Evaluation and Optimization of Micronutrients, Functional Properties and Sensory Qualities of Complementary Food from Sorghum-*Telfaria Occidentalis* Blends.

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Abstract
The study evaluated the effects of *Telfaria occidentalis* incorporation and baking temperatures on the micronutrient properties, functional and sensory properties of sorghum based complementary food. The effects of process variables on the quality of complementary food, optimization of the process variables and responses were investigated using Response Surface Methods (RSM). A two factor central composite rotatable design resulting to nine experimental runs was adopted for the study. Independent variables considered were feed composition, X_1 (15 - 35%) and baking temperature X_2 (120 – 160 ºC) while functional properties, micronutrients, vitamins and sensory properties were the responses. A quadratic polynomial regression model ($Y = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_{11}X_1^2 + \beta_{22}X_2^{2} + \beta_{12} X_1X_2 + \varepsilon$) was used for predicting product responses. The models were significant ($p<0.05$) for all responses investigated, lack of fit was non significant, adequate precision was >4 and high coefficients of determination (R^2) was observed. Result showed that micronutrients; Zinc content ranged from 0.08- 0.39 mg/100g, Potassium 1.17- 4.09 mg/100g, Vitamins ranged from; thiamine 1.2- 2.1 mg/100g, vitamin C 1.3- 2.6 mg/100g. Functional properties ranged from; viscosity 2000- 4800 cP, bulk density 0.27- 0.59 g/m^3, water absorption capacity 88.90- 170.80 % and pH 5.2- 6.8. The complementary foods had average scores in all the sensory attributes tested and sample 5 containing 10.85% *Telfaria occidentalis* flour and baked at 140 ºC had the highest overall acceptability score (6.6). The optimal process condition for was 35 % feed composition and 120 ºC baking temperature. The optimal responses were 2.0 mg/100 vitamin B_1, 2.3 mg/100 vitamin C, 0.4 mg/100 Zinc, 0.4 mg/100 Potassium, 0.29 g/m^3 bulk density, 2276.5 cP viscosity, 175.4 % WAC, 6.9 color, 6.07 taste, 6.7 texture, 5.7 aftertaste, 5.8 mouth feel, and 6.25 overall acceptability. The desirability values for the responses were high and ranged from 0.60 to 0.90.

1.0 Introduction

Adequate nutrition during infancy and childhood is fundamental to the development of a child. Infancy period (0 - 2 years) is a "critical window" for promotion of optimal growth, health and behavioral development (Onoja *et al*., 2014).

Complementary foods, also known as 'weaning foods' or 'baby foods', facilitate the transition from a liquid diet based on breast milk and/or infant formula, to one which includes solid foods (PAHO/WHO, 2003). Legumes and cereals are the main source of nutrients for traditional complementary foods in developing countries (Chavan and Kadam, 1989). The major cereals such as sorghum, rice, wheat and maize constitute about 85% of total global cereals production amounting to about 200 million tones of harvest annually at average of

10% protein content, out of which a sizeable proportion goes into human consumption (Sofi *et al.*, 2009). The gruel is too watery (liquid gruel) and thus have a low energy density or too bulky (thick porridge), which cannot be consumed in sufficient quantity by infants (Svanberg, 1987). Globally, more than one billion people are undernourished and in Africa there are more than 70 million undernourished children due to poverty and shortage of food (Serrem, 2010). This vulnerable population survives mainly on starchy staple cereal food such as maize, wheat, rice, sorghum and millet with few or no meat and dairy products (Mayer *et al.*, 2008).

Cereals and legumes are also rich in micronutrients; however, the availability of those nutrients is usually low due to the presence of antinutritional factors such as phytic acid and tannins. Fermentation and soaking are simple traditional processing treatments that decrease the level of antinutrients in cereals and legumes and increase the nutrients content of diet by increasing the content of minerals, vitamins, amino acids and others (Nadeem *et al.*, 2010).
Consumption of cereal based food products formulated from sorghum is very common and popular in Nigeria and is produced in significant quantities in the country annually. Sorghum (*Sorghum bicolor*) is an important starchy staple in many parts of Africa particularly, Nigeria. It has protein level of about 9%, enabling dependent human population to subsist on it in times of famine (FAO/WHO, 2001). Sorghum is an important source of vitamin B-complex and some other minerals like phosphorous, magnesium, calcium and iron. However, cereals are generally low in protein and are deficient in the essential amino acids lysine and tryptophan. Like every other cereal, it is ideal to combine them with legume as this will improve their nutritive value.

Legumes are common sources of protein because of their very high protein content (>20g protein/100g dry matter), dietary fiber, variety of micronutrients and phytochemicals and are able to fixate nitrogen (Messina, 1999). Incorporation of oilseeds such as *Telfairia occidentalis* seed flour to cereals may improve the protein content, functionality and other nutrient of complementary food and also help solve the problem of protein-energy malnutrition. *Telfaria occidentalis*, a tropical crop, a drought-tolerant, recalcitrant seed, dioecious perennial crop and belongs to the family of Cucurbitaceae known for its great genetic diversity and widespread adaptation (Bello *et al.*, 2011) are grown for its vegetable and oil-bearing seeds (Ehiagbonare, 2008). *T. occidentalis* seeds serve as a good source of fat, protein and with other nutritional properties and chemical composition easily obtained when locally processed.

