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OPTIMUM REDUCTION OF ANTI-NUTRITIONAL FACTORS FROM BLEND OF SORGHUM AND GROUNDNUT CAKE FLOUR ENRICHED WITH DATE FRUIT FLOUR AS POST COVID-19 SNACK FOOD

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Abstract

This study aimed at optimization and development of sorghum snack enriched with groundnut cake and date flour using response surface methodology (RSM). Consumer Acceptance and optimum reduction of Anti-nutritional factors were studied. As the concentration of groundnut in the formulation increased, the product was disliked due to the strong nutty flavour of the groundnut cake, thus affecting the overall acceptability. Date fruit flour (%) was composited to enriched snack. Central composite design was used to develop a polynomial model for the responses. It was observed that higher composition of groundnut in the feed composition and moisture content significantly (p≤0.01) affected the optimum reduction of AFNs making it less palatable, and thereby reducing the overall acceptability of the snack. Based on the response surface 3D plots, the AFNs content of the samples were optimized at 17.08% (fc), 17.89%(mc) and 6.0ds(mm) with optimal reduction in the predicted responses of 3.758 mg TIA /g, 0.218 mg Tanic

KEYWORDS:
Optimum, anti-nutritional factors (AFNs), overall acceptability, extruded snack, sorghum, groundnuts cake, date palm flour and Covid-19

acid /g and 112.556mg phytate /g at an optimum desirability of 0.742. The sensory data obtained in this study had revealed that samples produced from appropriate blends of flours from sorghum, date palm fruit and defatted groundnut cake were highly acceptable by the panellists used for this study and it can be used as a post covid 19 food.

INTRODUCTION

Part of the way to overcoming the challenge of the Covid-19 pandemic is to eat a well-balanced diet. With the advancement in technology for producing nutrient-dense foods, there is a growing need in the consumer industry for new goods that encourage the use of indigenous raw materials. Snacks are a quick-to-eat food that offers calories while satisfying short-term hunger. It is mostly consumed in a rush and it's produced with a significant amount of sweetener, preservatives, and fragrance ingredients to cater to the consumer's palate (Iwe, 2003).

Proper eating includes an adequate diet of carbohydrates, proteins, and fats, as well as fibre, vitamins, and minerals (Deshpande et al., 2008). The need for adequate diet has increasingly become a major public health concern due to the high levels of table sugar used in the production of chocolate, cookies, and beverages; as a result of increased public consciousness and exposure to diet, consumers are more likely to consume organic, fresh foods with lower sugar content. Dates are a healthier substitute to table sugar, as well as a decent source of fibre and a variety of nutrients. Appropriate processing and judicious blending and appropriate processing of healthy available indigenous food crops could result in improved nutrient intake by the populace, preventing malnutrition problems that could compromise immunity system that will make an individual vulnerable to covid-19and other related diseases (Kumari & Sangeetha, 2017).

Cereals and legumes such as rice, maize and groundnut respectively are considered as staple food crops in Nigeria due to being a rich source of vitamins, minerals, carbohydrates, fats, oils, and proteins (Nikmaram et al., 2017). Some of these crops contain ANFs in abundance such as trypsin inhibitor, phytate, and tannin which are known to form reversible or

irreversible complexes with proteins, leading to the reduction of amino acid bioavailability, as well as affecting the protein digestibility. Iwe and Ngoddy (2000) ; Juvvi (2012) reported many beneficial physiological effects of the used of legumes in the daily diet including reducing plasma cholesterol level and preventing and mitigating common coronary heart disease, cancer, metabolic diseases of diabetes mellitus, and boosting of immune systems to fight common viral diseases. However, in spite of the health benefit concerns associated, the presence of several anti-nutritional factors in legumes make them not acceptable to consumers and restricted their utilisation as an ingredient for food production, which could likely result in several health-complications in humans (Ajibola & Olapade,2021). ANFs are naturally-occurring compounds in edible seeds that affect nutrient absorption in the body when ingested. The normally bind to proteins, vitamins, and minerals to form a complex compound and hence reduce their absorption in the gastrointestinal tract (Nikmaram et al., 2017).

However, AFNs are heat labile and as a result, heat-based processing methods can be used to inactivate it (Ajibola & Olapade,2021). Extrusion cooking has unique features when compared to other conventional heat processing method that deteriorates the nutritional quality of food during processing. Extrusion cooking processing is a fully automated technology that allowed more efficient use of energy during cooking and better process control (Rathod & Annapure, 2016). The degradation of nutritional content poses is a troublesome issue in traditional processing when requiring high temperature. In this respect, extrusion processing is more preferable to achieve a more important nutrient preservation as this technique typically performed under high temperature and short time where raw materials are subjected to strong mechanical shear, which causes the covalent bonds in biopolymers to break down and structural damage to further texturize the finished materials (Nikmaram et al., 2017).

