Full Paper

High Nutrient Dense Gluten Free Pasta From Quality Protein Maize, Sorghum And Water Melon Seed Flours: Chemical Composition, In Vitro Protein Digestibility And Sensory Properties

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ABSTRACT

The aim of this study was to produce and assess high nutrient dense gluten free pasta from quality protein maize (QPM) and sorghum fortified with watermelon seed that can serve as alternative to wheat pasta for celiac disease patient. The grains were separately processed and blended at various proportions. The resulting blends were analysed for proximate, mineral composition, total dietary fibre, in vitro protein digestibility and sensory properties using standard methods. The results showed that the protein and in vitro protein digestibility increased from 9.46 to 16.42% and 59.66 to 62.56% respectively with the inclusion of watermelon seed flour. The QPM based pasta had lower dietary fibre (4.37%) compared to the sorghum based pasta (4.53%). The mineral content improved with the addition of water melon flour. Iron content ranged between 0.45 - 0.56 mg/100g, calcium 4.96 - 5.56 mg/100 g. There was no significant difference ($p>0.05$) between the QPM base pasta and commercial pasta in terms of sensory properties. However, there exists a significant difference ($p<0.05$) between the sorghum based pasta and QPM based pasta in terms of colour and appearance. The study concluded that pasta of high nutrient dense and of comparable quality to wheat based pasta could be produced from QPM which could serve as good alternative to wheat based pasta especially for patient of celiac disease.

Keywords: *celiac disease; dietary fibre; in vitro protein; pasta; quality protein maize; sorghum*

1. INTRODUCTION

Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. Gluten is a complex mixture of storage proteins of wheat, a staple food for most populations in the world, and other cereals (oat, rye and barley) (Shan *et al*., 2002, Schober and Bean, 2008). Celiac disease is one of the most common lifelong disorders on a worldwide basis. The condition can manifest with a previously unsuspected range of clinical presentations, including the typical malabsorption syndrome (chronic diarrhea, weight loss, abdominal distention) and a spectrum of symptoms potentially affecting any organ or body system (Fasano and Catassi, 2001).

Pasta has been regarded as a staple food item in many cultures or families around the world for many centuries. Pasta dough is generally made by mixing flour, water, and egg (Kahlon *et al*., 2013). Pasta is produced from wheat which has been implicated in the cases of celiac disease. Sorghum (*Sorghum bicolor L.* Moench) and maize (*Zea mays*) are closely related members of the subfamily Panicoideae in the family Gramineae. Sorghum is grown throughout the world, with the majority (>55%) produced in Asia and Africa. Maize is a major cereal grain that is grown worldwide and ranks second only to wheat in total production area and second to rice in total amount produced (Farnham *et al*., 2003, Schober and Bean, 2008).

Overall, the proteins of maize are similar to those of sorghum. The dominant protein class is the prolamins, which are called zeins in maize. Like the sorghum prolamins which are called kafirins. These proteins cannot form gluten when hydrated like gliadin and glutenin in wheat and as such could not cause celiac disease.

Suhendro *et al*. (2000) produced sorghum noodles from decorticated sorghum flour, water, and salt by preheating, extrusion, and drying. The noodles were sticky, soft, and had a high dry matter loss during cooking. Maize (normal maize) has been used in the production of several products including pasta. However, there is no information on the utilization of quality protein maize (a new variety of maize) in the production of noodles / pasta hence the focus of this study. Since such products are typically made without any wheat, they are safe for people with celiac disease, and could therefore, fill a specialty market for the celiac community. Quality protein maize is a newly developed variety of maize from Opaque-2 maize, with superior amino acid profile in terms of the lysine and tryptophan content compared to normal maize which is deficient in the two limiting amino acids (Prassana *et al*., 2001; Abiose and Ikujenlola, 2014).

When working with gluten free flours, some of the strength impacted by gluten can be achieved by the addition of agar, guar gum carrageenan, locust bean gum, sodium alginate, tara gum, xanthan, modified starches and other hydrocolloids. These hydrocolloids have the potential of improving the viscoelastic properties of non-gluten flours (Kahlon *et al*., 2013).

