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Sensory profiling of plantain-lima bean *Momo* (A Nigerian food pudding) using chemometric approach

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ABSTRACT

Plantain and lima beans are important food crops with food nutrition security potentials in Nigeria. Plantain-lima bean *momo* is a nutrient-enriched pudding produced from unripe plantain and lima beans. The study aimed at evaluating the sensory profile of the plantain -lima bean *momo* to drive its consumers' acceptability. Plantain and lima beans flour blends of various ratios were processed into *momo*. The *momo* samples were presented to panelists for sensory evaluation. Scores were based on nine point hedonic scale. Data obtained were subjected to Principal component and Agglomerative hierarchical clustering analysis. Results show that the addition of more than 20% of lima beans negatively affected the colour, appearance, flavour, texture and taste of the plantain-lima bean *momo*. PP (100% plantain flour *momo*) had the strongest positive correlation with appearance and texture. PA (90% unripe plantain flour + 10 % lima bean flour *momo*) was preferred mostly of all the *momo* samples in terms of overall acceptability. The principal component analysis (PCA) divided the sensory parameters of the *momo* samples into five factors with PC1 and PC2 accounting for 96.68% of the variance. Agglomerative hierarchical clustering (AHC) showed that PA and PP have similarities in all the sensory properties evaluated and that addition of 10% and 20% of lima beans to plantain flour did not have negative effect on the sensory characteristics of the product. Lima bean flour could be added to plantain flour up to 20% level for enhancement of *momo* nutritional quality, while still retaining its organoleptic qualities.

Introduction

Legumes are plants belonging to the family *Leguminosae* (Staniak et al., 2014). They are an inexpensive meat alternative and are considered the second most important food source after cereals worldwide (Kouris-Blazos and Belski, 2016). Legumes have high nutrition potential providing proteins with essential amino acids, complex carbohydrates, dietary fibre, unsaturated fats, vitamins and essential minerals (Rebello et al., 2014; Annor et al., 2014). Some legumes, though available, are underutilized. Therefore, it is of utmost importance to increase the utilisation of legumes and to introduce new legume-based products that will be affordable to low-income groups as a way to reduce poverty and alleviate malnutrition. Examples of food legumes include peas, broad beans, lentils, soybeans, lupins, lotus, sprouts, mung bean, green beans, lima beans and peanuts (Yorgancilar and Bilgicli, 2014).
Plantain (*Musa* spp.) is a staple food for over three million households in West and Central Africa with Nigeria being the world's top plantain producer (Lescot, 2020). It is an important source of carbohydrates, vitamins A, C and B6, potassium, calcium, sodium and magnesium. (Doymaz, 2010; Amah et al., 2019; Bhuiyan et al., 2020). In Nigeria, plantain can be consumed as dodo (fried ripe pulp),

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boli (roasted unripe–ripe pulp), fufu (boiled and pounded unripe pulp), amala (unripe pulp milled into flour and reconstituted into a stiff dough), *momo* (unripe pulp dried, milled into flour, made into paste with additional ingredients and steamed), porridge/pottage (unripe pulp boiled with additional ingredients), chips (fried unripe pulp) and dodo Ikire (fried overripe pulp with additional ingredients such as chili pepper) (Amah, 2020).

Lima bean (*Phaseolus lunatus*), like other legumes, are considered one of the most valuable nutrient sources in developing countries (Seidu et al., 2018). Lima bean is called kokondo in West Africa. It is known as kapala in South Western Nigeria and ukpa in South Eastern Nigeria (Baudoin, 2006). Lima beans are significant source of plant proteins, carbohydrates and dietary fibres. They are an excellent source of B-complex vitamins, especially vitamin B6 (pyridoxine), thiamine (vitamin B1), pantothenic acid, riboflavin and niacin. They also contain minerals like molybdenum, iron, copper, manganese, calcium, magnesium (Oraka and Okoye, 2017). Lima bean is usually consumed in combination with cereals such as rice, maize, sorghum or with roots and tubers such as yam, cocoyam, or with plantain (Farinde, 2019).