MATERIALS AND METHODS.

Study area

The study was conducted at the Federal Polytechnic Mubi, Adamawa State, Nigeria. Mubi lies on latitude 10° 16′ 8″ N of the equator and

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longitude 13° 16′ 14 ″ E of Green-wich Meridian (Anonymous, 2015).Mubi is the second largest to Yola, the state capital. Mubi LGA is located at the northern part of old Sardauna Province which now forms Adamawa north senatorial district as defined by INEC ,2006 (Ajawara, 2006). Mubi region is bounded to the north by Borno state, to the west by Hong and Song LGA and to the south and east by the Republic of Cameroon. It has a land area of about 4,728,77 km^2 and human population of about 151,000 going by 2006 census projected figure (Ajawara, 2006).

Processing / Extraction of Sorghum

To extract all contaminants and impurities, all raw materials were manually sorted. Sorghum grains were washed in portable water and drained through a perforated basket at a nearby location. The sorghum was washed and dried in the sun for three days (72hrs). In the month of April, 2019, fresh date palm fruits were de-pitted, cut into small pieces, and dried in the sun for three days before being milled in a grinder (M-20, KA-werke, GMBH AND CO.KG, Staufen, Germany) for five minutes. To extract small flour particles, the powder was sieved in a steel-mesh sifter (0.85mm aperture). For future usage, the powder was sealed and packed in a polyethylene container. Defatted groundnut cake was milled with a hammer mill (Iika labortec Hnik, Staufen, Germany) and sieved with a 0.85mm sieve before being dried in a hot air oven at 600°C for 5 hours, then cooled and placed in a polyethylene bag for later use. The extrusion was performed in a twin-screw extruder (SGL 65) at 140rpm available at the Department of Food Science and Technology, Federal Polytechnic Mubi Adamawa State, Nigeria. The temperature was set at 110°C for the entire sample.

Determination of Anti-Nutritional Factors

AFNs analyses were conducted on all the experimental runs on raw blends and extruded snacks formulations. Trypsin inhibitor activity was determined according to the method of Mukhopadhyay *et al.* (2007). Trypsin inhibitory unit per mL (TIU/ml) vs. volume of extract was plotted and extrapolated to zero. One trypsin unit was defined as an increase in 0.01 absorbance units at 410nm per 10mL of reaction mixture under condition used. Trypsin inhibitor activity was expressed in terms of

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trypsin inhibitor units (TIU) and the value expressed as TIU/mg of sample. Tannin content was determined by the Folic-Denis calorimetric Iwe (2003).

The irrespective absorbance was measured in a spectrophotometer at 260 nm using the reagent blank to calibrate the instrument at zero. The Phytate content of the flour was determined by Maga, (1989) method. The concentration of Phytic acid was obtained by extrapolation from a standard curve using standard phytic acid solution. For plotting the standard curve different concentrations (0.2-1.0mL) of sodium phytate solution containing 40-200µg Phytic acid were taken and made to 1.4mL with water (0.4O D corresponding to70µg phytic acid).

Sensory evaluation

The method used by (Rathod & Annapure, 2016) was adopted and modified to evaluate the Sensory attributes of milled extruded snacks. it was served warm to 30 untrained but regular consumers of snacks panellists. Attributes rated includes appearance, aroma, taste, and overall acceptability using a 9-point Hedonic scale scored from like extremely (9) to dislike extremely (1). The panellists were provided with clean potable water to rinse mouth between tastes of samples. The first, second, third, fourth, and fifth mean scores of each sample were determined, and the mean score comparison yielded the overall rating. For optimization, the mean scores of each sample were used as responses.

Experimental Design

For this analysis, Response Surface Methodology (RSM) with Central Composite Design (CCD) was used, which typically has three levels of variables (Nwabueze & Iwe, 2006). Die scale (2-6mm), feed moisture content (12-18%), and feed composition (10-30%) were used as extrusion variables, whereas all other parameters were held unchanged with 10% date fruit flour across all the experimental runs.

Table 1. Experimental levels of the variables

Independent Variables	Coded	-1	0		+1
Feed Composition (%)	X_1	10	15		30

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Moisture Content (%)	X_2	11	15		18
Die Size (mm)	X_3	2	4		6

X_1 = feed composition, X_2 = moisture content, X_3 = die size

The Central composite design (CCD) used in this work was produced using Design Expert statistical software (v.11.1.2.0, Stat-Ease Inc., Minneapolis, MN).

