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Research Paper

Influence of Moringa Leaf Powder on Acceptability of Extruded Sorghum - Cowpea Formulated Foods

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ABSTRACT
Box Benken design and sensory evaluation were used to assess the consumer acceptability of extruded samples. In the experiment, Sorghum flour was blended with cowpea flour CPF) and Moringa leaf powder (MLP) in varying proportions (15 to 25% CPF and 5 to 15% MLP). Extrusion cooking of the flour mixes was done in a double screw extruder at 110, 120, and 130^oC. The nine point hedonic scale was used to assess the consumer acceptability of the extrudates. Results showed that addition of MLP beyond 5% to the feed made the extrudates unacceptable to the panelists. The coefficients of determination (R^2) were 0.80 for colour, 0.98 for flavour, 0.99 for texture, 0.92 for taste and 0.96 for overall acceptability respectively. This implies that 80 to 99% of the variations in all sensory parameters could be explained by the second order model. The lack of fit for the model was also not statistically significant for flavour, texture, and overall acceptability.

KEYWORDS: *Moringa leaf powder, sorghum, acceptability, extrusion, cowpea.*

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I. INTRODUCTION

Sorghum has never been developed as a major food for urban areas.It is a crop consumed largely in the areas where it is produced. This need not continue because sorghum deserves the attention given to other basic food commodities; stockpiling, purchase of surpluses, price support, research and policy support (NAS, 1996).

Sorghum is reported to be next to rice and wheat, among the major staples of Indian diet, especially in the drier areas (Vogel and Graham, 1979). It is used as one of the staple foods of the people of Tanzania, Sudan, Kenya, Uganda, Zimbabwe and Nigeria. Nigeria has been the largest producer of sorghum and millets in Africa (Nkama *et al.*, 1998; FAO, 2004; 2008 and 2012) and second to Mexico the world over.

One particular constraint on sorghum consumption has been the lack of commercially processed foods – flour, meal, breads, or other materials for use by those who do not have enough time to make flour from the raw grain. The development of a sorghum – based food processing industry would do much to offset Africa’s shift in demand towards imported rice and wheat (NAS, 1996).

Annual production is increasing due to the introduction of improved varieties and breeding conditions. Several improved sorghum varieties adapted to semi-arid and tropical environments are released every year by sorghum breeders (Dicko *et al.*, 2006). Selection of varieties meeting specific local food and industrial requirements from this great biodiversity is of high importance for food security. In developing countries in general and particularly in West Africa, demand for sorghum is increasing. This is not only due to the growing population but also to the countries’ policies to enhance its processing and utilization (Akintayo and Sedgo, 2001). More than 7000 sorghum varieties have been identified (Kanguama and Rumel, 2005); therefore there is need for their further characterization to the molecular level with respect to food quality. The acquisition of good quality grains is fundamental to producing acceptable food products from sorghum. Sorghum is not only crucial in food security in Africa; it is also a source of income (Anglani, 1998).

Pushpamma *et al.* (1979) demonstrated in experiments with young children that sorghum has an acceptable protein digestibility and nitrogen retention in mixed diets containing legumes. These results indicate that sorghum contains potentially rich sources of carbohydrate and protein which can be utilized if proper supplementation with other protein sources is done.

Although a primary food for millions of Africans, and Latin Americans, sorghum is low in protein digestibility and also deficient in critical amino acids, most importantly lysine followed by threonine (NAS, 1996).

Cowpea is drought-tolerant forage and an edible pulse. The seeds can be eaten green or dried (Coulibaly *et al*., 2009). Davis *et al*. (1991) stated that cowpea seed is a nutritious component in the human diet, as well as a nutritious livestock feed. Nutrient composition of cowpea grain shows that it contains 24.8% protein 1.9% fat, 6.3% fibre, 63.6% carbohydrate 0.00074% thiamine, 0.00042% riboflavin and 0.00281% niacin (Davis *et al*., 1991). The protein in cowpea seed is rich in the amino acids, lysine and tryptophan; it is deficient in methionine and cysteine when compared to animal proteins. This is the reason cowpea seed is valued as a nutritional supplement to cereals such as sorghum. Dry mature grains are also suitable for cooking and canning. In Nigeria the beans are either eaten as boiled beans or consumed in other forms such as moin-moin, akara or kosai, and danwake.