Momo is a traditional steamed plantain-based pudding native to Nigeria and commonly consumed by the people of Osun and Ondo States of Nigeria. It is usually prepared from unripe plantain flour. The unripe plantain fingers are normally peeled, sliced, dried and milled into powder. The plantain flour is then reconstituted in water and made into paste; palm oil, pepper and salt are then added. The plantain paste and the ingredients are mixed, wrapped in cooking leaves and steamed to cook. The steamed cooked *momo* is then allowed to cool and removed from the cooking leaves. It can be consumed as sole diet or consumed with other food products such as pap, bread or rice.

According to the Institute of Food Technologists (IFT), sensory evaluation can be defined as a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, hearing, touch, smell and taste (IFT, 2007). Humans are the measuring instrument for all sensory assessment methods. The sensory panel must be screened, calibrated and validated in order to obtain valid results for sensory assessment. Sensory evaluation of a product can help to pinpoint the important sensory characteristics driving acceptability, it can be useful to ascertain target consumers and product competitors and to assess new ideas. Sensory evaluation also determines the impact of scaling up pilot samples and it gives assurances that inferior products are not released in the market (Sharif et al., 2017).

Malnutrition, food insecurity and hunger have persisted in Nigeria. Hence, there is a need to promote product development from local food crops of high nutritional potential, like plantain and lima bean, and evaluate the product's sensory qualities for consumer acceptability and enhanced food and nutrition security in the country.

Materials and methods

Source of materials

Lima bean seeds (dark-brown variety) and matured unripe plantain were purchased from Ita-Ogbolu market, Akure, Ondo State , Nigeria. Processing materials and sensory utensils were made available at the food processing laboratory and sensory evaluation room of Agricultural Value Addition Programme, Institute of Agricultural Research and Training, Ibadan, Nigeria.

Processing plantain into flour

Processing of plantain flour was carried out following the methods described by Anajekwu et al. (2020). The unripe plantain fingers were separated from the bunches, washed thoroughly with water, peeled manually, sliced thinly, blanched in hot water at 80 °C for 5 min, and dried in a cabinet drier (BOV – V6 25F) at 65 °C for 48 h. The dried slices were dry milled, sieved to pass through a 0.25 mm mesh, packaged in air tight container and kept at ambient (28 ± 2 °C) for subsequent use.

Processing lima beans into flour

Lima bean seeds were processed into flour using the method of Farinde (2019). Lima bean seeds (1kg) were soaked in water (1:3 w/v) for 2 hours and then boiled for 20 minutes, drained and poured into cold water to cool the beans down for comfort of hand dehulling. The beans were then manually dehulled by rubbing between palms and floating the hulls in water. Dehulled cotyledons were separated from shaft through washing in water and sieving. The clean dehulled lima bean seeds were drained, spread on aluminum tray, and dried in a cabinet dryer (BOV – V6 25F) at 60 °C for 24 to 30 h to a moisture content of about 10% or less. The dried lima beans were dry milled into fine powder to pass through a 0.25 mm sieve, packed in air tight container and kept at ambient (28 ± 2 °C) for subsequent use.

Processing of plantain-lima momo

The composite mixture of plantain and lima bean flour was processed into *momo* following the method of Otunola and Afolayan (2017); Farinde (2019). Plantain flour and lima bean flour blends were mixed in varying combination ratios and coded as shown in Table 1. Other ingredients were added in constant ratio as presented in Fig. 1. The composite flour and the other ingredients were mixed together with spoon or stirred to form a paste. The paste was then dispensed into already washed and dried cleaned cooking leaves (*Thaumatococcus daniellii*) and the leaves were wrapped.