In order to fill the information gap on the utilization of QPM, sorghum and water melon seed in the production of high nutrient dense gluten free pasta this study was embarked upon to provide necessary data and to produce affordable alternative pasta for celiac patient. This study aimed to utilise quality protein maize, sorghum and water melon in producing high nutrient dense gluten free pasta for people suffering from and susceptible to celiac disease

2. MATERIALS AND METHODS

2.1. Materials

The quality protein maize (EVDT-Y2000 STR) QPM was purchased from the Department of Crop Production Department, Obafemi Awolowo University, Ile-Ife, Osun state, Nigeria. Other raw materials such as; sorghum (white), watermelon seed, egg, guar gum and vegetable oil were purchased from Central Market, Ile-Ife, Osun state, Nigeria.

2.2. Methods

2.2.1. Production of Quality Protein Maize and Sorghum flours.

Maize grains were cleaned and sorted to remove mouldy, spoilt and broken grains. The cleaned grains were washed, conditioned, decorticated, milled, sieved and then packaged as quality protein maize flour (Ikujenlola and Adurotoye, 2014). The sorghum grains were cleaned to remove damaged grains, stones, dust, and other extraneous materials. The cleaned grains were dried in drying oven at 60 °C for about 2 hours. The dried sorghum grains were milled, sieved and packaged in high density air tight plastic container until needed (Lee *et al*., 2002).

2.2.2. Production of the watermelon Seed Flour

The shelled watermelon seeds were cleaned, washed with water, air-dried at 60 °C for 6 hours in an air oven. The dried seeds were milled and sieved. The resulting flour was packaged in air tight plastic container and stored until needed (Ubbor and Akobundu, 2009).

2.2.3. Formulation of High nutrient gluten free pasta blends

Quality protein maize, sorghum and water melon seed flours were blended at various proportions to produce gluten free pastas. The pastas were prepared at the ratios of 100: 0: 0; 70: 0: 30; 70: 15: 15; 0: 70: 30 and 0: 0: 100 QPM: sorghum: watermelon seed respectively (Table 1).

Table 1: Sample coding and different treatments used to prepare gluten free pasta

Treatment	QPM (%)	Water melon (%)	Sorghum (%)
T1	100	-	-
T2	70	30	-
T3	70	15	15
T4	-	30	70
T5	-	-	100

2.2.4. Preparation of pasta

For each formulation the pre-gelatinized pasta was produced from 500 g of the flour mixed with 350ml of water in the Hobart mixer for 30 minutes to distribute the water uniformly throughout the flour to form homogeneous dough. This mass was heated to 80 °C for 15 minutes (Petito *et al*., 2010). Subsequently, the pre-gelatinized dough was cooled to 40 °C and the guar gum (1%), egg (10%) and vegetable oil (1%) were added and kneaded for 30 minutes. The resulting dough was sheeted to about 2 mm thickness and subsequently cut to into 15cm strips with the aid of pastry cutter. The pasta was dried in the hot air oven at 75 °C for 3 hours (Manthey *et al*., 2004). The dried pasta was packed in air tight plastic containers.

2.2.5. Proximate Analysis

The gluten free pasta was subjected to proximate analysis (carbohydrate, protein, ash, fat, crude fibre, moisture content) using the standard methods of Association of Official Analytical Chemists (AOAC, 2000). Carbohydrate was determined by difference (carbohydrate = 100 - (%protein + %ash + %fat + %crude fibre + %moisture content). The energy value (kcal) was calculated from the physiological energy values of carbohydrate (4 x 1g) + protein (4 x 1g) + fat (9 x 1g) (AOAC, 2000).

2.2.6. In vitro protein digestibility determination

In vitro protein digestibility of samples was measured according to the modified methods of Saunders *et al.* (1973) and Chavan *et al.* (2001). Two hundred and fifty milligrams of the sample was suspended in 15 ml of 0.1 M HCl containing 1.5 mg pepsin, followed by gentle shaking for 1hr at room temperature. The suspension obtained was neutralized with 0.5 M NaOH and treated with 4.0 mg pancreatin in 7.5 ml of phosphate buffer (0.2 M, pH 8.0). The mixture was shaken for 24 hr at room temperature using incubator shaker Brunswick (USA). The mixture was then filtered using Whatman No 1 filter paper and the residue washed with distilled water, air-dried and used for crude protein determination using Kjedhal procedure (AOAC, 2000).