Extrusion processing has become increasingly popular in the cereal, snack and pet food industries, which utilize starchy and proteinacious raw materials. It exhibits several advantages, the principal one being that the ingredients undergo a number of unit operations, e.g. mixing, shearing, shaping, cooking, drying and texturization, in an energy efficient and rapid process (Stanley, 1986). Usually the food is compressed and worked to form a semi-solid mass. This is forced through a restricted opening (the die) at the discharge end of the screw. The main purpose of extrusion is to increase variety of foods in the diet by producing a range of products with different shapes, textures, colours, and flavours from basic ingredients (Lewis, 1987).

Extrusion is a variant of the flaking process. The moistened and half cooked grains are squeezed out through small holes. This is how noodles and pastas of all kinds are prepared. It improves water absorption and cooking quality. Noodle-like products can probably be made from all the other grains. The pearled grains are first soaked for a day or two then drained, mashed, cooked, extruded and dried, (FAO, 1995).

Extrusion cooking destroys antinutritional factors that are present or may be inactivated. Microorganisms are largely destroyed and the product shelf-life is extended (Riaz, 2007). The products are easily fortified with additives (FAO, 1995). Unlike the most conventional processing techniques, extrusion cooking combines a number of unit operations to completely transform the food material (Cheftel, 1986).

In Africa, due to deforestation by utilization of wood for fuel, there is great need for pre-cooked foods. High temperature short time (HTST) extrusion cooking could be used to produce sorghum-based foods of high nutritional quality and in a ready-to-eat form. Research works abound on the extrusion cooking of cereal-legume composites (1978, Pelembe *et al*., 2002, Filli *et al*., 2012, Gbenyi et al., 2016).

M. oleifera leaves have been used as an alternative food source to combat malnutrition; especially among children and infants (Anwar *et al*., 2007). The leaves contain 19 to 29% protein, 16 to 24% fibre, substantial amounts of vitamin A, C and E (Hekmat, *et al*., 2015). They are agood source of total phenols, calcium, potassium, magnesium, iron, manganese and copper. (Hekmat, *et al*., 2015). It is also sufficient in phytochemical such as carotenoids, tocopherols, and ascorbic acid (Saini *et al*., 2014b and 2014d) which are known to scavenge free radicals when combined with a balanced diet. The intent of this work was to assess the effect of supplementation of sorghum-cowpea extrudates with *Moringa oleifera* leaf powder on the consumer acceptability of the product.

II. MATERIALS AND METHODS

2.1 Procurement of raw materials

The red sorghum variety (Chakalarired),cowpea (var kananede) and fresh Moringa leaves were obtained from Mubi main market, Adamawa State.

2.2 Preparation of sorghum flour

Sorghum grains were cleaned using a laboratory aspirator (Vegvari Ferenc Type OB125, Hungary) to remove stalks, chaff, leaves and other foreign matter. They were then washed with clean water and sun dried. This was then dehulled using a commercial rice dehuller (Konching 1115, China) and milled using an attrition mill (Imex GX 160, Japan). The flour was packed in polythene bags and stored for further use.

2.3 Preparation of cowpea flour

Cowpea was steeped for 10 min to loosen the seed coat. The kernels were then lightly crushed in a mortar with pestle. The seed coat was washed off in excess water. The beans were dried in a Chirana convection air oven (Model: HS 201A, Hungary) to 12% moisture content and milled (Imex GX 160, Japan) into flour before packing in polythene bags for further use (Filli *et al*., 2010).

2.4 Preparation of Moringa leaf powder

Fresh leavesof*Moringa oleifera*purchased from Mubi market was dried and processed into powder in the Department of Food Science Technology laboratory, Federal Polytechnic Mubi. The Moringa Leaf Powder (MLP) obtained was packaged in polythene bags for further use (Rweyemamu, Yusuph and Mrema, 2015).