The wrapped leaves and the content were placed in cooking pot containing appropriate boiling water and steamed on gas burner for about 40 to 45 mins. Steamed *momo* was removed from the fire and allowed to cool. Samples of cooled plantain-lima bean *momo* were subjected to sensory evaluation.

Table 1. Blends of plantain /lima bean flours mixture for *momo* processing

Sample	Plantain flour	Lima bean flour	Total flour(%)
PP	100	-	100
PA	90	10	100
PB	80	20	100
PC	70	30	100
PD	60	40	100
PE	50	50	100

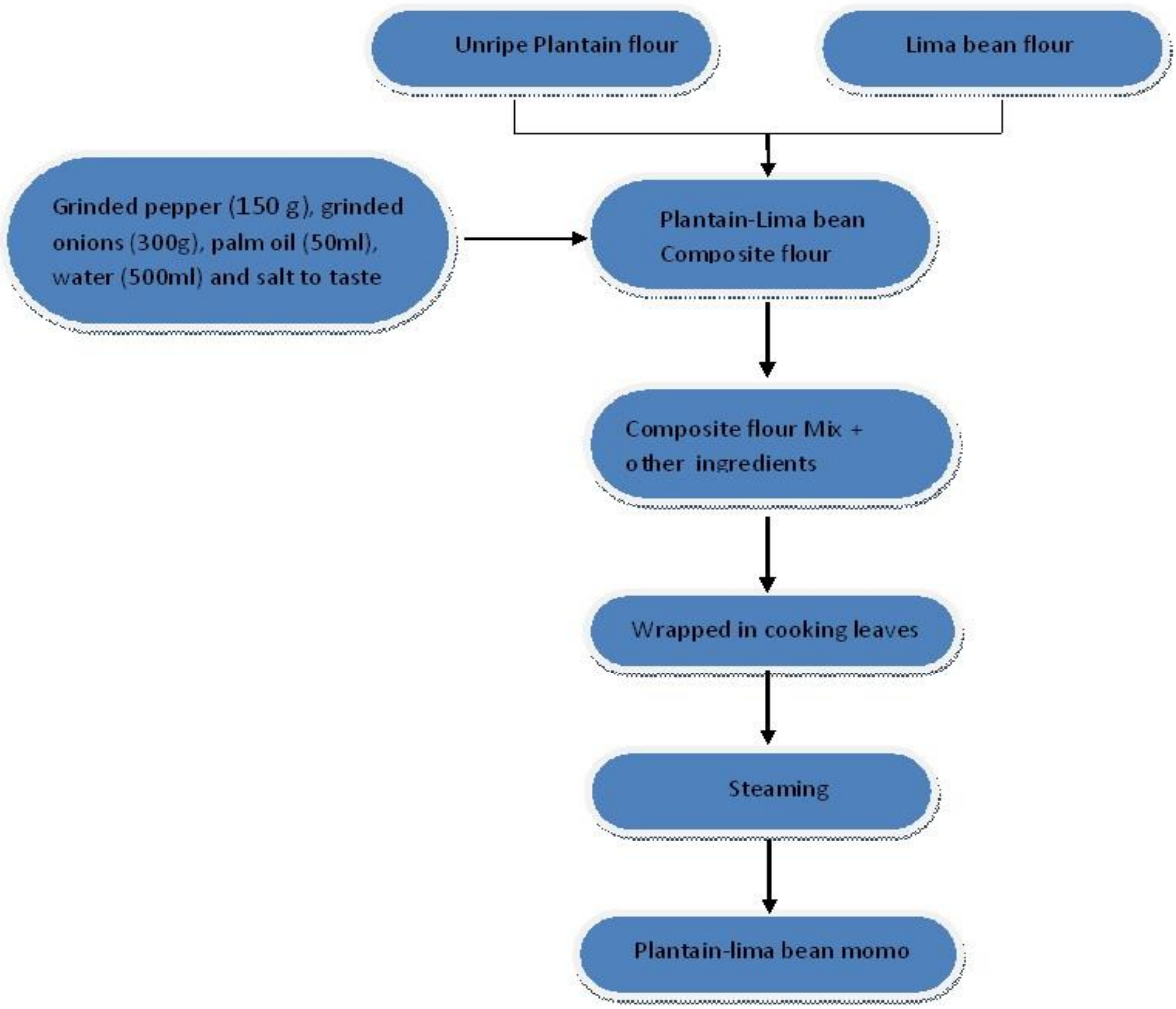

Figure 1. Flow chart showing processing of plantain-lima bean *Momo*

Sensory evaluation of plantain-lima momo

Sensory evaluation of the plantain-lima bean *momo* was carried out following the method described by Farinde et al. (2017). Plantain-lima bean *momo* was prepared fresh and coded. The coded samples were presented to twenty semi-trained panel of judges (Staff of Institute of Agricultural Research and Training, Ibadan, Nigeria). The judges were presented with water for mouth rinsing after each tasting and they were asked to score the samples for colour, appearance, flavour, texture, taste and overall acceptability using 9 point hedonic scale, where 9 represented the highest score and 1 represented the lowest score (Yangilar and Yildiz, 2017).

Statistical analysis

Sensory data obtained were subjected to descriptive and inferential statistics (ANOVA) using SPSS (version 20). Means were separated using Duncan Multiple Range Test. The significance was accepted at 5% level. Also, samples sensory attributes and assessors' responses were subjected to Principal Component Analysis and Agglomerative Hierarchical Clustering using XLSTAT, 2014.

Results and discussion