The response was then expressed as second-order polynomial equation according to eqn 1.

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X_1^2 + b_{22}X_2^2 + b_{33}X_3^2 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 \quad (1)$$

where X_1 = Feed Composition, X_2 = Feed Moisture, X_3 = Screw Speed, b_0, b_i, b_{ii}, and b_{ij} are intercepts, linear, quadratic and interaction regression coefficient terms, respectively.

CCD is suitable for sequential experimentation and provides a detailed information for testing lack-of-fit while not using large number of experimental runs. Experimental runs in CCD can be estimated by:

$$\mathbf{N = k^2 + 2k + c_p}$$

where k is the number of independent variables and c_p is the number replicate of the central point.

$$\mathbf{N = 3^2 + 2 \times 3 + 5 = 9 + 6 + 5 = 20}$$

Optimization of the Antinutritional factors

The Design expert software version 11.1.2 (Stat-Ease Inc., Minneapolis) was used in this study. The ranges of TIA, Tannins and phytate obtained from this study were analysed using design expert to predict the process conditions that gives the optimum anti-nutritional factors. These process conditions were optimized based on the selected parameters, thereby minimizing all the AFNs contents to improve the utilization of the nutritional contents. The coefficients of polynomial models, coefficient of determination (R^2), adjusted R^2 and adequate precision values of the chemical properties of the blends were used to evaluate the model fitness as indicated in Table 2.

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RESULTS AND DISCUSSION

Anti-Nutritional Factors

Extrusion cooking, is a high temperature short time process in which raw feed composition is subjected to controlled conditions of high temperature, pressure, and moisture, it has been shown to degrade a variety of anti-nutritional factors(Mukhopadhyay et al., 2007). Table 2: shows some anti-nutritional factors of extruded snacks and raw blends of sorghum, defatted groundnut cake and date flour. Just like other legumes, groundnut contains anti-nutritional factors such as trypsin inhibitor, tannins and phytate.

Legumes are known to contain AFNs that limit their nutritional quality especially digestibility and acceptability(Halilu et al., 2020; Rathod & Annapure, 2016). Trypsin inhibitors, saponins, phytic acid, and tannins are some of the undesirable components in legumes that can reduce the nutritional value of legume seeds by reducing protein digestibility and mineral availability, as well as hindering the utilisation and absorption of important minerals like magnesium, calcium, iron, and zinc, which can lead to mineral deficiency; however, they are heat labile and as a result, heat-based processing methods can be used to inactivate it. (Ajibola & Olapade, 2021). Processing methods such as dehulling, milling, soaking, cooking, germination, fermentation, autoclaving, roasting and drying were reported to reduce or eliminate these AFNs(Halilu et al., 2020; FAO, 1995). The results of this research are in agreement with this observation.

Table 2: Anti-nutritional Factors of Extruded Snacks and Raw Blends

				Extruded Samples			**Raw Samples**		
	X_1:FC	X_2:MC	X_3:DS	TIA	Tannic acid	Phytate	TIA	Tannic acid	Phytate
	%	%	mm	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
1	10	12	2	4.65	0.21	115	9.54	0.49	164
2	30	12	2	6.12	0.3	125	12.1	0.62	184
***3**	**10**	**18**	**2**	**4.23**	**0.11**	**112**	9.44	0.45	160
4	30	18	2	3.67	0.28	122	12.4	0.7	184
5	10	12	6	3.98	0.22	107	8.94	0.52	164

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6	30	12	6	5.89	0.28	120	11.8	0.66	180
7	10	18	6	3.42	0.18	110	10.2	0.52	164
8	30	18	6	5.67	0.34	121	12.6	0.68	186
9	3.18	15	4	3.68	0.1	102	7.4	0.42	172
10	36.82	15	4	6.63	0.3	128	12.8	0.82	188
11	20	9.95	4	5.81	0.26	120	10.8	0.5	169
12	20	20.05	4	3.02	0.22	118	10.4	0.48	168
***13**	**20**	**15**	**2**	**4.23**	**0.26**	**118**	10.9	0.42	160
14	20	15	6	3.89	0.17	115	10.4	0.44	170
15	20	15	4	3.95	0.21	117	10.5	0.46	172
16	20	15	4	4.01	0.2	119	10.9	0.48	170
17	20	15	4	3.98	0.2	115	10.4	0.48	176
18	20	15	4	4.12	0.18	115	10.6	0.46	172
19	20	15	4	4.01	0.15	118	10.6	0.44	177
20	20	15	4	4.32	0.15	118	10.25	0.48	172

FC=feed composition, MC=moisture content, DS=die size, TIA= Trypsin inhibitor activity