2.5 Experimental design

The feed was made up of blends of sorghum cowpea and Moringa leaf powder(MLP) in the ratios shownin Table 1. The levels of the various independent variables were arrived at after preliminary extrusion runs and as well as available information from literature. The Box Benken Design used in this work was produced using MINITAB 14 (2003) statistical software. Table 2presents the Box Benken design matrix and the independent variables in their natural forms.

Table 1: Process variables and their levels used in the Box Benkendesign

Variable	Code	-1	0	+1
Cowpea flour (%)	X_1	15	20	25
Moringa leaf powder (%)	X_2	5	10	15
Extrusion temp. (^oC)	X_3	110	120	130

Table 2: Experimental runs used in the extrusion process.

Runs	Cowpea flour	MLP	Barrel temp.
1.	15	5	120
2.	15	15	120
3.	25	5	120
4.	25	15	120
5.	20	5	110
6.	20	15	110
7.	20	5	130
8.	20	15	130
9.	15	10	110
10.	25	10	110
11.	15	10	130
12.	25	10	130
13.	20	10	120
14.	20	10	120
15.	20	10	120

2.6 Blending of sorghum flour with cowpea and Moringa flours and moisture adjustment

Sorghum flour was blended with cowpea and Moringa leaf powder(MLP) in varying proportions (15 to 25% cowpea flour and 5 to 15% MLP). The total moisture content of samples was adjusted to the desired level according to Zasypkin and Tung- Ching (1998).

2.7 The extrusion process

Extrusion cooking of sorghum-cowpea-Moringa leaf powderwas done in a double screw extruder. The diameter of the die used was4mm. The extruder was fed manually using a plastic bowl through a screw operated conical hopper. The hopper which is mounted vertically above the end of the extruder is equipped with a screw which rotates at constant speed and conveys the feed into the extruder. Extrudates resulting from the process were kept on stainless steel work benches overnight to dry. They were then packaged in polythene bags prior to analysis. The independent variables and the experimental runs are shown in Tables 1 and 2.

2.8 Sensory evaluation

The nine point Hedonic scale (Lim, 2011) was used to determine the degree of acceptability of the extrudate samples by panelists drawn from the Department of Food Science Technology, Federal Polytechnic Mubi.

2.9 Statistical analysis

The data collated from the experiments was fitted to a second-order multiple regression analysis by employing the least square technique (Jideani and Onwubali, 2009, Annor *et al*., 2009 and Gacula and Singh, 1984). MINITAB Version 14 (2003) Statistical Analysis Software was used in the analysis of data. Analysis of variance (ANOVA) was used to establish statistical significance. The generalized second order model equation was used in the regression analysis of the data thus:

$$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}(X_1)^2 + b_{22}(X_2)^2 + b_{33}(X_3)^2 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + \varepsilon.$$

Where:

Y = response variable
X_1 = cowpea flour
X_2 = Moringa leaf flour
X_3 = barrel temperature
b_o = intercept
b_1, b_2 and b_3 = linear regression terms
b_{11}, b_{22} and b_{33} = quadratic regression terms
b_{12}, b_{13} and b_{23} = cross-product regression terms
ε = error term

Multiple regression analysis and analysis of variance were used to assess the adequacy of the second-order model equation and in predicting the effects of the independent variables on the product characteristics.

III. RESULTS

3.1 Effect of feed blends on acceptability of the extrudates

Results of sensory evaluation of sorghum-cowpea extrudates are presented in Table 3. Sensory evaluation is the scientific measurement of food product properties as are perceived through the five human senses of sight, smell, taste, touch, and hearing (Oliveira, 2011). Sensory evaluation is used to evaluate quality, improve quality, provide inputs for decision making in product development, ingredient substitution in product formulation, determine storage conditions and compare products with those of competitors (Oliveira, 2011).