Malnutrition in children is a major nutritional problem in African developing countries which leads to morbidity and mortality, retardation in physical growth and mental development, working capacity and increased risk of adult disease (Michaelsen *et al.,* 2009). This nutrition problem is due to the low nutritional value of traditional complementary foods, inappropriate complementary feeding practices and high cost of quality protein-based complementary foods.

Product and process optimization can be achieved using Response surface methodology (RSM), a basic principle used to relate product properties (micronutrients, functional, nutritional and sensory) to process variables (raw materials, feed composition, operating variables among others). This is done by means of regression equations that describe inter-relations between input parameters and product properties; using a statistically designed multi-factor experiment for economy of experimental points (Iwe, 2002).

The aim of this study was to produce, evaluate and optimize micronutrients, functional properties and sensory attributes of complementary foods from sorghum- *telfaria occidentalis* seed blends.

2.0 Materials and methods

Source of raw materials

Sorghum (*Sorghum bicolor* L. Moench) and matured *Telfairia occidentalis* seeds were sourced from Ogige Market in Enugu State, Nigeria.

Sorghum flour processing

Seed grains were sorted and cleaned manually to remove broken seeds, dust and other extraneous materials. The seeds were dehulled after mild wetting using the rice duhuller for grains at Food Science and Technology Department. After dehulling, grains were washed and the remaining hulls floated off, then oven dried for 6 hours to 10 % moisture content. Dried seeds were milled to flour in a locally fabricated attrition mill and were milled thrice in order to obtain fine flour. The flour was passed through a 150 µm pore sized sieve and stored in airtight plastic container at room temperature prior to use (Eze, 2015).

Telfairia occidentalis flour / paste processing

Telfaria occidentalis seeds were processed by the modified method of Fagbemi *et al.*, (2005), *s*eeds surrounded by pulp were cut into smaller sizes piled on a sack bag, covered with leaves and left for 6 - 8 days, with continuous turning to ensure even fermentation. The fermented seeds were sundried for 3 - 5 days and roasted in an open cast iron at temperature of 210 °C for 30 minutes. The roasted seeds were thoroughly winnowed to remove the seeds coats and milled. The paste was stored in airtight plastic container at cooling temperature in refrigerator until it was needed.

Experimental design and data analysis

A two factor central composite design (CCD) by Box and Hunter, (1957) were adopted to study the interactive effects of feed composition (X_1) (*T. occidentalis* incorporation) and baking temperature (X_2) on the micronutrients, functional properties, and sensory attributes of the complementary food on rotatable design $2^2 = 4$. The centre points were replicated up to 5 times as desired but one point was chosen leading to total design points / runs/ trials, M = 4 + 4 + 1 = 9 . All treatments were performed in a randomized order and two factors considered were feed composition (X_1) and baking Temperature (X_2). The details of the experiments are given in Table 1 and 2. Baking temperature, feed composition and product responses were optimized by keeping process variables within range while, the responses were set to desired goals using second degree polynomial equation.

$$Y = f(y) = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X_i^2 + \sum_{i=1}^{k} \quad \sum_{i=1}^{k} \beta_{ij} X_i X_j + \varepsilon$$

(Shahidi and Wanasundara, 1996).

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2 + \varepsilon$$

Where Y = Objective response, X_1 = Feed composition, X_2 = baking temperature, β = polynomial coefficient and ε = random error in which the linear, quadratic and interaction effects were involved.

For each response, 3D surface plots were produced from the fitted quadratic equations i.e. after removal of the non-significant terms, using computer statistical software - STATEASE, Design expert 12.0, by holding the variable with the least effect on the response equal to a constant value and changing the other variable.

Table 1: Independent variables and levels used for central composite design

Variables	Coded variables				
	-α	Low	Medium	High	+α
	-1.41	-1	0	1	1.41
Feed composition % (X_1)	10.85	15	25	35	39.14
Baking temperature ^{0}C (X_2)	111.72	120	140	160	168.2

Table 2: Experimental design for complementary food in their coded forms and natural units

Run	Coded form		Natural form	
	X_1	X_2	X_1 (%)	X_2 (^{0}C)
1	-1	-1	15.00	120
2	+1	-1	35.00	120
3	-1	+1	15.00	160
4	+1	+1	35.00	160
5	-1.41	0	10.85	140
6	+1.41	0	39.14	140
7	0	-1.41	25	111.72
8	0	+1.41	25	168.28
9	0	0	25	140

-1 = Lowest value, +1=Highest value, 0=Medium value, -1= -α, +1 = +α. feed composition = X_1 and baking temperature = X_2. Each design point was run in triplicates and the average recorded. The experimental runs were randomized

Analytical methods

Determination of iron, calcuim, zinc and potassium

Iron, Calcium, Zinc and Potassium were determined using AAS as described by AOAC (2010).

Determination of vitamins B_1 (Thiamine) and C

Thiamine and Riboflavin content was determined according to the method of Onwuka, (2005), Vitamin C was determined according to the method of Olokodona, (2005) while Beta carotene was determined according to the method described by Pearson, (1976).

Evaluation of some functional properties (water absorption, viscosity and bulk density)

Water absorption capacity (WAC) was determined using the method of Lin *et al.* (1974), viscosity was determined using an Ametek Brook field Viscometer as described by Sathe and Salunkhe, (1981) while bulk density was determined by the method described by Onwuka, (2005).