The result of the sensory score for the *momo* samples and the correlation between the samples and the sensory attributes are presented in Tables 2 and 3, respectively. There was no significant difference ($p > 0.05$) in the colour of PA, PB and PP, as shown in Table 2. Colour is an important quality of many foods and it influences the sense of judgment of consumers (Abata et al., 2019). The correlation matrix (Table 3) showed that PA, PB, PC and PP had positive correlation with colour showing values of 0.268, 0.255, 0.104 and 0.255, respectively. PD had weak negative correlation with colour (-0.074), while PE had the strongest negative correlation (-0.808). This indicates that addition of more than 30% of lima beans negatively affects the colour of plantain *momo*. Colour and appearance give the first attraction to foods by consumers (Abata et al., 2019). The score of appearance for PP (8.10) was significantly high, compared to that of the other *momo* samples. PE had the lowest score for appearance (Table 2). PP had the strongest positive correlation with appearance, followed by PA and PB with values of 0.472, 0.382 and 0.333, respectively. PA had the highest score (8.10) for flavour followed by PP (7.90) and the difference was significant ($p < 0.05$). The increase in addition of lima beans significantly decreased the score for flavour, as shown in Table 2. Table 3 also shows that PB, PC, PD and PE containing 20%, 30%, 40% and 50%, had negative correlation with the flavour. This showed that the addition of lima beans above 20% had significant effect ($p < 0.05$) on the production of beany flavour in plantain *momo*. The scores for texture of plantain *momo* decreased with the increase in addition of lima bean (Table 2). PA, PB and PP had positive correlation of 0.347, 0.553 and 0.347, respectively, while PC, PD and PE had negative correlation. There was no significant difference ($p > 0.05$) in the taste of PA, PB and PP (Table 1), although addition of 10% and 20% lima beans to plantain *momo* increased the score for taste in PA (8.00), PB (8.00) and PP (7.90). The increase in the concentration of lima bean from 20% to 30%, 40% and 50% significantly decreased ($p < 0.05$) the score for taste of the *momo* samples.