2.2.7. Total Dietary Fibre Determination

The Total Fibre Assay kit (TDF-100A; Sigma-Aldrich, St. Louis, Missouri, USA) based on the enzymatic-gravimetric method of AOAC (AOAC, 2000) was used to determine the total dietary fibre (TDF), soluble dietary fibre (SDF) and insoluble dietary fibre (IDF). This method involves the gelatinization of the defatted samples with stable heat and α-amylase (A-3306). The sample was enzymatically digested with protease (P-3910) followed by amyloglucosidase (A 9913) to remove the protein and starch content in the sample, Insoluble dietary fibre was recovered with filtration. Soluble dietary fibre was precipitated with ethanol and filtered.

2.2.8. Mineral Analysis

The samples were burned in a muffle furnace at 550 °C for 6 hours, and the ashes were dissolved in concentrated hydrochloric acid. Iron, calcium, copper, magnesium, and zinc were determined by atomic-absorption spectrophotometer (Perkin- Elmer Model 3300). Sodium and potassium were determined by flame photometry and phosphorus by visible spectrophotometry, via the ammonium phosphovanadomolybdate. The analyses were performed according to AOAC (2000). The results were obtained after three readings of each triplicate and expressed in mg/100 g. All reagents used in the analysis were of analytical grade.

2.2.9. Sensory Evaluation

Sensory evaluation of the cooked pasta was conducted using 7-point hedonic scale where 1-dislike very much, 2-dislike moderately, 3-dislike slightly, 4-neither like nor dislike, 5-like slightly, 6-like moderately, 7-like very much . The samples were submitted to a panel of ten semi-trained panellists in order to evaluate the sensory attributes - appearance, colour, taste, flavour, texture and overall acceptability. The panelists were asked to indicate their preference or otherwise based on the quality attributes mentioned above. On completion of the sensory test, their responses was subjected to statistical analysis to determine the level of difference and the significance of such difference in the acceptability or otherwise of the samples by using ANOVA and Turkey's test for comparison of means at significant level of 5% (Muhimbula *et al*., 2011).

2.2.10. Statistical analysis

All the experiments were conducted in triplicate. The data obtained was analysed using Analysis of Variance (ANOVA) and Turkey's test for comparison of means at significant level of 5% ($p<0.05$). SPSS (version 20.0) was used to separate significant means with Duncan Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1. Proximate Composition of Gluten Free Pasta samples

The proximate composition of the gluten free pasta is presented in Table 2. The moisture content of the gluten free pastas ranged from 10.44 to 11.12%. The results showed that pasta produced from 70% QPM flour + 15% Sorghum flour + 15% watermelon seed flour (T3) had the highest moisture content (11.12% moisture) while the 100% sorghum (T5) had the lowest moisture content (10.44% moisture). These values were lower than 12% reported by Ferrari and Piazza (2006) for dried pasta. Moisture content of pasta is a function of the drying temperature, drying time and loading depth of fresh pasta. Higher moisture content indicates increased susceptibility to spoilage and thus reduced shelf life.

The protein content ranged from 9.46 to 16.42% with sample T1 having the lowest and T4 had the highest. The protein value of some of the gluten free pastas was higher than that of commercial sample (11.5 g per 100 g). Ferrari and Piazza (2006) reported 10.8% protein content for dried pasta. The protein values of the gluten free pasta were higher than the range (3.36 – 9.99%) reported by Ibitoye et al. (2013) for pasta from wheat and potato. Protein content of corn and sorghum based egg free pasta according to Kahlon et al., (2013) are 5.75 and 8.63 % respectively. The addition of watermelon seed flour improved the level of protein of the pasta.

