COOKING CHARACTERISTICS AND ACCEPTABILITY OF GLUTEN-FREE NOODLES PRODUCED FROM ORGANIC UNRIPE PLANTAIN (Musa paradisica)

Obi[1*], T. E. and Opara[2], C. N.

ABSTRACT

[1*]*Department of Chemical Sciences, Igbinedion University, Okada, PMB 0006, Okada, Benin, Edo State, Nigeria. theodoraobi@gmail.com. +2348035020918.* [2]*Department of Microbiology, Faculty of Sciences, Federal University Otuoke, PMB 126 Yenagoa Bayelsa State; xtyo2000@yahoo.com.+2348038925615.*

Study investigated cooking characteristics and acceptability of gluten-free noodles produced from unripe organic plantain (Musa paradisica L.).Matured green organic plantain cultivar "agbagba" was obtained from Federal University of Agriculture, Abeokuta organic plantain plot. Fruits were peeled and sliced into 3-4 mm thickness and dried in a cabinet drier. Dried slices were milled into flour (600 µm size) and used to prepare noodles using 2.5% and 3.5%xanthan gum to obtain two samples of noodles (Org2 and Org3 respectively) and packaged in high density polyethylene for further analyses. Cooking time, cooking loss, water absorption, colour and overall acceptability of noodles were carried out. Results showed that. L, a*, b* colour values reduced after cooking. Org2 had lowest cooking time of 7.10minutes and branded noodle2 (BN2), highest time of 8.29minutes. BN2 had lowest cooking loss of 6.4% and Org2 highest value of 7.2%. BN2 had lowest water absorption value of 111.3% and Org3, highest of 120.6%. Overall, Org3 was more acceptable than Org2. Therefore, it is possible to formulate unripe organic plantain-flour based gluten-free noodles with 3.5 % xanthan gum because it exhibited some properties that compared favourably with the branded noodles.*

Keywords*: Gluten-free, Noodles, Organic Plantain, Acceptability*

INTRODUCTION

The consumption noodles produced from durum wheat semolina has been on the increase as a result of their simple preparation requirement, desirable sensory attributes, long shelf- life, together with diversity and nutritive value (Ge *et al.*, 2001). Studies have been carried out to improve the nutritional quality of noodles by partially or totally adding or replacing durum wheat with flours from other sources (Brennan, 2008). The major raw material for making noodles is unique among other cereals because of its content of gluten protein which contains a high proportion of cysteine bonds (Osagie and Eka, 1998). It is also important to mention that presently, celiac disease and cereal allergy (including wheat allergy) are great problems. Celiac disease is an inheritable chronic systemic autoimmune disorder that occurs in the small intestine which is caused by a permanent intolerance to gluten proteins in individuals that are genetically susceptible (Freeman *et al.,* 2011). As a result of celiac disease, the significance of gliadin-free basic foods keeps growing in the world. There is growing interest in the use of pseudo cereals (amaranth, quinoa and buckwheat), rice, legumes (yellow pea), plantain, etc. as alternative ingredients for gluten-free (GF), non-traditional noodle products as alternative food sources for wheat-sensitive patients (Rasmay *et al.,* 2000). This has encouraged extensive research into gluten-free food products research and development celiac disease individuals whose only treatment is a strict adherence to a GF diet (Schoenlechner *et al.,* 2010).

Earlier authors such as Wang *et al.* (1999) and Chillo *et al.* (2010) worked on the different extrusion techniques for GF products processing. Huang *et al.* (2001), Singh *et al.* (2004) and Chillo *et al.* (2011) also studied the effects of gums and starches on production of gluten-free pasta products. Flores-Silva *et al.* (2014) studied the physicochemical, chemical, textural and sensory properties of GF spaghetti produced from composite flours of unripe plantain, chick pea and maize. Furthermore, evaluation of the use of different non-conventional flours in the production of GF products has been reported by Schoenlechner *et al.* (2010) and Mastromatteo *et al.* (2011). However more research work is needed for GF products made from non-conventional flours since they differ in quality from pasta products produced from durum wheat semolina (Hager *et al.,* 2011).