Trypsin inhibitor activity (TIA)

Table 2: shows the values of TIA in the raw blend of sorghum, defatted groundnut cake and date palm flour which ranged from 7.40TIU/mg to 12.80 TIU/mg. A Closer observation implies that trypsin inhibitor activity (TIA) increased with increase in addition of defatted groundnut flour. This observation agrees with that of Iwe (1998) that addition of soybean to sweet potato considerably increased its trypsin inhibitor level. Dahlin and Lorenz (1993) reported that rice did not exhibit any TIA whereas the blend of rice and defatted soy flour (70:30) showed high TIA. On a general note, reduction in TIA following extrusion cooking in this work is expected and agrees with earlier reports in the literature (Iwe and Ngoddy, 2000). The nutritional implication of this reduction in the concentration of trypsin inhibitor is that it will lead to improvement in

protein and digestibility. Negi et al. (2001) reported higher protein digestibility/quality after heat treatment (autoclaving and roasting), which they attributed to destruction of heat labile protease inhibitor and opening up of protein structures by denaturation, leading to increased accessibility of the protein to enzymatic attack. Moisture content plays an important role of for the inactivation of
trypsin inhibitor. The result of this study shows that, increase in moisture content causes the increase in removal of trypsin inhibitor during extrusion process (Rathod & Annapure, 2016).

Tannin

Tannins are generally defined as soluble astringent, complex and phenolic substance of plant origin, which play significant role in the reduction of dietary protein, digestibility by complexing either with dietary protein or digestive enzymes(Nikmaram et al., 2017). Tannins cause damage to intestinal tract, and increases the risk of carcinogenesis and also decrease palatability (Anuonye et al., 2012).
The tannin content of the raw blends in Table 4 ranged from 0.42 to 0.82 mg/100g, while the extruded blends, with a ranged of 0.11 to 0.34mg/100g which is similar to the result of Rathod & Annapure (2016) who developed a new extruded snack product prepared using fenugreek, the content of ANFs in the extruded product was found to be 0.38 mg/g for tannin, in which was lower than the raw ingredients. The result shows that extrusion had reduced the tannin content. Rathod & Annapure, (2016) reported a high extrusion temperature within in the range of 140 to 180°C causes a decrease in anti-nutritional factors more up to 93%, Anuonye et al. (2012). They also reported 61.22% reduction for extruded pigeon pea-unripe plantain flour blend which are associated with increasing in moisture content within the range of 14-18%.

Phytate

The result of the Phytate content of the extrudate ranged from 102 to 128mg/100g.The extrusion cooking process decreased the phytate content in the extruded. The presence of anti –nutritional factors like phytates in the plant-based food source limits the utilization of such minerals in the body (Hallen et al., 2004). Legumes such as cowpeas have

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higher phytate content than cereals such as sorghum (kumar *et al*., 2010). The enzymes phytate is sensitive to temperature and hence susceptible to degradation during extrusion Juvvi *et al.* (2012). Due to degradation of phytate, there was a decrease in phytate content of the extrudate.

Optimal reduction of Antinutritional factors

Quadratic models for desirability of FC and MC formulations were utilized to generate the three- dimensional response surface and a contour plots shown in Fig. 1. The optimal reduction of ANFs desirability is presented on vertical axis Fig. 1g and 1h; comparison of these AFNs revealed that the formulations was more affected at higher percentage of groundnut in the feed composition. Since the snacks was prepared by compositing sorghum, groundnut and palm fruit, the increase in groundnut level required an increase in other ingredients.

Table 3: Constraints

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
X_1:FC	maximize	10	20	1	1	3
X_2:MC	maximize	12	18	1	1	3
X_3:DS	maximize	2	6	1	1	3
TIA	minimize	3.02	6.63	1	1	3
Tannic acid	minimize	0.1	0.34	1	1	3
Phytate	minimize	102	128	1	1	3

FC=feed composition, MC=moisture content, DS=die size, TIA= Trypsin inhibitor activity

Optimization was done in order to achieve the levels of independent variables, which led to the optimum formulation of sorghum snack enriched with groundnut cake and date flour. Maximum Feed composition, moisture content and die size with minimum response of TIA, Tanic acid and Phytate were used for. Based on the response surface 3D plots, the AFNs content of the samples were optimized at 17.08% (fc), 17.89%(mc) and 6.0ds(mm) with the predicted TIA of 3.758 mg/g, Tanic

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acid of 0.218 mg/g and phytate of 112.556mg/g. The desirability of the optimum sample was 0.742.