Protein is needed for growth and development by replacing worn-out tissues. Gluten free pasta is an alternative to people suffering from celiac disease. Gluten is formed when protein gliadin and glutenin present in wheat are hydrated. The prominent protein fractions in QPM and sorghum are prolamins (zein) and kafirins respectively which cannot form gluten (Arendt and Zannini, 2013). QPM contain a better amino acid profile in terms of lysine and tryptophan which will benefit its consumers (Prassana et al., 2001; Abiose and Ikujenlola, 2014). These pastas especially those containing QPM and water melon should be valuable to children owing to its protein level.

The fat content of the pasta samples increased with increasing level of watermelon seed flour. The fat content ranged from 3.64 - 8.68% with sample T4 having the highest and T1 has the lowest. The pasta samples had higher fat content (3.64-8.68%) compared with the commercial sample (1.2%). Adegunwa et al., (2012) reported a range of 5.09 – 5.78 % for noodles enriched with soy flour and carrot powder. Fat is a macronutrient, carrier of fat soluble vitamins – A, D, E, K and high energy (9 kcal/g) producing nutrient. However, high content of fat in dried or fried product can result in short shelf life as a result of possible off flavour and rancidity development.

Ash content gives an indication of the mineral composition of the samples (Totlani, 2012). The ash values ranged from 2.04% to 2.17%. There was significant difference ($p<0.05$) between QPM and sorghum based pasta. The ash content of the gluten free pasta increased with increase in the watermelon seed flour substitution. The report of Ibitoye et al. (2013) show that commercial wheat noodles has ash content of 3.50% and noodles produced from a blend of wheat and potatoes ranged between 1.33 – 3.17%.

The crude fibre content ranged from 1.56% to 1.77%. Sample T1 had 1.71 % crude fibre and T2 had 1.56% fibre. It shows that addition of watermelon seed reduced the crude fibre content of the decorticated QPM and sorghum based pasta. This similar observation was made in a study by Tharise et al. (2014).

The carbohydrate content ranged between 67.06 and 72.42%. The commercial noodle has a carbohydrate content of 56.44% (Ibitoye et al., 2013). According to Adegunwa et al. (2012) carbohydrate content of noodles ranged from 60.17-72.42%. There were significant differences ($p<0.05$) in all the fortified QPM and sorghum pasta. According to Kahlon et al., (2013) gluten free egg free pasta from corn and sorghum have higher carbohydrate of 89.42% and 86.48% respectively. Carbohydrate functions as a source of energy for maintenance of life, also for voluntary and involuntary processes of the body. The study showed that the pastas were capable of supplying energy value not less than 360.28 kcal/100g. The energy value of the QPM based pasta was significantly different ($p<0.05$) from the sorghum based pasta. Energy is used to synthesize growing tissues and maintenance of certain voluntary and involuntary processes in humans.

3.2. *In Vitro* Protein Digestibility (IVPD) and Dietary Fibre of Pasta Samples

The protein digestibility (Table 3) of all the samples increased from 59.66% to 62.5% in all blends. Pasta samples fortified with watermelon seed has the highest *in vitro* protein digestibility; there was significant difference ($p<0.05$) in all the fortified pasta samples. Protein digestibility may be decreased and/ or increased without incurring amino acid destruction (Ravindran *et al.*, 1995). The presence of certain substances in food may impede the digestibility of protein. Digestibility measures the nutritional usefulness of foods and availability of food nutrients of components to fed species. *In vitro* protein digestibility is important not because they are rapid and less expensive, but also because they allow close observations of the dynamics of the breakdown of protein by using only small amount of raw materials (Sultana *et al* ., 2010). The protein digestibility of the QPM and sorghum based pastas were within the same range. The addition of water melon flour improved the protein digestibility.