The result of the overall acceptability showed that PA is the most preferred out of all *momo* samples, because the score was significantly higher ($p < 0.05$) than other samples. The correlation matrix showed that PA, PB and PP had positive correlation of 0.648, 0.220 and 0.337, respectively, with overall acceptability, while PC, PD and PP had negative correlation. This indicated that addition of lima beans above 30% will negatively affect the quality of plantain *momo*. This agrees with the report of Chinma et al. (2012), who similarly reported that inclusion of defatted seseme seed up to 30% level to plantain flour for biscuit production had the most tolerable acceptability. However, all the *momo* samples were accepted organoleptically, as the scores for all the samples were above 5.

The principal component analysis (PCA) performed on plantain *momo* samples divided the sensory parameters into five factors with PC1 and PC2 accounting for 96.68% of the variance (Fig. 2). PA, PB and PP are represented on the positive axis of PC1, while PC and PD are represented on the negative axis of PCI and PE on the positive axis of PC2. The biplot showed the relationship between the samples and the observations. PA, PB and PP clustered with the colour, overall acceptability, taste, flavour and appearance, while PC, PD and PE clustered together without these sensory parameters. This shows that increase in the addition of lima bean above 30% generally had negative effect on colour, texture, flavour, appearance, taste and overall acceptability of plantain *momo*. Agglomerative hierarchical clustering (AHC) divided the samples into three classes based on Euclidian distance (Fig. 3). PA, PB and PP are in class one indicating similarities in the sensory properties (colour, flavour, taste, appearance, texture and overall acceptability).

Table 2. Sensory score for plantain-lima *momo*

	Colour	Appearance	Flavour	Texture	Taste	Overall Acceptability
PA	7.02±0.30^{c}	7.90±0.35 ^{cd}	8.10±0.32 ^{e}	7.60±0.25 ^{c}	8.00±0.30 ^{c}	8.90±0.45 ^{d}
PB	7.00±0.31^{c}	7.80±0.26 ^{c}	7.00±0.19 ^{d}	7.60±0.25 ^{c}	8.00±0.29 ^{c}	7.80±0.32 ^{c}
PC	6.77±0.31^{bc}	5.80±0.28 ^{a}	6.70c±0.33 ^{c}	5.90±0.52 ^{b}	6.00±0.38 ^{b}	6.40±0.38 ^{b}
PD	6.50±0.40 ^{b}	6.90±0.36 ^{b}	5.90±0.29 ^{b}	5.90±0.31 ^{b}	5.70±0.34 ^{ab}	6.20±0.39 ^{ab}
PE	5.39±0.48 ^{a}	5.97±0.21 ^{a}	5.30±0.31 ^{a}	5.45a±0.32 ^{a}	5.45±0.31 ^{a}	6.00±0.38 ^{a}
PP	7.00±0.31 ^{c}	8.10±0.29 ^{d}	7.90±0.30 ^{e}	8.10±0.33 ^{d}	7.90±0.38 ^{c}	8.10±0.31 ^{c}

Values are means of three replicates ± standard deviation. Means followed by the same superscript in the same column are not significantly different at 5% level.
KEY:
PA = 90% unripe plantain flour + 10% lima bean flour *momo*
PB = 80% unripe plantain flour + 20% lima bean flour *momo*
PC = 70% unripe plantain flour + 30% lima bean flour *momo*
PD = 60% unripe plantain flour + 40% lima bean flour *momo*
PE = 50% unripe plantain flour + 50% lima bean flour *momo*
PP = 100% unripe plantain flour *momo*