The TIA, tannin and phytate contents in the flour blends were lower than the allowable level of 20 mg /g dry mass, 20 mg/g dry mass and 250-500 mg/100 g dry mass, respectively(Ajibola & Olapade, 2021). Up to 99 percent reduction of phytate, trypsin inhibitors, and tannin is possible. The thermal degradation of these molecules and the forming of insoluble complexes at high cooking temperatures could explain such a significant reduction during the extrusion phase(Nikmaram et al., 2017)

Table 4: Coefficient of Polynomial Models & ANOVA of TIA, Tannin and Phytate Contents of Snack

	TIA			*Tanic acid*			*Phytate*			
Source	**Coeff**	**F-v**	**p-v**	**Coeff**	**F-v**	**p-v**	**Coeff**	**F-v**	**p-v**	
Model	Quadra	81.55	< 0.0001	Rquadr	12.24	0.0002	Linear	42.43	< 0.0001	si
Intercept	3.68			0.1568			113.57			
X_1-*FC*	0.2507	57.55	< 0.0001	0.0273	39.69	< 0.0001	3.21	112.30	< 0.0001	
X_2-*MC*	-0.8323	147.9	< 0.0001	-0.0070	0.6600	0.4324	-0.3982	0.4312	0.5221	
X_3-*DS*	0.2561	8.65	0.0187	-0.0001	0.0001	0.9919	-1.97	6.46	0.0235	
X_1X_2	0.0451	1.66	0.2331	0.0228						
X_1X_3	0.0524	2.24	0.1728	0.0358						
X_2X_3	0.5628	64.68	< 0.0001							
X_1^2	0.1024	87.34	< 0.0001							
X_2^2	0.1478	11.41	0.0097		7.79	0.0163				
X_3^2	-0.2219	6.47	0.0346		5.69	0.0345				

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Lack of Fit	Ns	1.90	0.2468	ns	1.53	0.3296	ns	1.96	0.2366	ns
R^2	0.9892			0.8361			0.9009			
Adj R^2	0.9771			0.7678			0.8797			
Pred R^2	0.8368			0.6393			0.8066			
Adq Press	30.331			12.159			21.541			

X_1-FC = feed composition, X_2-MC = moisture content, X_3-DS = die size, Adj=adjusted, Pred R^2 = Predicted R^2,

p-v **= p-values, F-v = F-values, R**quadra = Reduced Quadratic, Quadra = Quadratic,

Final Equation in Terms of Coded Factors

TIA=$3.68+0.2507X_1-0.8323X_2+0.2561X_3+0.0451X_1X_2+0.0524X_1X_3+0.5628X_2X_3+0.1024X_1^2+0.1478X_2^2-0.2219X_3^2$ eqn.2

Tanic acid = $0.1568+0.0273X_1-0.0070X_2+-0.0001X_3+0.0228X_2^2+0.0358X_3^2$ eqn.3

Phytate = $113.57++3.21X_1-0.3982X_2-1.97X_3$ eqn.4

Using response surface method, fitted polynomial equation were obtained as Eqn.2,3 and 4 for TIA, Tanic acid and Phytate responses respectively. The above equations all had a $P<0.01$ significance level and a non-significant lack of fit. eqns. 3 and 4 for Tanic acid and Phytate, respectively, had a significant lack of fit in the predictive model, which was resolved by eliminating certain outliers from the experimental runs to get a reduced quadratic and linear model for tannic acid and phytate, runs 3 and 13 were removed from the forecast. R^2 and Predicted R^2 are in good agreement with both simulations, indicating that the fraction of variation of the response with the model agrees with the fraction of variation of the response predicted by the model (Waglay & Karboune, 2020). The signal-to-noise ratio is used to determine adequate precision. Anuonye et al. (2012) shows a ratio greater than 4 is a strong signal, indicating that the model predicted can successfully manoeuvre the design space.