Hager *et al.* (2011) recently reported that the intake of refined sugars in celiac patients is high and the addition of a good source of indigestible carbohydrates is of importance. The studies of Faisant *et al.* (1995a) and Faisant *et al.* (1995b) have suggested that consumption of unripe plantain (*Musa paradisiaca L.*) exerts a beneficial effect on human health; this is associated with indigestible components as resistant starch (RS). Plantain (*Musa paradisica L*) belongs to the family of banana and is popularly called cooking banana, since it is seldom eaten raw. Banana plants are monocotyledonous perennial and important crops in the tropical and subtropical regions of the world (Strosse *et al.,* 2006). Plantain is widely grown in the southern States of Nigeria where there is adequate rainfall distribution (Kure *et al.*, 1998). Plantain can be utilized in many different ways, such as frozen puree, flour, juice, jams, canned or fried slices, vinegar and wine (Guerrero and Alzamora, 1997). Plantain fruits are also among the green vegetables with the richest iron and other nutrient contents but it is not well utilized (Aremu and Udoessien, 1990). Plantain flour has also been successfully added to whole grain bars (Utrilla-Coello *et al.*, 2011), bread

(Juárez-García *et al.,* 2006) and spaghetti (Ovando-Martínez *et al.,* 2009), demonstrating that its addition results in a higher RS content and a lower starch digestion rate.
It has been reported by Wilkinson *et al.* (2001) that the quality attributes (colour, cooking characteristics, taste) of non-conventional GF pasta products should be close to the quality attributes of the traditional pasta products and hence consumer acceptability. As the world food market is being diversified, studying for the development and improvement of new and acceptable noodles satisfying consumer demands are imminent (Ge *et al*., 2001). The quality of noodle is not only evaluated in terms of colour (Miskelly, 1984), texture (Ross *et al.,* 1997) and cooking characteristic (Oh *et al.,* 1985) but, also the raw materials, ingredients and process technology in which starch and protein play major roles. According to the report of Tuorila and Cardello (2002), the colour of pasta products is used as a quality parameter that is directly associated with its acceptability. Also, sensory properties and hedonic pleasure are important attributes in food product development. Mastromatteo *et al.* (2011) reported that pasta products based on non-conventional flour sources need to achieve a proper satisfactory quality attributes. Most research works that have been published used composite flour which substituted a portion of the durum wheat semolina with other non-conventional flours. In addition, there is limited research on the use of unripe organic plantain flour in the production of noodles. Thus, this objective of this present investigation was to produce gluten-free noodles from unripe organic plantain flour and to evaluate its cooking characteristics and acceptability.

MATERIALS AND METHODS

Organic plantain cultivar

Entirely dark green and unripe organic plantain cultivar, "agbagba", was obtained from Federal University of Agriculture, Abeokuta, Ogun State, Nigeria organic plantain demonstration conversion plot (with a single dose of poultry 40tha^{-1} of manure application in randomized complete block design) situated at (7° 15´ N, 3° 25´ E) managed by Organic Agriculture Project in Tertiary Institutions in Nigeria (OAPTIN). The spacing between the plantain suckers was 3.0 m x 2.5 m.

Xanthan gum

Xanthan gum (Grindsted® Xanthan 200, Danisco USA, Inc., New Century, KS) was purchased from Chemicals' market, Lagos State, Nigeria.

Iodised salt

Iodised salt (NASCON PLC, Apapa, Lagos) was purchased from Chemicals' market, Lagos State, Nigeria

Olive oil

Cold pressed olive oil (GOYA en Espana, Sevilla Spain) was also purchased from Chemicals' market, Lagos State, Nigeria.