Sensory evaluation

The complementary food samples from sorghum-*Telfaria occidentalis* blends were evaluated for color, taste, texture, aftertaste, mouth feel and overall acceptability. Twenty panelists consisting of women of child bearing age who are acquainted with complementary food were recruited. A 9-point Hedonic scale, where 9 (like extremely) was the highest and I (dislike extremely) was the lowest score as described by Ihekoronye and Ngoddy (1985), was employed for evaluating the degree of likeness of the complementary food samples. The gruels were presented in coded plates after reconstituting 18g each with 100 ml of warm water. Water was served after each tasting for mouth rinsing and to reduce biased judgment from the panelists.

3.0 Results and Discussion

Micronutrient content of the complementary food samples

Effect of feed composition and baking temperature on the micronutrient content of the complementary food

The effect of feed composition and baking temperature on the micronutrient content of the complementary food is shown in Table 6.

Vitamin B_1 content of the complementary food blends ranged from 1.2 to 2.1 mg/100g, with moderate feed composition (25 %), baked with least temperature (111.72 ^oC) having the highest value. Feed composition played a positively non significant role here at the level tested (p>0.05). From the 3D plot in figure 1, increase in *Telfaria occidentalis* seed paste led to increased vitamin B_1 content of the complementary food. Daily recommended intake for infants within the age of 4 to 6 months is 0.3 mg/day (Garrow, 1999). The values observed in this study were higher than daily recommended intake for infants. However, change in baking temperature had a negative influence on vitamin B_1 content and could be attributed to the unstable nature and changes in its structure at high temperature. Vitamin C ranged from 1.3 to 2.6 mg/100g. Samples with moderate feed composition (25 %), baked with least temperature (111.72 ^oC) had highest vitamin C value. Feed composition was positive even though non-significant at the level tested (p>0.05), as shown in the 3D plot in figure 2. Higher baking temperature had a significant negative influence on the vitamin C content. Zinc ranged from 0.08 to 0.39 mg/100g. There was significant (p<0.05) differences in zinc content among the blends. Feed composition positively (0.05) influenced the zinc content of the blends as shown the 3D plot in Figure 3. Samples 4 and 6 with higher feed composition and baking temperatures of 120 °C and 140 °C) had the highest (0.39 mg/100g) zinc content, the recommended daily zinc for infants (0.6mg, FAO/WHO, 1991) was higher than values observed in this study. Potassium ranged from 1.17 to 4.09 mg/100g with significant ($p<0.05$) difference among the complementary food samples. Sample No. 6 had the highest (4.09 mg/100g) potassium content. High value of potassium in sample 6 could be due to the high proportion of *Telfaria occidentalis* seed in the blend. Baking temperature was also positive and significant ($p<0.05$) on the potassium content. From the 3D plot in Figure 4, increase in feed composition resulted to increased potassium content of the complementary food.