Table 2: Proximate composition of the various pasta samples (%)

Properties	T1	T2	T3	T4	T5
Protein	9.46±0.01^{a}	9.86±0.02^{b}	10.26±0.01^{d}	10.37±0.01^{e}	10.19±0.01^{c}
Crude Fat	3.64±0.01^{a}	8.26±0.01^{d}	3.68±0.01^{b}	3.68±0.02^{b}	3.75±0.01^{c}
Ash	2.10±0.01^{b}	2.17±0.01^{c}	2.06±0.01^{a}	2.16±0.02^{c}	2.04±0.01^{a}
Crude Fibre	1.71±0.02^{bc}	1.56±0.01^{a}	1.66±0.02^{b}	1.77±0.01^{c}	1.68±0.02^{b}
Moisture	10.67±0.02^{b}	11.09±0.04^{d}	11.12±0.01^{e}	10.87±0.01^{c}	10.44±0.01^{a}
Carbohydrate	72.42±0.02^{e}	67.06±0.01^{a}	71.22±0.01^{c}	71.15±0.01^{b}	71.90±0.01^{d}
Energy value (kcal)	360.28±0.2^{b}	382.14±0.02^{d}	359.04±0.03^{a}	359.20±0.2^{a}	362.11±0.02^{c}

* Data are means values of triplicate determination ± standard deviation
* Mean values carrying the same letters along rows are not significantly different ($p>0.05$).

Table 3: In vitro protein digestibility and Total dietary fibre of the pasta samples (%)

Parameters	T1	T2	T3	T4	T5
In vitro Protein digestibility	59.66±0.01a	60.36±0.01b	62.56±0.01c	60.49±0.01b	59.98±0.01a
Soluble fibre	1.33±0.01d	1.17±0.02a	1.07±0.01c	1.24±0.01b	1.27±0.01c
Insoluble fibre	3.21±0.01a	3.17±0.02a	3.29±0.01b	3.30±0.01b	3.23±0.01ab
Total dietary fibre	4.44 ± 0.01b	4.37 ± 0.01a	4.45 ± 0.01e	4.53 ±0.02d	4.50± 0.01c

**Data are mean values of triplicate determination ± standard deviation*

**Mean values carrying the same letters along rows are not significantly different (p>0.05)*

Table 4: Mineral content of the pasta samples (mg/100g)

Mineral	T1	T2	T3	T4	T5
Fe	$0.45{\pm}0.01^a$	$0.49{\pm}0.01^c$	$0.56{\pm}0.01^e$	$0.52{\pm}0.01^d$	$0.47{\pm}0.01^b$
Ca	$4.96{\pm}0.01^a$	$5.56{\pm}0.01^d$	$5.14{\pm}0.01^b$	$4.97{\pm}0.01^a$	$5.23{\pm}0.01^c$
Mg	$5.35{\pm}0.03^b$	$5.49{\pm}0.01^c$	$5.23{\pm}0.04^a$	$5.66{\pm}0.01^d$	$5.39{\pm}0.01^b$
Na	$0.36{\pm}0.01^c$	$0.26{\pm}0.01^b$	$0.35{\pm}0.00^c$	$0.28{\pm}0.01^b$	$0.24{\pm}0.01^a$
K	$120.06{\pm}0.01^d$	$119.67{\pm}0.01^c$	$120.44{\pm}0.01^e$	$118.31{\pm}0.78^b$	$117.74{\pm}0.03^a$
P	$80.36{\pm}0.01^e$	$79.46{\pm}0.01^d$	$73.33{\pm}0.03^c$	$72.22{\pm}0.06^b$	$69.65{\pm}0.1^a$