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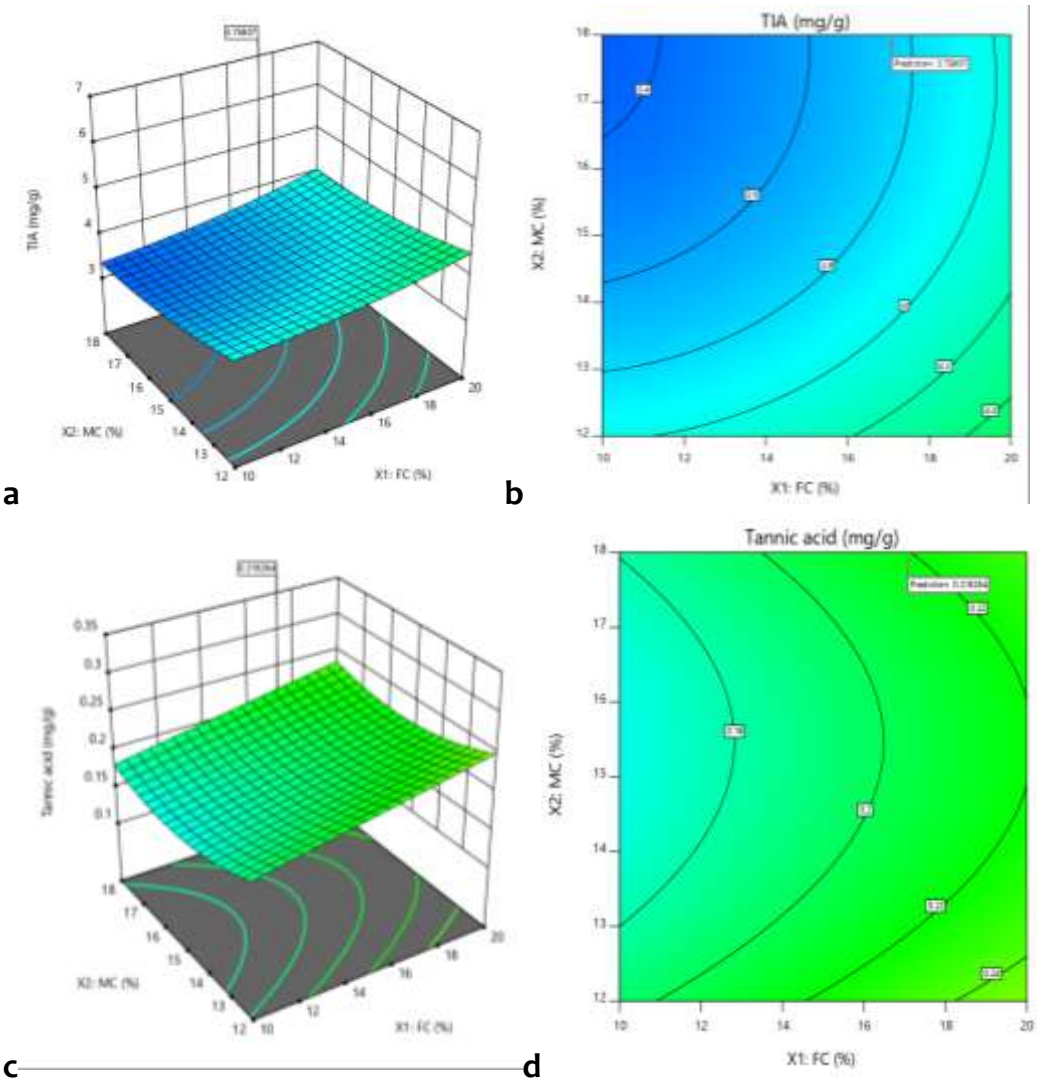
Sensory Evaluation

The data related to sensory evaluation was shown in Table 4. Experimental run 6 had the highest consumers' acceptance, the consumers disliked the Run 10, which means the overall acceptability, crispness, aroma and appearance with 8.11, 8.11, 7.78, and 8.00 respectively, the only run that had the highest rating than run 6 is run 4 with a ranking of 8.9 compare to 8.33 for run 6 which had the highest score in term of overall acceptability, crispness, aroma and appearance. Consumers described run 10 with lowest scores for all parameters which could be due to higher quantity of groundnut cake content of the run. They disliked Run 10 sample may be due to the strong nutty flavour of the groundnut cake.