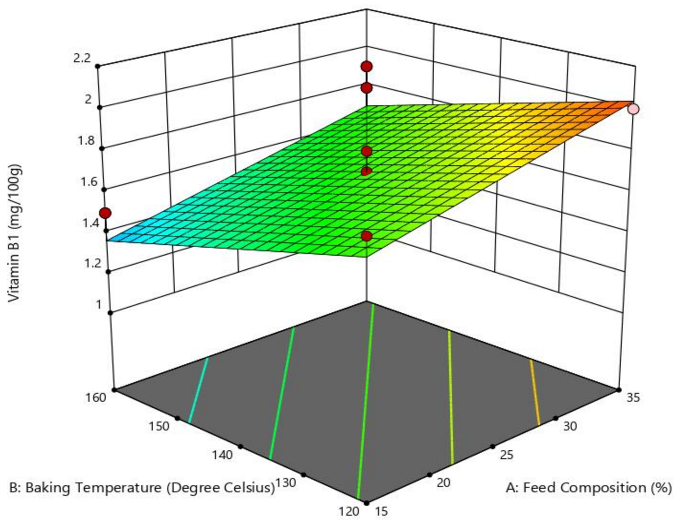

Figure 1: 3D Effect of FC and BT on the vitamin B_1 of the complementary food

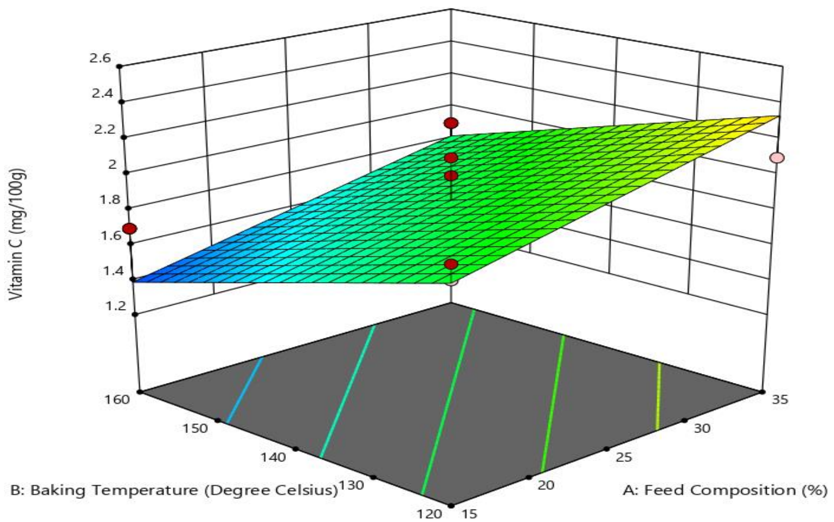

Figure 2: 3D Effect of FC and BT on the vitamin C of the complementary food

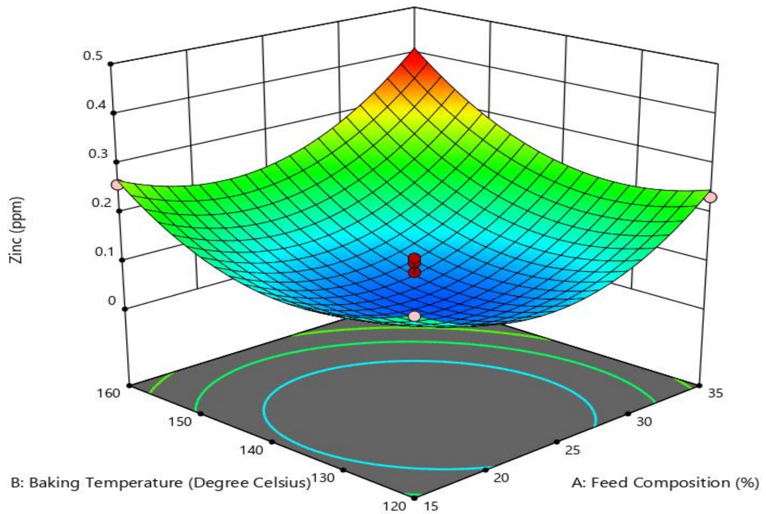

Figure 3: 3D Effect of FC and BT on the zinc content of the complementary food

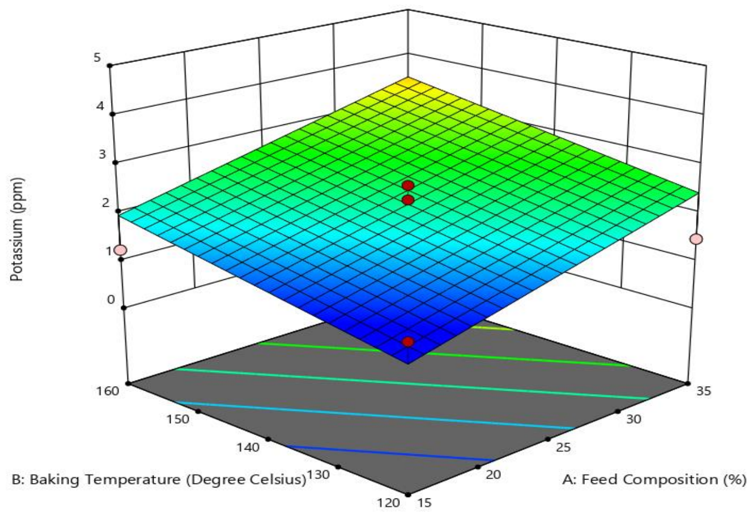

Figure 4: 3D Effect of FC and BT on the potassium of the complementary food

Regression equation coefficients for micronutrient content of the complementary food

Regression equation coefficient with their probability level for the micronutrient content of the complementary food is shown in Table 3. The model for all the responses was found to be significant (ranged from 0.01 to 0.04) at the level tested ($p<0.05$) and this indicates the goodness of the model as a predictor of most of the responses. Lack of fit was not significant (ranged from 0.11 to 0.79) and non significant lack of fit was desired for a good fitted model. Adequate precision value (ranged from 6.13 to 16.97) was greater than 4 for all the responses which were desirable (Statease, 2017). The adjusted R^2 values (>0.5) indicates appropriateness of the developed model equation in predicting most of the responses when the two independent variables are mathematically combined.

Table 3: Regression equation coefficients with their probability level for micronutrient content of the complementary food

	Responses			
	Vitamin B1	**Vitamin C**	**Zinc (Zn)**	**Potassium (K)**
Intercept	1.70	1.86	0.07	2.19
Linear effects				
X_1	0.16^{ns}	0.21^{ns}	0.05	0.77
P	0.07	0.05	0.01	0.01
X_2	-0.17^{ns}	-0.26	0.06	0.54
P	0.05	0.03	0.01	0.05
Interaction effects				
X_1X_2			0.02^{ns}	
P			0.23	
Quadratic effects				
X_1^2			0.11	
P			0.01	
X_2^2			0.09	
P			0.00	
Model	4.33*	5.49*	42.90*	7.69*
	0.04	0.02	0.01	0.01
Lack of Fit	0.49^{ns}	0.79^{ns}	0.45^{ns}	3.74^{ns}
	0.79	0.61	0.73	0.11
Adequate Precision	6.13	6.87	16.97	8.04
Adjusted R^2	0.35	0.43	0.95	0.53

X_1 = feed composition, X_2 = baking temperature, p = probability level, * = significant, ns = not significant

Functional properties of the complementary food samples

Effect of feed composition and baking temperature on the functional properties of the complementary food samples

Effect of feed composition and baking temperature on the functional properties of the complementary food is shown in Table 7.