** Data are mean values of triplicate determination ± standard deviation*

**Mean values carrying the same letters along rows are not significantly different (p>0.05).*

Dietary fibre is the edible parts of the plant and analogous carbohydrate that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine (Tarleton and DiBaise, 2011). It include polysaccharides, lignin and associated plant substances. For people with diabetes, eating foods that contain soluble fibre can help control or lower the level of sugar in their blood and decrease insulin needs. A low dietary fibre diets typically contains less than 2 to 3 grams of fibre per serving. The total dietary fibre content of the formulated pasta samples indicated that pasta from 100% QPM had the lowest value of 4.37% and pasta from 70% QPM + 15% sorghum + 15 watermelon seed (T3) contained the highest total dietary fibre content of 4.55%. There were significant differences (p<0.05) between the dietary fibre content of the pasta samples. The soluble fibre in sample 100% QPM (T1) was found to be the highest (1.33%) as compared with samples T2, T3, T4 and T5 which recorded mean values of 1.17%, 1.27%, 1.24% and 1.27% respectively. The soluble fibre, insoluble fibre and total dietary fibre reduced with the addition of watermelon seed to QPM, while it was on the increase when sorghum was blended with water melon. The range of total dietary fibre in this study was higher than the 2.00% reported by Arendt and Zannini (2013). However, Kahlon *et al*., (2013) reported 6.53% for corn based pasta. Dietary fibre plays a very important role in the prevention of several diseases such as cardiovascular disease, diverticulosis, constipation, irritable colon, cancer and diabetes (Slavin, 2005; Elleuch *et al*., 2011). For the celiac disease patient the values reported in this study should be adequate to maintain healthy living.

3.3. Minerals Content of Formulated Pasta Samples

The mineral content of pasta made from QPM and sorghum flour fortified with water melon seed flour is presented in Table 4. The selected minerals are useful for various functions in human as specified below. There were significant differences (p<0.05) in all the minerals determined. Iron content ranged from 0.45 to 0.56 mg/100 g with sample T3 having the highest and T1 had the lowest. This range of values are higher than the range (0.10 – 0.28%) reported by Ibitoye *et al*., (2013). Iron value improved with the inclusion of water melon to QPM and sorghum base pasta. Iron is needed for blood formation. It helps in transporting oxygen in the body.

Calcium content ranged from 4.96 to 5.56 mg/100 g with sample T2 having the highest (5.56 mg/100 g) and T1 had the lowest (4.96 mg/100 g). Calcium content increased with the addition of watermelon seed. Calcium is needed for the formation of strong bones and teeth. Calcium is essential for normal cell functioning of the nerves, heart and functioning of the enzymes. Its deficiency in children can lead to rickets and osteomalacia. Ibitoye *et al.* (2013) reported 0.73 – 0.90 % for noodles produced from wheat and potato starch blends. Magnesium content ranged between 5.23 and 5.66 mg/100 g with sample T4 having the highest and T3 had the lowest. Magnesium content increased with the addition of watermelon seed. Magnesium is needed for more than 300 different enzymes systems in the body. It is important in the formation of ATP, storage of carbohydrates, fats and protein, in nerves and muscle activities. Man has a remarkable capacity to conserve magnesium. Its deficiency can lead to defective growth abnormalities, central nervous systems and disturbance in the pathway the body handles the fat (Nieman, *et al*., 1992). The phosphorus content of the pasta samples ranged from 69.65 to 80.36 mg/100g with pasta sample T5 (100% sorghum) having the lowest value and pasta sample T1 (100% QPM) had the highest value. The phosphorus content decreased with addition of watermelon seed flour. Phosphorus helps in cellular transmission of impulses in the nerves. Sodium content of the pasta ranged from 0.24 - 0.36 mg/100 g, with pasta sample T1 (100% QPM) having the highest sodium content of 0.36 mg/100 g and pasta sample T5 (100 % sorghum) had the lowest sodium value of 0.24 mg/100 g. The sodium content decreased with the addition of watermelon seed flour. Sodium (0.21 – 0.29%) reported by Ibitoye *et al*. (2013) falls within the range reported in this study. The potassium content of the formulated pasta samples ranged from 117.74 mg/100 g to 120.44 mg/100 g, with pasta T5 (100% sorghum) recording the lowest value and pasta T3 (70% QPM + 15% sorghum + 15% watermelon seed) had the highest value. Potassium is one of the most important electrolytes in the human body. Potassium is vital to the healthy functioning of all body cells. Potassium is particularly important for the ability of skeletal and smooth muscles to contract.