Processing mature unripe organic plantain fruits into flour

The organic flour sample was produced by adopting the method of Kure *et al.* (1998) with slight modification. The organic plantain fruits were separately weighed, the fingers were removed from bunches, washed, hand peeled and sliced into about 3-4mm thickness under water using a slicer. The slices were dried in a cabinet drier at 60 °C for 24hours. After which the dried plantain slices were milled into flour using attrition mill. The resulting flour was sieved with a sieve of 600 µm aperture size into flour and packed in high density polyethylene film sealed and kept until analyses were carried out.

Processing of unripe organic plantain flour into noodles

The organic plantain noodle samples were produced by adopting the method of Nagao, (1996) with slight modification. Two hundred grams of organic plantain flour was mixed with 130 ml distilled water, 0.3% NaCl, 5 ml cold pressed olive oil (GOYA en Espana, Sevilla Spain) and 2.5 and 3.5% xanthan gum (Grindsted® Xanthan 200, Danisco USA, Inc., New Century, KS). The resultant dough was kneaded with hand for 5 minutes and allowed to rest for 20minutes, then folded and sheeted through a noodle machine (VillaWare classic Italian Kitchen ware, Cleveland, OH) with the gap set at 4. The sheet was cut into strips of diameter 0.8 mm. The noodle strips were dried in the cabinet dryer at 60 °C for 12 hours, packed and sealed in high density polyethylene film and kept for further analyses

Samples of plantain noodles produced:

Org3: unripe organic plantain noodles with 3.5% xanthan gum

Org2: unripe organic plantain noodles with 2.5% xanthan gum

Colour of organic plantain noodles

Commission Internationale de l'Eclairage (CIE) tristimulus L* a* b* parameters were determined using colour meter (Color Tec PCMTM Color Tec Associates, Inc., Clinton, NJ, USA). The colorimeter operates on the CIE L*, a*, b* colour scheme, *L (lightness) axis – 0 is black, 100 is white, *a (red-green) axis – positive values are red; negative values are green and 0 is neutral, *b (yellow-blue) axis – positive values are yellow; negative values are blue and 0 is neutral. The instrument was first standardised (L* = 93.24, a* = 00.96, b* = –02.75) with a Business Xerox 80gm^{-2}) white paper with 136 CIE whiteness D65. Three grams of plantain noodles was ground and weighed into a clean paper and the colour meter was placed on the sample by allowing the sensor to touch the sample. The reading was taken directly for L*-a Light to Dark direction (Francis *et al.,* 2001).

Cooking characteristics of noodles

Cooking characteristics considered in this study included cooking time, loss and water absorption. Time was determined by cooking about 10 g of noodles in 300 ml of deionised water in a covered 500 ml beaker. Cooking time was determined by the removal of a piece of noodle every 2minutes and pressing the noodle between 2 pieces of watch glasses. Optimum cooking was achieved when the centre of the noodles became transparent or when the noodle was fully hydrated. Cooking was stopped by rinsing briefly in deionised water (AACC, 1995).

Loss was determined by cooking approximately 10g of noodles in 300ml of distilled water in a 500 ml beaker until the central opaque core in the noodle strand disappeared. Cooking loss (%) was measured by transferring the cook water to a pre-weighed beaker and evaporating the water in a conventional oven overnight at 100℃, then reweighing the beaker with left over solids (AACC, 1995).

$$\text{Cooking loss (\%)} = \frac{driedresidueincookingwater}{noodleweightbeforecooking} \times 100$$

Water absorption is the difference in weight of cooked noodles and uncooked noodles, expressed as the percentage of the weight of uncooked noodles. Cooked noodles were rinsed with water and drained for 30s then weighed to determine the gain in weight. This analysis indicates the amount of water absorbed by the noodles during cooking process (AACC, 1995).

Overall acceptability

Overall acceptability of the noodles was evaluated by 100 panelists to indicate their preference for the samples on a nine point hedonic scale, where 1 and 9 represent dislike extremely and like extremely respectively (Iwe, 2002).