Table 3. Correlation between the samples and the sensory attributes

Variables	PA	PB	PC	PD	PE	PP	Colour	Appearance	Flavour	Texture	Taste	Overall Acceptability
PA	**1**	-0.2	-0.2	-0.2	-0.2	-0.2	0.268	0.38	0.552	0.347	0.438	0.648
PB	-0.2	**1**	-0.2	-0.2	-0.2	-0.2	0.255	0.333	0.079	0.347	0.438	0.22
PC	-0.2	-0.2	**1**	-0.2	-0.2	-0.2	0.104	-0.59	-0.052	-0.354	-0.318	-0.324
PD	-0.2	-0.2	-0.2	**1**	-0.2	-0.2	-0.074	-0.084	-0.393	-0.354	-0.431	-0.402
PE	-0.2	-0.2	-0.2	-0.2	**1**	-0.2	-0.808	-0.511	-0.651	-0.539	-0.526	-0.48
PP	-0.2	-0.2	-0.2	-0.2	-0.2	**1**	0.255	0.472	0.466	0.553	0.4	0.337
Colour	0.268	0.255	0.104	-0.074	-0.808	0.255	**1**	0.57	0.701	0.649	0.626	0.594
Appearance	0.38	0.333	-0.59	-0.084	-0.511	0.472	0.57	**1**	0.703	0.856	0.827	0.809
Flavour	0.552	0.079	-0.052	-0.393	-0.651	0.466	0.701	0.703	**1**	0.834	0.841	0.844
Texture	0.347	0.347	-0.354	-0.354	-0.539	0.553	0.649	0.856	0.834	**1**	0.902	0.837
Taste	0.438	0.438	-0.318	-0.431	-0.526	0.4	0.626	0.827	0.841	0.902	**1**	0.873
Overall Acceptability	0.648	0.22	-0.324	-0.402	-0.48	0.337	0.594	0.809	0.844	0.837	0.873	**1**

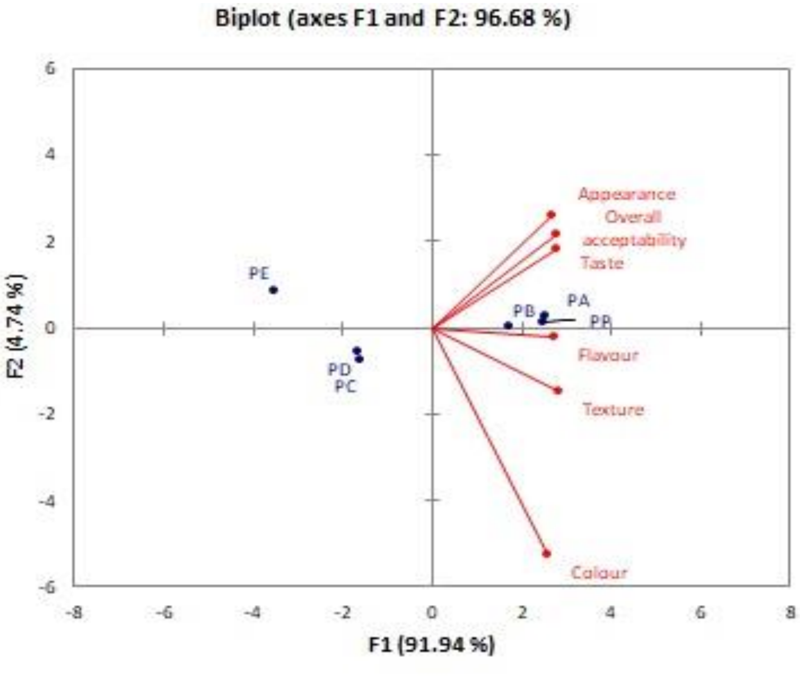

Figure 2. Biplot showing the relationship between the samples and the sensory attributes

This also showed that addition of 10% and 20% of lima beans to plantain flour compared well with the control (100% plantain flour *momo*) and did not have negative effect on the sensory characteristics. Kiin-Kabari and Giami (2015) similarly reported that consumers prefer 15% bambara groundnut protein concentrate inclusion in plantain flour for cookies and that the sample showed no significant difference with the control in all sensory attributes evauated. PC and PD were categorized in class two indicating that addition of 30% and 40% of lima beans slightly affected the sensory quality of plantain *momo*. PE was the only sample in class three indicating that the higher the concentration of lima beans, the lower the sensory quality and acceptability of the plantain momo. The results of the PCA and AHC showed that addition of 10% and 20% of lima beans either improved or had no negative effect on the sensory attributes of plantain *momo*. Thus, lima bean flour could be added to plantain flour up to 20% level for enhancement of its nutritional quality, while still retaining its organoleptic qualities.