The bulk density of samples ranged from 0.27 to 0.59 g/m^3. The highest value was observed in sample 1 while the least value was observed in sample 4. From the 3D plot in Figure 5, bulk density was not influenced by feed composition in all the samples. Baking temperature had negative influence as higher baking temperature led to decrease in bulk density. Low bulk density would be an advantage in the formulation and packaging of complementary foods (Akpata and Akubor 1999). Viscosity ranged from 2000 to 4800 cP (mPa) and was significantly ($p<0.05$) influenced by feed composition. From the 3D plot in Figure 6, higher feed composition increased the viscosity while increased baking temperature decreased the viscosity. Their interactive effects of baking temperature and feed composition showed reduced the viscosity of the complementary food samples.Water absorption capacity ranged from 88.9 to 170.8 %. The highest value observed in sample 8 contained moderate amount of feed composition (25 %) and baked with high temperature (168.28 ^{o}C) while the lowest value was observed in sample 7 containing the same feed composition but was baked with least baking temperature (111.72 ^{o}C). From 3D plot in Figure 7, water absorption capacity was positively and significantly ($p<0.05$) influenced by baking temperature.

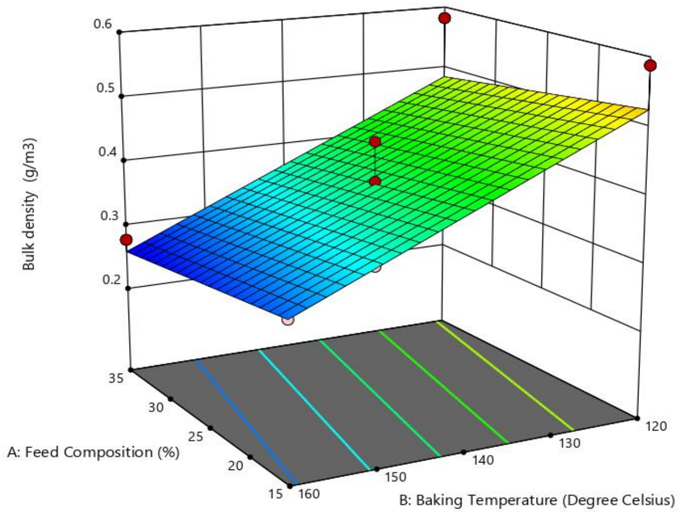

Figure 5: 3D Effect of FC and BT on the bulk density of the complementary food

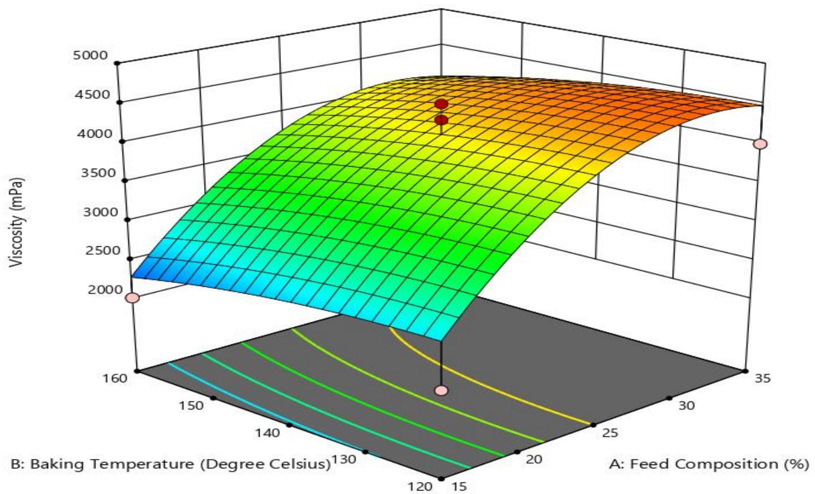

Figure 6: 3D Effect of FC and BT on the viscosity of the complementary food

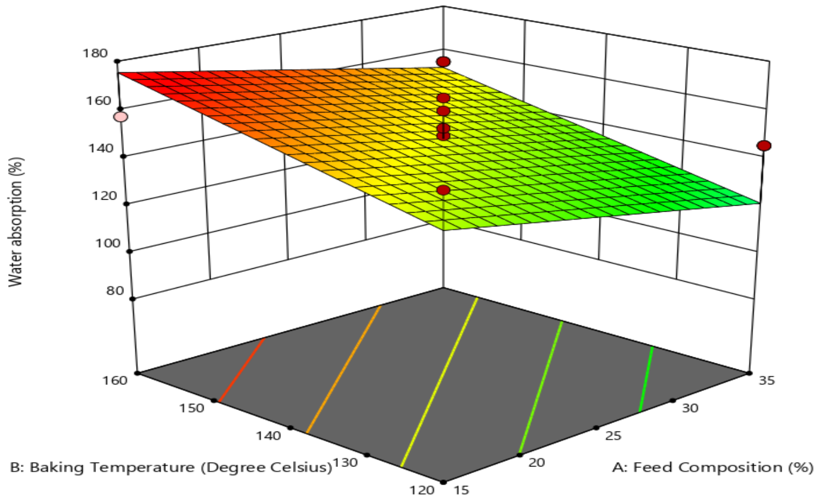

Figure 7: 3D Effect of FC and BTon the water absorption capacity of the complementary food

Regression equation coefficients for the functional properties of the complementary food

Regression equation coefficient for functional properties of the complementary food is shown in Table 4. The model for the functional properties and pH responses was found to be significant (ranged from 0.01 to 0.04) at the level tested ($p<0.05$) and this indicates the goodness of the model as a predictor of most of the responses. Lack of fit was not significant (ranged from 0.06 to 0.56) and non significant lack of fit was desired for a good fitted model. Adequate precision value (ranged from 6.13 to 9.74) was greater than 4 for all the responses which were desirable (Statease, 2017). The adjusted R^2 values (>0.5) indicates appropriateness of the developed model equation in predicting most of the responses when the two independent variables are mathematically combined.