Colour is one of the most important attributes used to determine the acceptability of foods. This is because no matter how nutritious, flavoured or well textured a food is, it is unlikely to be accepted unless it has the right colour and appearance (Serna-Sardivar *et al*., 1990). The colour of the sorghum-cowpea -MLP extrudates varied from 1.5 to8.0. The lowest value for the colour preference was located at Run 6 (25: 15: 120) while the highest value was found at Run 7 (20: 5: 130). The colour of extrudates increased as the amount of MLP in the composite flour increased. Samples with less MLP had less colour intensity and were more acceptable to the panellists.Addition of MLP beyond 5% in the feed caused rejection of the products by the panellists(Govender and Siweh, 2020, Sengev, Abu and Gernah, 2013). Such extrudates were rated 1.5 (dislike very much) to 5.75(like slightly).

The flavour of the sorghum-cowpea-MLP extrudates varied from 3.4 to 7.0. The lowest value for flavour preference was located at Run 4 (25: 15.5: 120) while the highest value was found at Run 7 (20: 5: 130). The rating of flavour of the extrudates was negatively affected by increase in MLP in the feed. Samples with up to 15% MLP were rated as low as 3.4 (dislike moderately) while those with 5% MLP were rated 7.0 (like moderately). The results for taste ranged from 3.25 to 7.25. The most preferred sample for taste was rated 7.25 (like very much) with blend ratio of (25:5:120).The least preferred sample in terms of texture was rated 2.4(dislike very much) while the most preferred sample was rated 7.5 (like very much). The overall acceptability rating of the sorghum-cowpea MLP extrudates ranged from 1.5(dislike very much) to 7.75 (like very much). The lowest value was recorded at Run 6 (20:15:110) while the highest value was at Run 7 (20:5:130).

Table 3. Results of sensory evaluation of extrudates

Runs	CPF:MLF:BT	Flavor	Color	Taste	Texture	Ovaccept.
1.	15: 5 :120	6.2	2.2	5.3	6.6	6.7

2.	15: 15:120	3.6	2	3.25	2.4	2.5
3.	25: 5 :120	7	7.25	7.25	7.2	7.25
4.	25: 15:120	3.4	2.75	4	2.4	3.5
5.	20: 5 :110	7.0	6.75	7	7.2	6.5
6.	20: 15:110	3.6	1.5	3.5	2.6	1.5
7.	20: 5 :130	7	8	8.25	7.5	7.75
8.	20: 15:130	4.3	2.6	3.6	3.3	2.6
9.	15: 10:110	5.5	3.9	4.6	5.6	4.8
10.	25: 10:110	5.4	3.7	5.5	4.8	4.25
11.	15: 10:130	5.4	7	7.25	6.4	6.5
12.	25: 10:130	5.8	5.75	5.75	6.6	5.5
13.	20: 10:120	4.2	5.4	5.4	6.1	5.4
14.	20: 10:120	4.6	4.8	5.6	6.4	5.6
15.	20: 10:120	5.1	5.2	5.5	6.5	5.8

CPF = Cowpea flour (%), MLP = Moringa leaf powder (%), BT = barrel temperature (^{o}C

3.2 Regression equations for sensory attributes of sorghum-cowpea extrudates

The regression models for colour, flavour, texture and overall acceptability of sorghum-cowpea-MLP extrudates are presented in Table 4. In the models, X_1, X_2 and X_3 are the independent variables; that is cowpea flour (CPF), Moringa leaf powder (MLP) and barrel temperature (BT) respectively. The equations were used to generate the coefficients for the dependent variables of colour, flavour, taste, texture and overall acceptability. The regression equations for sensory evaluation of sorghum-cowpea-MLPextrudates are presented below:

Colour = $40.263 + 2.135X_1 + 1.35X_2 -1.134X_3 - 0.024X_1^2 - 0.039X_2^2 + 0.006X_3^2 - 0.043X_1X_2 – 0.005X_1X_3 - 0.001X_2X_3$ ($R^2 = 0.80$)…………………(2)

Flavour = $113.225 - 0.551X_1 – 0.674X_2 - 1.653X_3 + 0.009X_1^2 + 0.007X_2^2 + 0.007X_3^2 - 0.01X_1X_2 + 0.0027X_1X_3 + 0.003X_2X_3$($R^2 = 0.98$)……………...(3)