The relationship between the responses of the assessors is presented in Fig. 4. The assessor number 4 had the highest variance in colour as it was represented in the inner eclipse, followed by the assessor number 15. There were similarities in the responses of other assessors as the responses clustered at the outer eclipse. The responses of all assessors were similar for appearance, but the response from the assessor number 16 was slightly different, even though it was represented on the same eclipse with other assessors. All assessors clustered at the outer eclipse showing similarities in responses on texture of momo with slight difference in the response of the assessor 15. All assessors had similar responses for flavour and taste of the momo samples; these two descriptors had the closest responses. The responses of all assessors also clustered at the outer eclipse, but there was a slight variation in the response of assessor number 4. This shows that the assessors accurately judge the colour, taste, flavour, texture and overall acceptability of the *momo* samples.

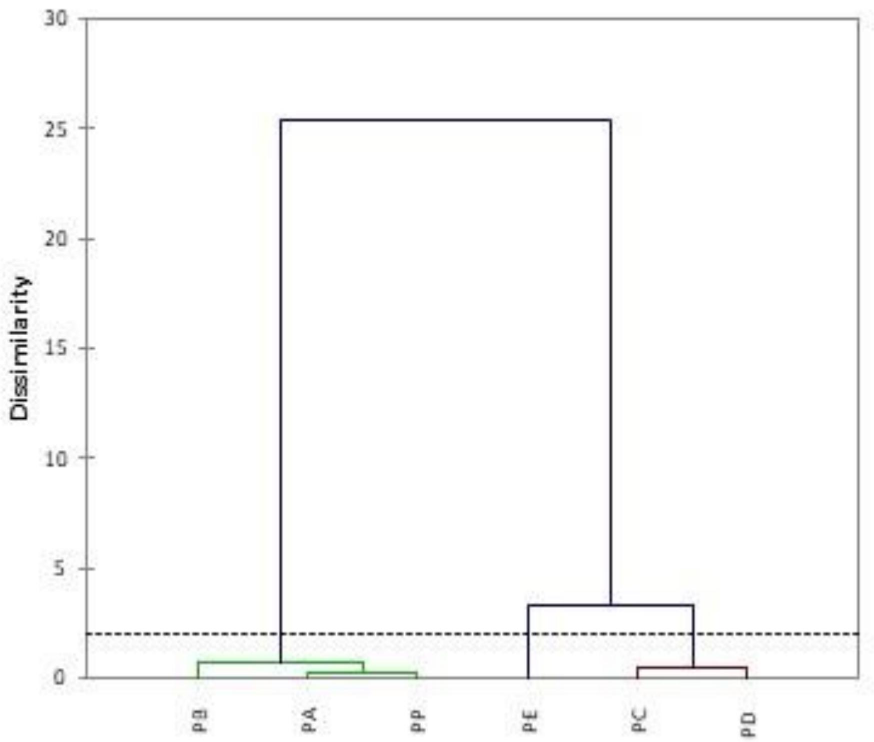

Figure 3. Agglomerative hierarchical clustering (AHC) grouping plantain-lima *momo* samples into different classes