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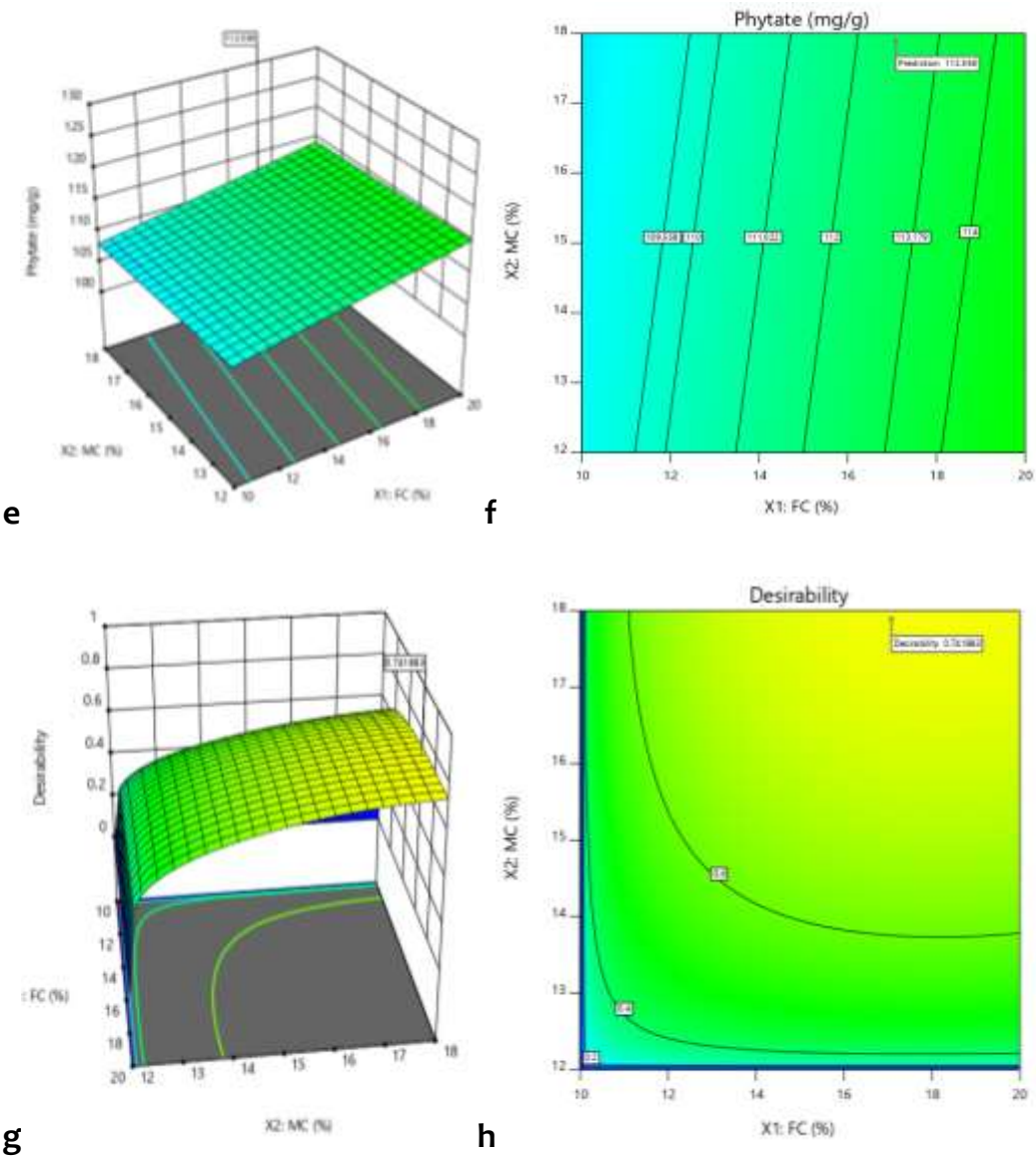

Figure 1. The response surfaces and estimated contours of (a and b) Trypsin inhibitor activity (TIA), (c and d) Tannic acid, (e and f) Phytate (g and h) desirability

Table 4: Sensory Scores of Extruded Snack from Sorghum -Groundnut-Date flour Blend

S/NO	FC	FCM	DS	Appear	Aroma	Taste	Crispness	OA
1	10	12	2	7.56±0.03[b]	7.11±0.00[b]	6.67±0.01[h]	8.00±0.00[b]	8.11±0.00[a]
2	30	12	2	5.33±0.01[k]	6.33±0.06[f]	6.44±0.06[j]	5.78±0.01[m]	6.78±0.01[g]

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3	10	18	2	6.78±0.01^{e}	7.00±0.01^{b}	6.67±0.03^{h}	7.33±0.01^{e}	7.33±0.01^{d}
4	30	18	2	7.11±0.00^{c}	7.00±0.01^{b}	8.90±0.00^{b}	7.44±0.06^{d}	7.44±0.06^{c}
5	10	12	6	6.67±0.01^{f}	6.44±0.03^{e}	7.11±0.00^{e}	7.00±0.00^{g}	7.00±0.00^{f}
6	30	12	6	8.00±0.00^{a}	7.78±0.00^{a}	8.33±0.04^{a}	8.11±0.00^{a}	8.11±0.00^{a}
7	10	18	6	5.67±0.01^{j}	6.44±0.03^{e}	7.00±0.01^{f}	6.67±0.01^{h}	6.67±0.01^{h}
8	30	18	6	6.78±0.00^{e}	6.22±0.02^{g}	7.00±0.01^{f}	7.00±0.00^{g}	7.00±0.00^{f}
9	3.18	15	4	7.00±0.00^{d}	6.67±0.00^{e}	7.22±0.03^{d}	7.56±0.01^{c}	7.56±0.01^{b}
10	36.8	15	4	6.11±0.00^{i}	6.33±0.01^{h}	6.67±0.01^{h}	6.14±0.03^{l}	6.14±0.03^{k}
11	20	9.95	4	6.37±0.02^{h}	6.33±0.06^{f}	7.11±0.00^{e}	6.78±0.01^{h}	6.78±0.01^{g}
12	20	20.05	4	6.56±0.01^{g}	6.44±0.06^{e}	6.89±0.01^{i}	6.44±0.57^{h}	6.44±0.06^{i}
13	20	15	2	6.67±0.01^{f}	6.56±0.01^{d}	6.89±0.00^{g}	7.11±0.00^{f}	7.11±0.00^{e}
14	20	15	6	8.00±0.00^{a}	7.11±0.01^{b}	67±0.01^{c}	7.56±0.01^{c}	7.56±0.01^{b}
15	20	15	4	8.00±0.01^{a}	7.11±0.01^{c}	6.22±0.03^{k}	6.33±0.04^{k}	6.33±0