Statistical analysis

Analyses were carried out in 3 replicates and results obtained in this study were expressed by mean ± standard error (SE). Differences among the means obtained in each of the determinations were evaluated by one-way analysis of variance (ANOVA) and the significantly different treatment means were separated with Duncan's multiple range test at 5% level of probability using SPSS software (16.0 version).

RESULT AND DISCUSSION

Colour of uncooked and cooked unripe organic plantain and branded noodles

The colour of the uncooked and cooked unripe plantain and branded noodle samples are shown in Tables 1 and 2. The data obtained showed significant differences ($p<0.05$) among all noodle samples for "L*", "a*", and "b*" colour values. The L* colour values for all the uncooked noodles ranged from 76.82-84.24. Branded noodle2 (BN2) had the highest L* colour value of 84.24, while organic plantain noodles produced with 2.5% xanthan gum (Org2) had the lowest L* colour value of 76.82.The a* colour values ranged from 1.23-1.86, while organic plantain noodles produced with 3.5% xanthan gum (Org3) had the highest a* colour value of 1.86, BN2 had the lowest a* value of 1.23. The b* colour values ranged from 19.12-20.96. While BN2 had the highest b* colour value of 20.96, Org2 had the lowest b* colour value of 19.12. The L* colour values for the cooked noodles, ranged from 73.54 to 80.12 with BN2 having the highest value of 80.12 and Org2 with lowest value of 73.54. The a* colour values ranged from 0.32 to 0.92 with Org3 having the highest value of 0.92 and BN2 having the lowest value of 0.32. The b* colour values ranged from 17.18 to 18.72 with BN2 having the highest value of 18.72 and Inorg2 with the lowest value of 17.18.

Table 1: colour values of uncooked unripe organic plantain and branded noodles

Noodle samples	L*	a*	b*
Org3	78.60c± 1.62	1.86a± 0.12	19.64c± 0.46
Org2	76.82d± 1.40	1.66b± 0.21	19.12d± 0.16
Branded noodle1	82.57b± 0.71	1.36c± 0.20	20.72b± 0.08
Branded noodle2	84.24a± 0.16	1.23d± 0.11	20.96a± 0.12

Results are expressed as mean values and standard deviation of three replicate samples. Mean values with different alphabets in a column are significantly different ($p< 0.05$). Org3: unripe organic plantain noodles with 3.5 % xanthan gum. Org2: unripe organic plantain noodles with 2.5 % xanthan gum

Cooking characteristics of unripe organic plantain and branded noodles

The result of the cooking characteristics of unripe organic plantain noodles comprising Org3, Org2 and branded noodles are shown in Table 3. There was significant differences ($p<0.05$) in the cooking characteristics among all noodle samples. The cooking time ranged from 7.10-8.29minutes, Org2 had the lowest time (7.10minutes), while Branded Noodle2 (BN2) had the highest time of 8.29minutes. Cooking loss ranged from 6.4-7.2%, with BN2 having the lowest value of 6.4 % and Org2 with the highest cooking loss of 7.2 %. Furthermore, water absorption of the noodle samples ranged from 111.3 % (BN2) to 120.6 % (Org3).

Acceptability of cooked unripe organic plantain and branded noodles

The acceptability of cooked unripe organic plantain and branded noodles are shown in Fig 1. The result showed that there was no significant difference in all the sensory attributes (appearance, flavour, taste, texture and colour) examined in both samples of organic plantain noodles but significant difference ($p<0.05$) existed between the plantain noodle samples and the branded noodles. The range scores for appearance was 6.3 – 7.6 with Org2 and Org3 having the lowest score (6.3) and BN1 with the highest score (7.6). The scores for colour ranged from 5.6-7.2. While BN1 had the highest score (7.2), Org2 and Org3 were scored (5.6). Furthermore, in terms of the taste of the noodles, the range was 4.4 - 6.4. BN1had the highest score (6.4) while Org2 had the least score (4.4). The range of texture scores was (6.4 – 7.0) with Org3 having the highest score (7.0) and Org2 and BN2 having the least score (6.4). The range of mean scores for colour of noodles was (6.3 – 7.4) with BN1 having the highest colour score (7.4) and Org2 having the lowest score (6.3). The range of overall acceptability scores was (6.3-7.0). While BN1 and BN2 had the highest acceptability score (7.0), Org2 had the lowest score (6.3).