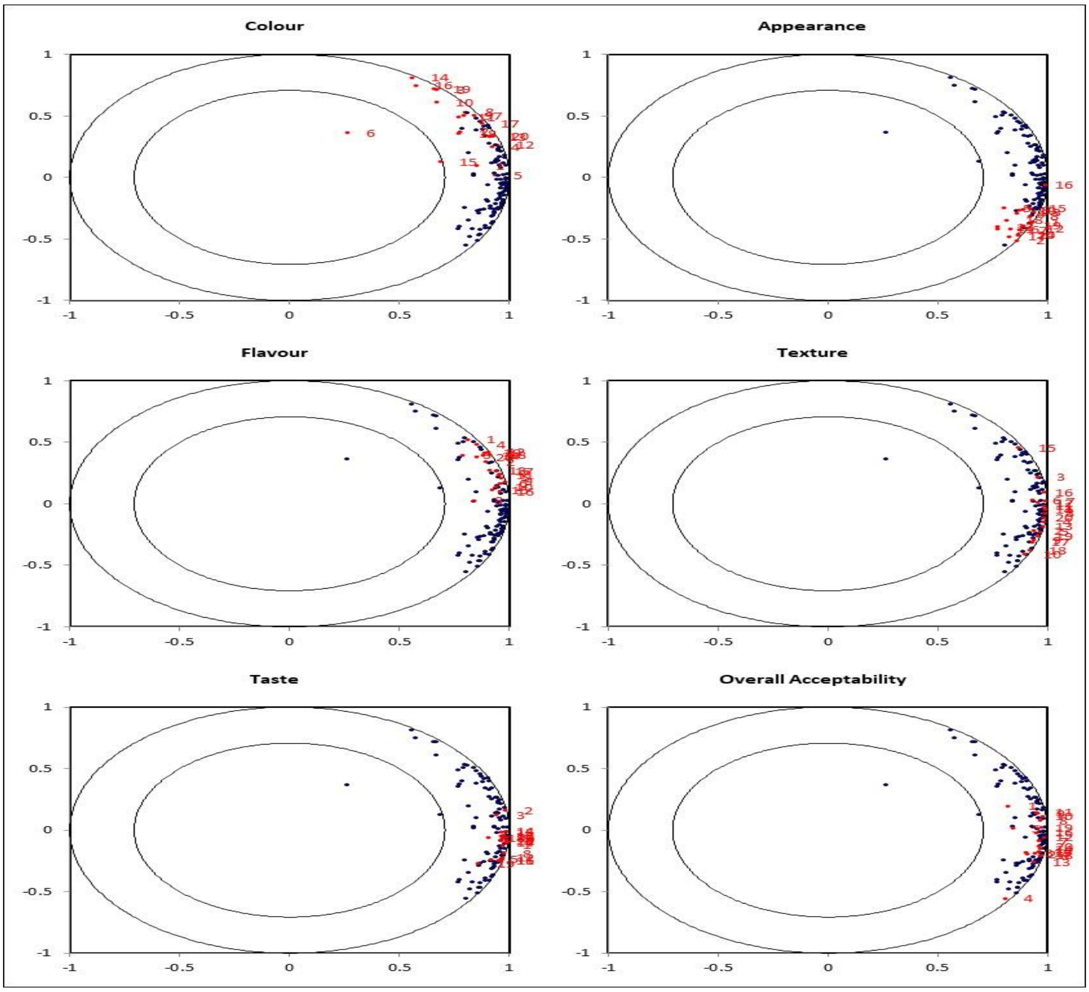

Figure 4. PCA correlation plot showing relationship between the responses of different assessors

Conclusions

Momo samples with 10% and 20% of lima bean inclusion and the control (100% plantain flour) had positive correlation with overall acceptability of the product. Principal component analysis (PCA) and Agglomerative hierarchical clustering (AHC) revealed that the addition of 10% and 20% lima bean inclusion to plantain flour compared well with the control (100% plantain flour *momo*) and did not have negative effects on the sensory characteristics of the *momo*. All the assessors accurately judged the colour, taste, flavour, texture and overall acceptability of the *momo* samples. Plantain-lima *momo* of good sensory qualities could be produced from plantain flour with 10% and 20% lima bean flour inclusion. *Momo* acceptability could promote lima bean utilization and enhance food security.

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Conflicts of Interest: The authors declare no conflict of Interest

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