Table 4: Regression equation coefficients with their probability level for the functional properties and pH of the complementary food

	Responses			
	Bulk density	Viscosity	Water absorption	pH
Intercept	0.39	4120	148.43	6.46
Linear effects				
X_1	0.02^{ns}	901.76	-11.59^{ns}	0.35
P	0.43	0.01	0.10	0.01
X_2	-0.11	-199.28^{ns}	15.40	0.09^{ns}
P	0.01	0.29	0.03	0.43
Interaction effects				
X_1X_2		-5.00^{ns}		
P		0.98		
Quadratic effects				
X_1^2		-648.75		
P		0.01		
X_2^2		-98.75^{ns}		
P		0.61		
Model	11.29*	7.93*	4.43*	4.86*
	0.01	0.01	0.04	0.03
Lack of Fit	0.89^{ns}	4.90^{ns}	5.30^{ns}	2.64^{ns}
	0.56	0.07	0.06	0.18
Adequate Precision	9.74	8.70	6.13	6.26
Adjusted R^2	0.63	0.74	0.36	0.49

X_1 = feed composition, X_2 = baking temperature, p = probability level, * = significant, ns = not significant

Sensory properties of the complementary food

Effect of feed composition and baking temperature on the sensory properties of the complementary food

The effect of feed composition and baking temperature on the sensory properties of the complementary food is shown in Table 8.

Color scores of the complementary food ranged from 6.4 to 7.2. Highest score was observed in sample 5 while lowest score was observed in sample 6. Color of the complementary food was significant but negatively affected by feed composition rather than baking temperature. This may be attributed to the dark brown color of the complementary food as shown in the 3D plot in Figure 8. Higher feed composition resulted to lower color scores by the panelists while increased baking temperature increased the color scores although not significant. The result of color from the sensory analysis of the complementary food revealed that most of the panelist preferred samples baked at higher baking temperatures 160 ^{o}C and 168.28 ^{o}C with moderate or low feed composition. Taste scores of the complementary food ranged from 5.35 to 6.5 with highest score observed in sample 5 and the least in samples 2 and 4. From the 3D plot in Figure 9, higher feed composition led to lower taste scores from the panelists while samples baked at higher temperatures had higher scores for taste although not significant. Texture of the product ranged from 5.1 to 7.1. Highest score was observed in sample 5 while least score was observed in sample 6. From the 3D plot in Figure 10, increased feed composition resulted to decreased texture score of the complementary food by the panelists. However, higher baking temperatures, even though not significant led to higher texture scores by the panelists. Aftertaste scores of the complementary food ranged from 4.85 to 6.15 with highest score observed in sample 5 while least score was found in sample 2. From the 3D plot in Figure 11, higher feed composition had a negative influence on the aftertaste score of the panelists. Mouth feel scores ranged from 5.05 to 6.2 with highest score observed in sample 5 while least score was observed in sample 4. 3D plot in Figure 12 showed that higher feed composition and baking temperature led to lower mouth feel score by the panelist. The negative influence of the feed composition may be attributed to the high content of fat in the *occidentalis* seed. Overall acceptability scores of the complementary food ranged from 5.25 to 6.6 with highest score observed in sample 5 while least score is found in sample 2. From the 3D graph in Figure 13, increased feed composition led to decrease in overall acceptability score of the panelists while higher baking temperature, although had no significant influence, but led to higher scores on the overall acceptability of the complementary food.