Taste= $24.663 + 1.903X_1 – 0.889X_2 – 0.744X_3 - 0.007X_1^2 - 0.015X_2^2 + 0.005X_3^2 - 0.012X_1X_2 - 0.0012X_1X_3 - 0.006X_2X_3$($R^2 = 0.98$)……………….(4)

Texture = $7.150 + 0.247X_1 + 0.388X_2 – 0.950X_3 - 0.197X_1^2 - 0.048X_2^2 - 0.006X_1X_2 + 0.005X_1X_3 + 0.002X_2X_3$($R^2 = 0.98$)………………………………(5)

Ovaccept. = $-58.400 + 0.175X_1 + 0.063X_2 + 1.004X_3 + 0.001X_1^2 - 0.026X_2^2 - 0.004X_3^2 - 0.005X_1X_2 – 0.002X_1X_3 + 0.001X_2X_3$ ($R^2 = 0.96$)…………………..(6)

3.3 Effect of extrusion conditions on the sensory parameters of sorghum-cowpea-MLP extrudates.

The effects of cowpea flour, MLP and extrusion temperature on the flavour, colour, taste, texture and overall acceptability of sorghum-cowpea-MLP extrudates are presented in Table 4. The coefficients of determination (R^2) were 0.80 for colour, 0.98 for flavour, 0.99 for texture, 0.92 for taste and 0.96 for overall acceptability respectively. This implies that 80 to 99% of the variations in all sensory parameters could beadequately explained by the second order model. The lack of fit for the model was also not statistically significant for flavour, texture, and overall acceptability. This implies the second-order model significantly ($p \leq 0.05$) described the flavour, texture, and overall acceptability of the extrudates. The flavour of the extrudates was significantly ($p<0.05$) influenced by the linear and quadratic effects of barrel temperature. The texture of the extrudates was significantly affected by the quadratic effects of cowpea flour and MLP. The overall acceptability of the extrudates was negatively influenced by the quadratic effects of MLP, BT interaction effects of MLP and BT. The second-order model was therefore used to predict the colour, flavour, and overall acceptability of extrudates.

One important objective of sensory evaluation is to determine the particular characteristics of a product that leads to higher level of acceptance. Knowledge of the relationship between a process and the sensory description provides an important link between product development and eventual acceptance. The products were not generally acceptable to the taste panel as evidenced from the overall acceptability of the extrudates probably because of the colour intensity of the MLP.

Table 4. Regression coefficients for sensory evaluation of sorghum-cowpea extrudates fortified with Moringa leaf flour (MLF).

Coefficients	Colour	Flavour	Taste	Texture	Ovaccept
Linear					
b_0	40.263	113.225**	24.663	7.150	-58.400
b_1	2.135	-0.551	1.903	0.247	0.175
b_2	1.350	-0.674	0.889	0.388	0.063
b_3	-1.134	-1.653**	-0.744	-0,950	1.004
Quadratic					
b_{11}	-0.024	0.009	-0.007	-0.197*	0.001

b_{22}	-0.039	0.007	-0.015	-0.048**	-0.026
b_{33}	0.006	0.007**	0.005	0.000	-0.004
Interaction					
b_{12}	-0.043	-0.010	-0.012	-0.006	0.005
b_{13}	-0.005	0.002	-0.012	0.005	-0.002
b_{23}	-0.001	0.003	-0.006	0.002	-0.001
R^2	0.804	0.980	0.915	0.988	0.960
Adjusted R^2	0.452	0.944	0.762	0.966	0.888
Lack of fit	S	NS	S	NS	NS

$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}(X_1)^2 + b_{22}(X_2)^2 + b_{33}(X_3)^2 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + \varepsilon$.
X_1 = cowpea flour, X_2 = Moringa leaf powder, X_3 = Barrel temperature
*significant at $p \leq 0.05$, and **$p \leq 0.01$ respectively, NS = not significant, S = significant.