Table 2: Colour values of cooked unripe organic plantain and branded noodles

Noodle samples	**L***	**a***	**b***
Org3	75.16c± 1.32	0.92a± 0.01	17.38c± 0.85
Org2	73.54d± 1.21	0.73b± 0.20	17.15d± 0.43
Branded noodle1	78.94b± 0.46	0.44c± 0.17	18.68b.± 0.18
Branded noodle2	80.12a± 0.10	0.32d± 0.10	18.72a± 0.10

Results are expressed as mean values and standard deviation of three replicates samples. Mean values with different alphabets in a column are significantly different ($p< 0.05$). Org3: unripe organic plantain noodles with 3.5 % xanthan gum. Org2: unripe organic plantain noodles with 2.5 % xanthan gum

Table 3: Cooking characteristics of unripe organic plantain and branded noodles

Noodle samples	Cooking time (minutes)	Cooking loss (%)	Water absorption (%)
Org3	7.21b± 0.01	7.1c± 0.02	120.6d± 0.05
Org2	7.10a±0.10	7.2d± 0.01	115.3c± 0.03
Branded noodle1	8.21c± 0.05	6.5b± 0.02	112.6b± 0.01
Branded noodle2	8.29d± 0.04	6.4a± 0.04	111.3a± 0.10

Results are expressed as mean values and standard deviation of three replicate samples. Mean values with different alphabets in a column are significantly different ($p< 0.05$). Org3: unripe organic plantain noodles with 3.5 % xanthan gum. Org2: unripe organic plantain noodles with 2.5 % xanthan gum

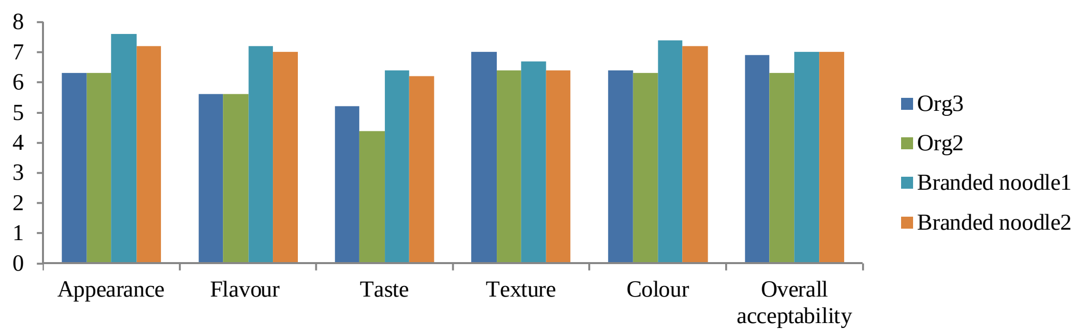

Fig. 1: Acceptability ofcooked unripe organic plantain and branded noodles (Org3: unripe organic plantain noodles with 3.5% xanthan gum; Org2: unripe organic plantain noodles with 2.5% xanthan gum)