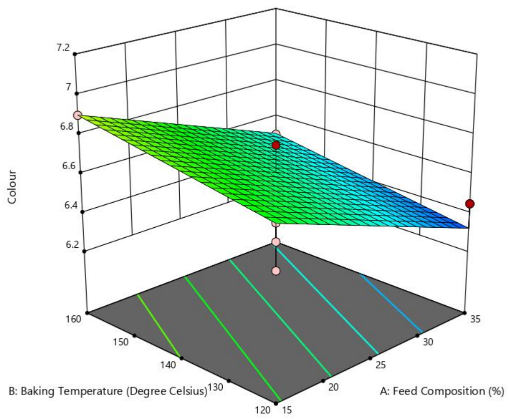

Figure 8: 3D Effect of FC and BT on the color of the food samples

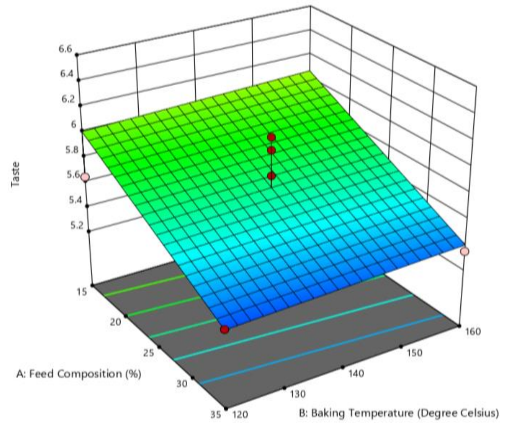

Figure 9: 3D Effect of FC and BT on the taste of the food samples

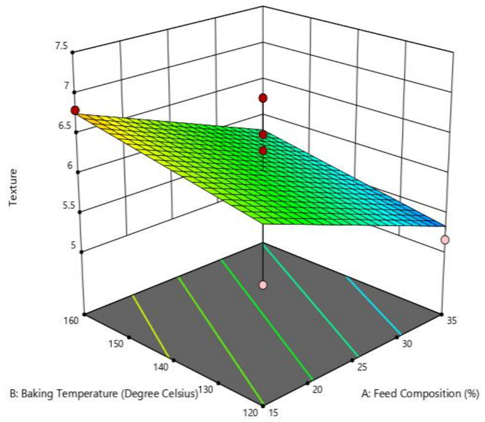

Figure 10: 3D Effect of FC and BT on the taste of the foods

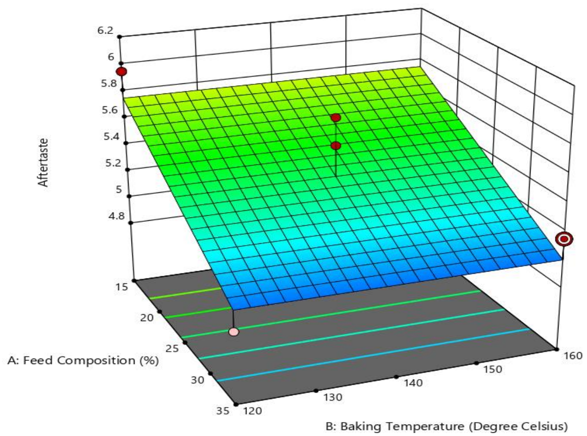

Fig. 11: 3D Effect of FC and BT on the aftertaste of the foods

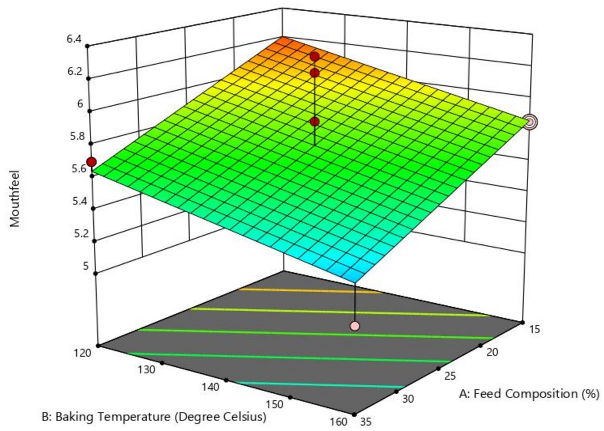

Fig. 10: 3D Effect of FC and BT on the mouthfeel of the foods

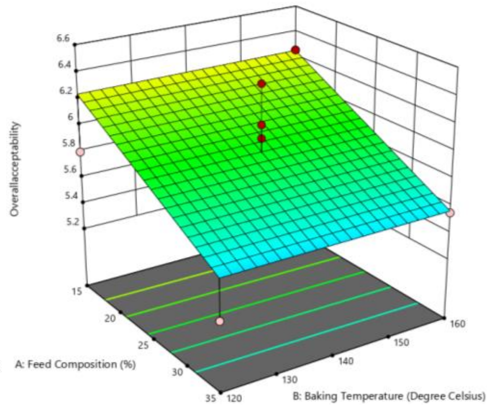

Fig. 10: 3D Effect of FC and BT on the o/acceptability of the foods

Regression equation coefficients for the Sensory properties of the complementary food

Regression equation coefficient with their probability level for the sensory properties of the complementary food is shown in Table 5. The model for all the responses was found to be significant (ranged from 0.01 to 0.04) at the level tested ($p<0.05$) and this indicates the goodness of the model as a predictor of most of the responses. Lack of fit was not significant (ranged from 0.29 to 0.93) and non significant lack of fit was desired for a good fitted model. Adequate precision value (ranged from 5.83 to 7.89) was greater than 4 for all the responses which were desirable (Statease, 2017). The adjusted R^2 values (>0.5) indicates appropriateness of the developed model equation in predicting most of the responses when the two independent variables are mathematically combined.

