0.7	7.2±0.8	7.5±1.3
B	6.5±1.5	6.8±1.4	6.1±0.6	6.8±0.2	7.2±1.4
C	6.8±0.6	6.0±1.2	5.3±1.5	6.0±0.7	6.8±1.6
D	7.0±1.8	6.2±1.3	5.8±0.5	7.0±1.0	7.0±1.3
E	7.0±2.0	5.8±1.2	5.0±0.7	6.8±0.5	7.0±1.1

The values are mean± S.D of 10 independent determinations
Where, A= RWF noodle, B = 10% MCF + 90% RWF noodle, C = 20% MCF + 80% RWF noodle, D = 10% FCF + 90% RWF noodle, E = 20% FCF + 80% RWF noodle

the evolution of texture and mouth feel. The textural properties of cooked noodles in the present study were determined using the compression method and results pertaining to textural properties are presented in Table 4. The maximum force required during the first cycle of compression was hardness. The hardness of all the noodles prepared from various blends was observed to be lower that of control noodles and the harness of the blend noodles decreased in the order of B > D > C > E. The decrease in hardness values was attributed mainly to the structural degradation of starch and protein during malting and fermentation processed (Chung *et al.*, 2012). The replacement of gluten containing wheat flour with non-gluten flours could also be responsible for decreased hardness of the noodles. The adhesiveness was the maximum negative force observed during first compression cycle and the noodles prepared from refined wheat flour (-522.83 g.sec) revealed maximum adhesiveness and minimum adhesiveness value was observed in noodles prepared from 20% fermented cowpea flour (-77.89 g.sec). The cohesiveness is the ratio of positive area during the second cycle of compression to that of the first cycle. It determines the behavior of intermolecular attraction within the product. Thus, it is a measure of the extent to which noodle structure was disrupted during first compression (Yadav *et al.*, 2011). Maximum cohesiveness (0.44) was observed in noodles prepared with supplementation of 20% fermented cowpea flour while the minimum cohesiveness (0.23) was observed in noodles prepared from 20% malted cowpea flour. Resilience defines the elastic recovery of the sample from deformation. Minimum resilience (0.47) was observed in noodles prepared from 10% malted cowpea flour and maximum (0.75) was observed in noodles prepared from 10% fermented cowpea flour.

Sensory evaluation of cooked noodles

Noodle prepared from flour blends were evaluated for the slipperiness, firmness, tooth packing (stickiness), appearance and overall acceptability by sensory evaluation (Table 5). Slipperiness may be defined as the extent to which the product slides across the tongue. All types of flour blend noodles scored higher for slipperiness when compared to the control sample. Firmness is the amount of force required to bite through the flour noodle strands. The cooked noodles should be neither too firm nor too soft. The noodles prepared from flour blends scored lower values for firmness in comparison to control sample with noodles prepared with supplementation of 10% malted cowpea flour showing the highest firmness. Higher value of firmness in RWF noodles was due to highest gluten content of RWF as gluten has been reported to be responsible for the firmness of noodles (Chompreeda *et al.,* 1987). Tooth packing was defined as the amount of starch noodle left on the teeth after masticating one strand of noodle. Thus a low score is desirable for tooth packing. All flour blend noodles scored lower for tooth packing in comparison to RWF noodles. The appearance of RWF noodles was most desirable, whereas in case of flour blends, noodles prepared with 10% fermented flour scored highest for the appearance. Among blends, the noodles prepared with 10% malted flour showed the highest overall acceptability.

Conclusion

Substitution of refined wheat flour with fermented cowpea or malted cowpea flours altered the functional and pasting properties of the flour blends. For the noodle prepared with various types of composite flours, cooking time was lower whereas cooking yield was higher than that of control sample. The noodles prepared with supplementation of malted cowpea flour revealed lower cooking loss in comparison to control sample. These finding suggested that supplementation of refined wheat flour with fermented and malted cowpea flours up to an extent of 20% could not only increase the nutritive profile of the noodles, but also improved the cooking quality characteristics of the noodles.

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