Brightness is a required colour for all noodles and creamy white colour is the best noodle colour and flour colour is one of the most important factors in the quality of noodle (Miskelly, 1984). Miskelly and Moss (1985) reported that flour protein content is negatively correlated with white noodle brightness and that high protein content is associated with increased greyness. Jun *et al.* (1998) found that noodle colour is influenced more by protein than by ash content. The L*, a* and b* values of all samples of noodles decreased after cooking, and this agrees with the findings of Baik and Lee (2003) who reported that all the L* values of wheat noodles decreased from 76.68 to 61.06, a* values from -0.37 to -1.22 and b* values from 11.68 to10.21 after cooking. Cooking loss may be defined as the amount of noodle solids that dissolve in the cooking water during the cooking process. This measurement indicated the ability of the noodles to maintain structural integrity during the cooking process. High cooking loss is not desirable for noodle quality. Cooking loss for all the samples of noodles in this study was below 12%. Inglett *et al.* (2003) reported that the cooking loss for the wheat and rice flour noodles at compositions of 70:30, 60:40, and 50:50 were 5.8, 5.8, and 6.8 %, respectively. Water uptake indicates that the degree of noodle hydration and may affect the eating quality of noodles. Water absorption observed in this study for the samples of

noodles agree with the findings of Inglett *et al*. (2003), who reported the water uptake for wheat and rice flour noodles blends at compositions of 70:30, 60:40, and 50:50 to be 119.6, 132.4, and 135.6%, respectively.
The cooking time of noodles is influenced by protein contents. Higher protein contents led to longer cooking times by slowing down water penetration into the noodle (Moss *et al.,* 1987). The cooking time observed in this study agrees with the findings of Vijayakumar *et al.* (2009) who reported a range of cooking time of (9.30-16.23minutes) for noodles from millet flour blend incorporated composite flour. Paulus and Reisch (1980) defined sensory evaluation as the individual likeness and dislikes of a product as a result of biological variation in man and perception of appropriate sensory properties. The overall acceptability of the sensory properties of colour, texture, taste, flavour and appearance of experimental noodles Org 2 and Org3 and two branded noodles (branded noodles 1 and 2) reveals that there were variations in the sensory attributes measured. However, the panelists preferred branded noodle 1 in terms of all the measured attributes but texture. The panelists preferred Org3 to Org2 because it compared favourably with the branded noodles but not in terms of colour. Org2 was least preferred in terms of taste, texture, colour and overall acceptability. Based on these sensory properties, Org3 was preferred to Org2 in overall acceptability. According to Huang and Morrison (1988), the texture of noodle is a very important assessment of noodle quality. While the Chinese prefer noodle with medium firmness and strong chewiness texture, the Japanese prefer soft texture.

CONCLUSIONAND RECOMMENDATIONS

Gluten-free noodles produced from unripe organic plantain flour with 3.5% xanthan gum exhibited some properties that compared favourably with the commercial branded wheat flour noodles. Hence, it is possible to produce gluten-free noodles from unripe organic plantain that possess cooking characteristics and sensory properties that can compare favourably with wheat-based noodle. However, the colour and taste of the gluten-free noodles produced from unripe organic plantain flour should be worked on to improve the overall acceptability. Also, storage stability studies should be carried out on the produced noodles to determine the effect of storage on the cooking characteristics and overall acceptability of the noodles.

REFERENCES

AACC, 1995. Approved methods of the AACC 3rd edn.American Association of Cereal Chemist, St Paul Minnesota. MN, USA

Aremu, C. Y. and Udoessien, E. I. 1990. Chemical estimation of some inorganic elements in selected tropical fruits and vegetables. *Food Chem*. 37:229-240.

Baik, B. K. and Lee, M. R. 2003. Effects of starch amylose content of wheat on textural properties of white salted noodles. *Journal of Cereal Chemistry*, 80(3):304-309.

Brennan, C. S. 2008. High-fibre pasta products. In B. Hamaker (Eds.), Technology of functional cereal products. Boca Raton, FL: EUA, CRC Press, Woodhead Publishing Limited

Chillo, S., Civica, V., Iannetti, M., Mastromatteo, M., Suriano, N. and Del Nobile, M. 2010. Influence of repeated extrusions on some properties of non-conventional spaghetti. *Journal of Food Engineering.* 100:329-335.