Table 5: Regression equation coefficients with their probability level for the sensory properties of the complementary food

	Responses					
	Colour	Taste	Texture	Aftertaste	Mouthfeel	Overall acceptability
Intercept	6.61	5.71	6.05	5.38	5.75	5.9
Linear effects						
X_1	-0.19	-0.33	-0.48	-0.38	-0.28	-3.4
P	0.02	0.01	0.01	0.01	0.02	0.01
X_2	0.09^{ns}	0.03^{ns}	0.23^{ns}	-6.28^{ns}	-0.17^{ns}	0.01^{ns}
P	0.24	0.75	0.17	0.01	0.13	0.96
Model	4.46*	7.25*	5.58*	6.66*	4.88*	4.90*
	0.04	0.01	0.02	0.01	0.03	0.03
Lack of Fit	1.11^{ns}	1.14^{ns}	1.79^{ns}	0.59^{ns}	0.25^{ns}	0.74^{ns}
	0.48	0.47	0.29	0.73	0.93	0.65
Adequate Precision	5.83	7.89	6.58	7.59	6.32	6.51
Adjusted R^2	0.37	0.51	0.43	0.49	0.39	0.39

X_1 = feed composition, X_2 = baking temperature, p = probability level, * = significant, ns = not significant

Optimization of processing conditions and product responses of the complementary food

The results of general optimal solution obtained from the response optimizer for the processing conditions (at set goals) were 35 % feed composition and 120 °C baking temperature. The optimal responses were 2.0 mg/100 vitamin B_1, 2.3 mg/100 vitamin C, 0.4 mg/100 Zinc, 0.4 mg/100 Potassium, 0.29 g/m^3 bulk density, 2276.5 cP viscosity, 175.4 %

WAC, 6.2 pH, 6.07 % taste, 5.7 % aftertaste,6.9 % colour, 5.8 % mouth feel, 6.7 % texture and 6.25 % overall acceptability. The desirability values for the responses were high and ranged from 0.60 to 0.9.

Conclusion

Findings from this research showed that nutritious, acceptable complementary foods possessing good functional properties can be formulated using locally available *Telfaria occidentalis* seeds. Results indicate that complementary food produced with feed composition 35 % and baked at 120 °C temperature best suit to produce complementary food with desirable qualities such as high micronutrients, low bulk density and viscosity, with acceptable sensory properties.

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Appendix

Table 6: Effect of feed composition and baking temperature on the micronutrient content of the complementary food

Sample/Runs ratio	Vitamin B_1 (mg/100g)	Vitamin C (mg/100g)	Zinc (mg/100g)	Potassium (mg/100g)
1 (15:120)	1.8	2.0	0.18	1.31
2 (35:120)	2.0	2.1	0.23	1.47
3 (15:160)	1.5	1.7	0.26	1.24
4 (35:160)	1.9	1.9	0.39	3.09
5 (10.85:140)	1.2	1.3	0.23	1.17
6 (39.14:140)	1.7	2.3	0.39	4.09
7 (25:111.72)	2.1	2.6	0.18	2.01
8 (25:168.28)	1.4	1.5	0.36	3.94
9 (25:140)	1.7	2.0	0.08	2.09
10 (25:140)	1.4	2.1	0.04	2.58
11 (25:140)	2.1	1.5	0.09	2.28
12 (25:140)	1.5	1.4	0.10	1.58
13 (25:140)	1.8	1.8	0.20	1.68

Sample/Runs ratio = Feed composition (%): baking Temperature (Celsius)

Table 7: Effect of feed composition and baking temperature on the functional properties of the complementary food

Sample/Runs ratio	**Bulk density (g/m^3)**	**Viscosity cP (mPa)**	**Water absorption capacity (%)**
1 (15:120)	0.59	2.08×10^3	159.4
2 (35:120)	0.58	4.00×10^3	145.6
3 (15:160)	0.29	2.00×10^3	157.5
4 (35:160)	0.27	3.90×10^3	154.9
5 (10.85:140)	0.40	2.00×10^3	169.5
6 (39.14:140)	0.31	4.40×10^3	115.5
7 (25:111.72)	0.52	4.80×10^3	88.90
8 (25:168.28)	0.30	3.80×10^3	170.8
9 (25:140)	0.36	4.10×10^3	149.7
10 (25:140)	0.26	4.30×10^3	152.8
11 (25:140)	0.45	4.50×10^3	140.0
12 (25:140)	0.39	4.00×10^3	165.2
13 (25:140)	0.33	3.70×10^3	159.9

Sample/Runs ratio = Feed composition (%): baking Temperature (Celsius)

Table 8: Effect of feed composition and baking temperature on the sensory properties of the complementary food

	Responses					
Samples/Runs	Colour	Taste	Texture	Mouth feel	Aftertaste	Overall acceptability
1 (15:120)	6.50	5.65	5.60	5.95	5.95	5.80
2 (35:120)	6.45	5.35	5.16	5.70	4.85	5.25
3 (15:160)	6.90	5.95	6.80	5.85	5.65	6.25
4 (35:160)	6.50	5.35	6.25	5.05	5.15	5.55
5 (10.85:140)	7.20	6.50	7.10	6.20	6.15	6.60
6 (39.14:140)	6.40	5.25	5.10	5.35	5.15	5.55
7 (25:111.72)	6.65	5.55	6.40	5.85	5.10	6.20
8 (25:168.28)	6.85	5.50	6.10	5.40	5.10	5.70
9 (25:140)	6.75	5.80	6.50	5.90	5.30	6.00
10 (25:140)	6.60	6.00	5.90	6.20	5.60	6.40
11 (25:140)	6.55	5.50	5.60	5.70	5.10	5.50
12 (25:140)	6.35	6.10	6.30	5.30	5.80	6.10
13 (25:140)	6.25	5.70	5.80	6.30	5.00	5.80

Sample/Runs ratio = Feed composition (%): baking Temperature (Celsius)