3.4 Response surface plots for the flavour of extrudate samples

The effect of CPF, MLPand BT on flavour of extrudates is shown in Figure 1**.** The response surface plots show that increasing MLP in the feed had a negative effect on the acceptability of flavour of the extrudates(Govender and Siweh, 2020, Sengev, Abu and Gernah, 2013). Cowpea flour and barrel temperature did not show any significant effect on flavour as can be seen in Figure 1.
The colour intensity of the extrudates increased with increase in MLP in the feed (Fig. 2). Increase in the colour intensity of the extrudates however decreased the acceptability of the samples in with respect to colour and taste (Fig. 3) by the panelists. Cowpea flour and BT did not show and appreciable effect on the colour and taste of the samples.
Figure 4 shows the response surface plot for texture of the extrudates.Increase in MLP in the feed caused a corresponding decrease in acceptability of the texture of the etrudates. Increasing barrel temperature showed a slight correspond acceptability of the texture of extrudates.
The response surface plot for the overall acceptability of the extrudate samples is presented in Figure 5. Increasing the MLP with extrusion temperature progressively produced a decline in the overall acceptability of the extrudates (Govender and Siweh, 2020).

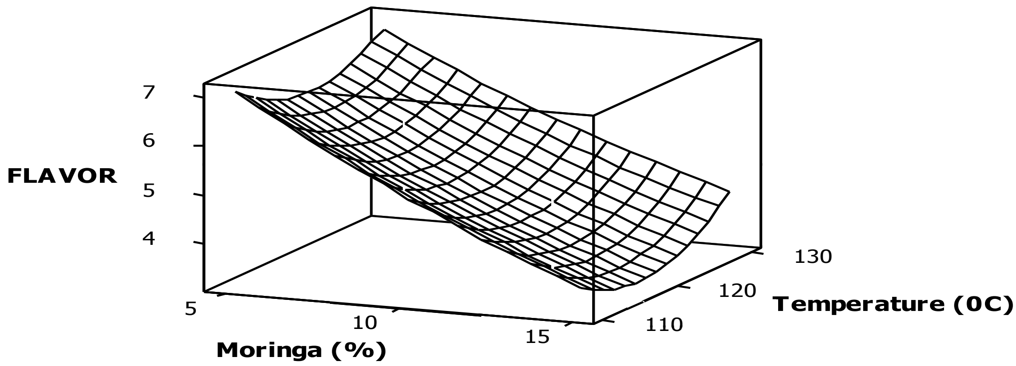

Fig.1. Response surface plot of flavor against MLP and barrel temperature

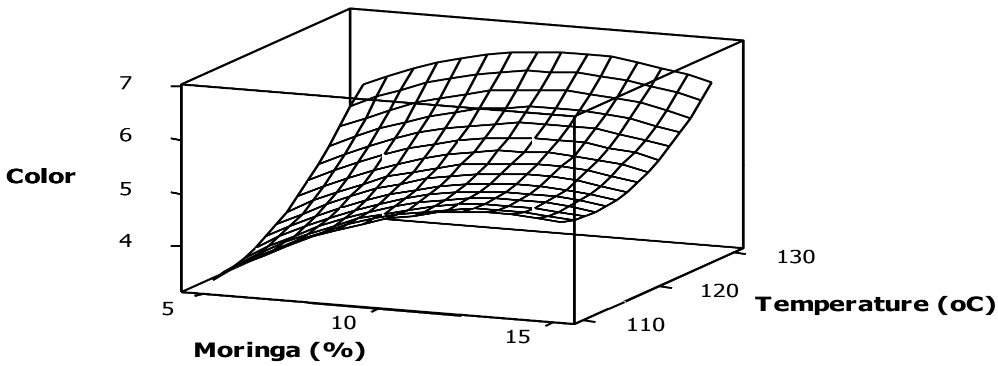

Fig. 2. Response surface plot of color against MLP and barrel temperature

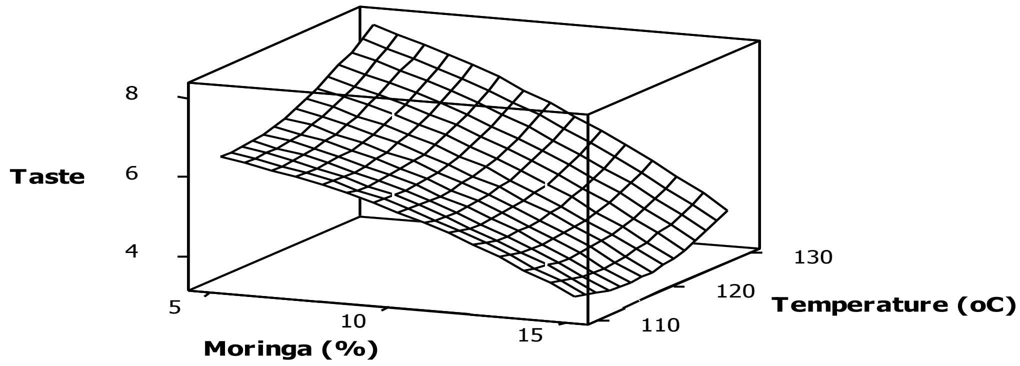

Fig. 3. Response surface plot of taste against MLP and barrel temperature

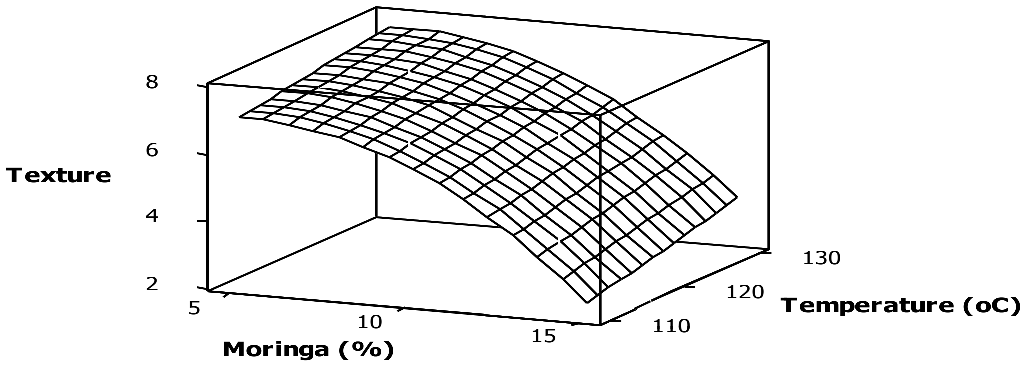

Fig. 4. Response surface plot of texture against MLP and barrel temperature

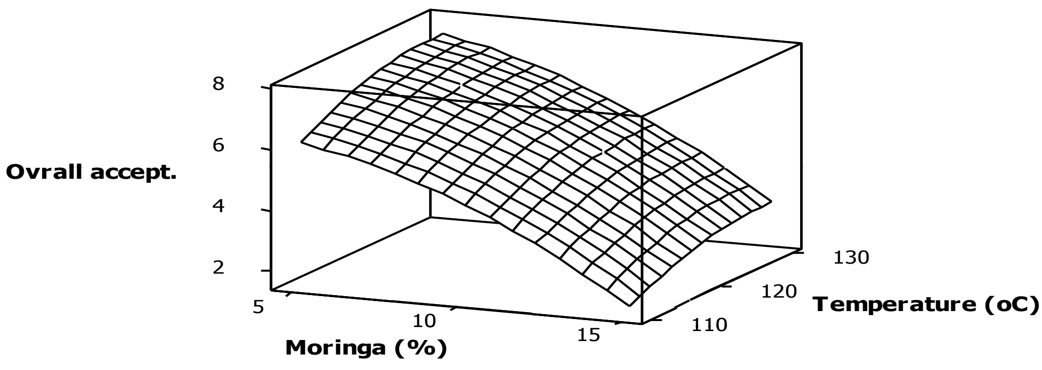

Fig. 5. Response surface plot of overall acceptability against MLP and barrel temperature

IV. CONCLUSION

Results of this work show that addition of MLP beyond 5% to the feed made the extrudates unacceptable to the panelists. The coefficients of determination (R^2) were 0.80 for colour, 0.98 for flavour, 0.99 for texture, 0.92 for taste and 0.96 for overall acceptability respectively. This implies that 80 to 99% of the variations in all sensory parameters could be adequately explained by the second order model. The lack of fit for the model was also not statistically significant for flavour, texture, and overall acceptability.

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