Chillo, S., Laverse, J., Falcone, P. M. and Del Nobile, M. A. 2007. Effect of carboxymethylcellulose and pregelatinized corn starch on the quality of amaranthus spaghetti. *Journal of Food Engineering.* 83:492-500.

Faisant, N., Buléon, A., Colonna, P., Molis, C., Lartigue, S., Galmiche, J. P. and Champ, M. 1995a. Digestion of raw banana starch in the small intestine of healthy humans: Structural features of resistant starch. *British Journal of Nutrition.* 73: 111-123.

Faisant, N., Gallant, D. J., Bouchet, B. and Champ, M. 1995b. Banana starch breakdown in the human small intestine studied by electron microscopy. *European Journal of Clinical Nutrition*. 49:98-104.

Flores-Silva, P. C., Berrios, J. J, Pan, J., Agama-Acevedo E., Monsalve-González, A. and Bello-Pérez, L. A. 2015. Gluten-free spaghetti with unripe plantain, chickpea and maize: physicochemical, texture and sensory properties. CyTA. *Journal of Food*. 13(2):159-166

Francis, G., Makkar, H. P. S. and Becher, K. 2001. Antinutritional factors present in plant-derived alternate fish ingredients and their effects in fish. *Aquaculture*, 199: 197-227.

Freeman, H. J., Chopra, A., Clandinin, M. T. and Thomson A. B. R. 2011. Recent Advances in Celiac Disease. *World Journal of Gastroenterology.* 17(18):2259-2272.

Ge, Y., Sun, A. and Cai, T. 2001. Study and development of a defatted wheat germ nutritive noodle. *Eur Food Res Technol*. 212: 344–348

Guerrero, S. N. and Alzamora, S. M. 1997. Effect of pH, temperature and glucose addition on flow behavior of fruit puree. I. Banana puree. *Journal of Food Engineering.* 33:239-256.

Hager, A. S., Axel, C., and Arendt, E. K. 2011. Status of carbohydrates and dietary fiber in gluten-free diets. *Cereal Foods World*. 56:109–114.

Huang, S. and Morrison, W. R. 1988. Aspects of proteins in Chinese and British common (hexaploid) wheats related to quality of white and yellow Chinese noodles. *Journal of Cereal Science*. 8:177-187.

Huang, J., Knight, S., and Goad, C. 2001. Model prediction for sensory attributes of non-gluten pasta. *Journal of Food Quality*. 24:495–511

Inglett, G. E., Carriere, C. J., Maneepun, S. and Boonpunt, T. 2003. Nutritional Value and Functional Properties of a Hydrocolloidal Soybean and Oat Blend for Use in Asian Foods. *Journal of the Science of Food and Agriculture.* 83:86-92.

Iwe, M. O. 2002. Handbook of Sensory Methods and Analysis.Rojoint Communication Services Ltd. Enugu. pp. 40-71

Juárez-García, E., Agama-Acevedo, E., Sáyago-Ayerdi, S. G., Rodríguez-Ambriz, S. L. and Bello-Pérez, L. A. 2006. Composition, digestibility and application in bread making of banana flour. *Plant Foods for Human Nutrition.* 61:131-137.

Jun, W. J., Seib, P. A., and Chung, O. K. 1998. Characteristics of noodle fours from Japan. *Journal of Cereal Chemistry.* 75:820-825.

Kure, O. A, Bahago, E. J. and Daniel, E. A. 1998. Studies on the proximate composition and effect of flour particle size of acceptability of biscuits produced from blends of soyabeans and plantain flours. *Namoda Tech Scope Journal*. 3(2):17-22.

Mastromatteo, M., Chillo, S., Iannetti, M., Civica, V., and Del Nobile, M. A. 2011. Formulation optimisation of gluten-free functional spaghetti based on quinoa, maize and soy flours. *International Journal of Food Science and Technology.* 46: 1201-1208.