3.4. Sensory evaluation of cooked pasta samples

Sensory quality is one of the quality parameters that determines the suitability and acceptability of a product to the intending consumers. The results of the sensory evaluation of

Table 5: Sensory evaluation of gluten free pasta samples

Attributes	T1	T2	T3	T4	T5	Control (wheat based)
Appearance	6.40_a	4.40_a	4.40_a	1.30_d	2.60_c	6.50_a
Colour	6.10_a	4.60_a	4.60_a	1.40_d	2.60_c	6.20_a
Taste	4.70_b	3.80_b	4.20_b	2.80_b	3.40_b	6.80_a
Flavour	3.90_a	3.70_a	4.20_a	3.10_a	4.20_a	6.50_a
Texture	4.90_b	3.90_c	3.90_c	2.00_e	2.70_d	6.70_a
General acceptability	5.10_a	3.90_b	3.70_b	1.70_d	2.70_c	6.70_a

** Data are mean*

**Mean values carrying the same letters along rows are not significantly different (p>0.05)*

cooked control (commercial pasta) and pasta samples from QPM and sorghum fortified with watermelon seed are shown in Table 5. There was significant difference ($p<0.05$) in the appearance of the cooked pasta from QPM and sorghum however, there was no significant difference ($p>0.05$) between the control and the QPM based pasta. The sorghum based pasta looked darker and unacceptable to the panelists. Among the gluten free pastas T1 (100% QPM) pasta was the most acceptable in terms of appearance. There was absence of stickiness and messy appearance; this is desirable quality in good quality pasta. The data suggest that yellow – coloured QPM pasta was preferred over the dark coloured pastas. This observation agrees with the report of Ubbor and Nwaogu (2010) who produced noodles from a blend of cocoyam, breadfruit and wheat flour.

In general, the other parameters evaluated followed similar trend as the appearance, there were significant differences ($p<0.05$) between the colour, texture, flavour, taste and the general acceptability of the pastas produced from QPM and sorghum. The observations in this study agrees with report of Kahlon *et al.* (2013) for gluten free, egg free pasta. The control pasta sample was the most preferred in terms of all the parameters evaluated followed by the QPM based pasta. This study shows that pasta of comparable quality with commercial pasta could be produced from QPM fortified with watermelon.

4. CONCLUSION

This study concluded that gluten free pasta of high nutrient density in terms of proximate and mineral compositions could be produced from QPM and sorghum fortified with water melon. The QPM based pasta compared favourably with the commercial pasta (wheat base) in some the parameters (sensory and chemical) assessed. These pastas will be advantageous to patient suffering from celiac disease as alternative to wheat base pasta. The addition of water melon improved the nutrient density of the gluten free pasta.

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REFERENCES

Abiose, S.H. and Ikujenlola, A.V. Consumption of chemical composition, functional properties and amino acids composition of quality protein maize and common maize (*Zea may*.L). African Journals of Food Science and Technology 5 (3): 81-89, 2014.

Adegunwa M.O., Bakare H.A. and Akinola, O.F. Enrichment of Noodles with Soy flour and Carrot Powder. Nigeria Food Journal. 30 (1): 74-81, 2012.

AOAC Official methods of analysis. Association of Official Analytical Chemist, 15th ed. Washington. D.C., 2000.

Arendt E.K. and Zannini E. Cereal grains for the food and beverage industries. Woodhead publishing Ltd, Oxford 1st edn. 67-104, 283-306, 2013.

Chavan, U., Mckenzie, D. and Shahidi, F. Functional properties of protein isolates from beach pea (Lathyrus maritimus L.). Food Chemistry. 74: 177–187, 2001.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C. and Attia, H. Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: Review Food Chemistry. 124: 411-421, 2011.

Farnham, D. E., Benson, G. O., and Pearce, R. B. Corn perspective and culture. In: White, P. J. and Johnson, L. A. eds. Corn Chemistry and Technology, 2nd edn. St. Paul, MN: American Association of Cereal Chemists. 1–34, 2003.

Fasano, A. and Catassi, C. Current approaches to diagnosis and treatment of celiac disease: an evolving spectrum. Gastroenterology. 120: 636–651, 2001.

Ferrari, L., and N. Piazza. *Nutritional Value of Pasta*. Professional Pasta. Newsletter. 31: 40-44, 2006..

Ibitoye W.O., Afolabi, M.O. Otegbayo, B.O. and Akintola A.C. Preliminary studies of the chemical composition and sensory properties of sweet potato starch-wheat flour blends noodles. Nigeria Food Journal. .31 (2): 48-51, 2012.