all means ±SD bearing the same superscripts are not significantly different (p>0.05)

Key=FC=feed composition, FMC=feed moisture content, DS=die size, appear=appearance, OA = overall acceptability.

Appearance

Panellists' scores for appearance of the extrudates are shown in Table 4. Appearance is a major response variable governing food acceptance (Maga and Kim, 1989). Panellists' responses ranged from 5.33 to 8.00. Since appearance relies in sense of sight, extrudates colour and shape were most outstanding in the decision of panellists. Effect of extrusion processing on product colour has been variously described in the literature (Hsich *et al*., 1990, Iwe *et al*., 2001; Iwe, 2003). Similar reports on the effect of protein source on starch-based blends were reported (Badire and Mellowes, 1992). Thermal processing of food can result in increase in the potential for interaction between lipids, protein and carbohydrates and their breakdown products.

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Aroma

Table 4. is showing the results of aroma. The value ranged from minimum score of 6.33 to a maximum score of 7.78 on the nine-point Hedonic scale. Aroma value ranging from 5.0 to 6.0 on the nine-point Hedonic scale for extruded mixtures of soy and sweet potato flour was reported by Iwe *et al*. (2001). Protein – starch (Dahlin and Lorenz 1993) and protein – lipid (Badire and Mellowes, 1992) interaction during extrusion processing could affect flavour development of extrudates. Protein and starch can interact due to the attraction of their opposite charges to form "ionic" bonds thus, preventing loss of extrudates from granules, resulting in a decrease in viscosity, (Dahlin and Lorenz 1993).

Taste

The results for taste ranged from 6.44 to 8.33 on the nine-point Hedonic scale. Nutty flavour was experienced, in terms of taste. This nutty flavour development can be attributed to dry heating that took place during extrusion, mallard reaction and caramelization interaction (Rathod & Annapure, 2016).

Crispness

Panellists' mean scores for crispness of the extruded snacks from the blends of sorghum, defatted groundnut cake and date palm (Table 4.), and ranged from 5.78 to 8.11. In general, slight increase in defatted groundnut cake in the blends led to an increase in the mean score for likeness. The observation confirms the reports by some researchers (Singh *et al*., 2007and Nwabueze, 2006) that slight addition of protein enhanced crispness of extruded product.

Overall acceptability

The mean scores for overall acceptability (Table 4.) ranged from 6.14 to 8.11. The overall acceptability is influenced by all the other sensory attributes (appearance, aroma, crispness, and taste).A similar report on the sensory properties of extruded snacks as influenced by feed composition have been documented by(Gupta & Premavalli, 2012) on extrudate. Feed composition and moisture content have been found to determine significantly the overall quality attributes of expanded food products especially in terms of the expansion ration, texture, sensory properties and shelf life (Nikmaram et al., 2017). Results of this study agreed with the earlier observations and hence it can be anticipated that at higher groundnut level together with higher concentrations of other ingredients, process variables and sensory properties of the snack

formulations and overall acceptability would be adversely affected. Similarly, at higher levels of groundnut interactions might have been affecting the properties of the formulations thus changing the AFNs and the overall acceptability(Deshpande et al., 2008).

CONCLUSION AND RECOMMENDATIONS

The overall acceptability sensory data obtained in this study had revealed that samples produced from appropriate blends of flours from sorghum, date palm fruit and defatted groundnut cake were highly acceptable by the panellists used for this study. The overall acceptability and the AFNs data obtained is reliable to predict the behaviour of the system under different factor combination which could be used to produce a good quality extrudates, with optimal reduction of anti-nutritional factors that could be used for the development of post-covid-19 snack food.

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