Miskelly, D. M. and Moss, H. J. 1985. Flour quality requirement for Chinese noodle manufacture. *Journal of Cereal Science*. 3:379.

Miskelly, D. M. 1984. Flour components affecting paste and noodle colour. *Journal of the Science of Food and Agriculture*. 35:463-471.

Moss, R., Gore, P. J. and Murray, I. C. 1987.The influence of ingredients and processing variables on the quality and microstructure of Hokkien, Cantonese and instant noodles. *Food microstructure*. 6: 63-74.

Nagao, S. 1996. Pasta and Noodle Technology.En Kruger JE, Matsuo RB, Dick JW (Eds.) Processing technology of noodle products in Japan. *Am. Assoc. Cereal Chemistry*. 53: 169-194.

Oh, N. H., Seib, P. A., and Chung, D. S. 1985a. Noodles. III. Effects of Processing Variables on Quality Characteristics of Dry Noodles. *Cereal Chemistry*. 62:437-440.

Osagie, A. U. and Eka, O. U. 1998. Nutrition quality of plant food, Ambik press, Benin, Edo- State.

Ovando-Martínez, M., Sáyago-Ayerdi, S., Agama-Acevedo, E., Goñi, I. and Bello-Pérez, L. A. 2009. Unripe banana flour as an ingredient to increase the undigestible carbohydrates of pasta. *Food Chemistry.* 113: 121-126.

Paulus, K. and Reisch, A. M. 1980. The influence of temperature on the threshold values of primary tastes. *Chemical Senses.* 5:11–21.

Rasmay, N. M. H., El-Shatanovi, G. and Ahassan, K. E. W. 2000. High protein macaroni from legume flours and their protein concentrates. *Ann. agric. Sci., Ain Shams.* 45:555–570.

Ross, A. S., Quail, K. J. and Crosbie, G. B. 1997. Physicochemical properties of Australian flours influencing the texture of yellow alkaline noodles. *Cereal Chemistry*. 74:814-820.

Schoenlechner, R., Drausinger, J., Ottenschlaeger, V., Jurackova, K. and Berghofer, E. 2010. Functional properties of gluten-free pasta produced from amaranth, quinoa and buckwheat. *Plant Foods for Human Nutrition.* 65:339–349.

Singh, S., Raina, C. S., Bawa, A. S., & Saxena, D. C. 2004. Sweet potato-based pasta product: Optimization of ingredient levels using response surface methodology. *International Journal of Food Science and Technology*. 39:191–200.

Strosse, H., Schoofs, H., Panis, B., André, E., Reyniers, K. and Swennen, R. 2006. Development of embryogenic cell suspensions from shoot meristematic tissue in bananas and plantains (*Musa spp.). Plant Science.* 170:104-112.

Tuorila, H. and Cardello, A. V. 2002. Consumer responses to an off-flavour in juice in the presence of specific health claims. *Food Quality and Preference.* 13:561-569

Utrilla-Coello, R. G., Agama-Acevedo, E., Osorio-Díaz, P., Tovar, J. and Bello-Pérez, L. A. 2011. Composition and starch digestibility of whole grain bars containing maize or unripe banana flours. *Starch/Stärke*. 63:416-423.

Vijayakumar, T. P., Mohankumar, J. B. and Srinivasan, T. 2009. Quality evaluation of noodles from millet flour blend incorporated composite flour. *Journal of Scientific and Industrial Research.* 69:48-53.

Wang, N., Bhirud, P. R., Sosulski, F. W. and Tyler, R. T. 1999. Pasta-like product from pea flour by twin-screw extrusion. *Journal of Food Science.* 64:671-678.

Wilkinson, C., Dijksterhuis, G. B., and Minekus, M. 2001. From food structure to texture. *Trends in Food Science and Technology.* 11:442-450.