Ikujenlola, A.V., Adurotoye, E.A. Evaluation of Quality Characteristics of High Nutrients Dense Complementary Food from Mixtures of Malted Quality Maize (*Zea mays* L.) and Steam Cowpea (Vigna unguiculata). Journal of Food Process Technology. 5: 291. Doi: 10.4172/2157-7110.1000291, 2014.

Kahlon T.S., R.R. Milczarek, and M.M. Chiu Whole grain gluten -free egg free pasta. Cereal Food World. 58 (1) : 4-7, 2013.

Lee, W. J., Pederson, J.F., Shelton, D.R. Relationship of sorghum kernel size to physiochemical, milling, pasting and cooking properties. Food Research International 35: 643-649, 2002.

Manthey, F.A., Yala, S.R., Dick, T.J., Badaruddin, M. Extrusion properties and cooking quality of spaghetti containing buckwheat bran flour. Cereal Chemistry. 81: 232-236, 2004.

Muhimbula, H. S., Abdulsudi Issa-Zacharia and Joyce Kinabo Formulation and sensory evaluation of complementary foods from local, cheap and readily available cereals and legumes in Iringa, Tanzania. African Journal of Food Science. 5(1): 26 – 31, 2011.

Nieman, D.C., Butterworth, D.E and Nieman, C.N Nutrition. 1st Edn. Brown Publisher. 273-308, 1992.

Prassana, B.M., Vasal, S.K., Kassahun A, B., and Singh, N.N. Quality Protein maize. Current Science. 81(10): 1308-1319, 2001.

Ravindran, V., Cabahug, S., Ravindran, G. and Bryden, W.L. Influence of microbial phytase on apparent ileal amino acid digestibility of feedstuffs for broilers. Poultry Science. 78: 699–706, 1995.

Saunders, R. M., Connor, M. A., Booth, A. N., Bickoff, E. N. and Kohier, C. O. Measurement of digestibility of alfalfa protein concentrate by invitro and invivo methods. Journal of Nutrition. 103: 530–535, 1973.

Schober T. J. and Bean S. R. Sorghum and maize In: Gluten-free cereal products and beverages. Eds. Elke K. Arendt and Fabio Dal Bello. Elsevier Inc. 1st edition. 101-113.

Shan, L., Molberg, O., Parrot, I., Hausch, F., Filiz, F., and Gray, G. M. Structural basis for gluten intolerance in celiac sprue. Science. 297: 2275–2279, 2002.

Slavin, J.L. Dietary fibre and body weight. Nutrition. 21: 411-418, 2005.

Suhendro, E. L., Kunetz, C. F., McDonough, C. M., Rooney, L. W., and Waniska, R. D. Cooking characteristics and quality of noodles from food sorghum. Cereal Chemistry. 77: 96–100, 2000.

Sultana Z., M.S. Ahmed, M.S. Iqball and Chisty M.A.H. Determination of in vitro protein digestibility of different feed ingredients for nilotica (*Oreochromis nilotica*). Bangladesh Research Publication Journals. 4 (1) 87-94, 2010.

Tarleton S. and DiBaise J. K. Low-Residue Diet in Diverticular Disease: Putting an End to a Myth. Nutrition in Clinical Practice 26: 137-142, 2011. doi:10.1177/0884533611399774.

Tharise, N., Julianti, E. and Nurminah, M. Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour. International Food Research Journal 21(4): 1641-1649, 2014.

Totlani, V.M. Investigation of centrifugal a rheological techniques to predict stability of peanut butter. Published M.SC, Graduate Faculty of the University of Georgia, USA. 2012.

Ubbor, S.C., Akobundu, E.N.T. Quality characteristics of cookies from Composite Flours of watermelon seed, cassava and wheat. Pakistan Journals of Nutrition. 8: 1097-1102, 2009.

Ubbor, C. and Nwaogu E. Production and evaluation of noodles from flour blends of cocoyam, breadfruit, and wheat. 28 (1) 173-198, 2010