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Research Article
Effects of Processing Conditions on the Proximate and Sensory Qualities of Groundnut Cake (*Kulikuli*)

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Abstract
Background and Objective: The composition and processing parameters of *Kulikuli* assure the desired culinary qualities, while the feelings of individuals during chewing of *Kulikuli* are the critical item reflecting its acceptability. Thus, the effects of the processing conditions, groundnut (*Arachis hypogaea*) variety, frying temperature (160-170°C) and frying time (1-3 min) for the proximate and sensory qualities of *Kulikuli* using the Taguchi technique was investigated. **Materials and Methods:** Different treatment combinations obtained by L_9 (3^3) of Taguchi orthogonal array were used to produce *Kulikuli*. The proximate and sensory qualities were determined using the standard AOAC method while a 9-point hedonic scale was used to determine the sensory qualities. **Results:** The optimum processing conditions for the proximate and sensory quality varied significantly ($p<0.05$). The proximate compositions of these products ranged between 5.99-6.99, 29.57-35.98, 10.62-22.38, 4.82-8.74, 1.17-2.56, 31.13-39.39 and 317.30-377.68 Kcal/100 g, respectively for moisture contents, protein contents, crude fats, ash, crude fibers, carbohydrates and energy values. The *Kulikuli* samples of GK, 160°C, 3 min and GK, 165°C, 2 min processing combinations were the most preferred by the panellists. **Conclusion:** The study provides an insight into the effects of processing conditions on the proximate and sensory qualities of *Kulikuli.*

Key words: Proximate composition, sensory quality, *Kulikuli*, Taguchi technique, groundnut

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Nigeria, groundnut cake, popularly known as *Kulikuli* is a by-product archived after expelling oil from the groundnut kernel[1]. It is a fried delicious snack frequently eaten with Akamu, Gari and vegetable salad. *Kulikuli* accords to the large dietary protein intake of broad sections of the population like young adults and school-age children[1]. Previously, groundnut cake and oil have contributed immensely to the development of the Nigerian economy with about 70% of total Nigeria export earnings, but, at present, the cake is consumed locally and used in the preparation of feed rations[2]. However, due to rudimental methods of production, standardizing the production process becomes difficult. The inability to standardize the processing condition makes it impossible to provide labels that can indicate vital information such as the name and address of producers, nutritional content and recommendations for storage and best-before date for human consumption.

Also, the scarcity of data regarding the proximate and sensory quality of *Kulikuli* across Nigeria or other *Kulikuli* consuming West African states may be because this product is mostly consumed by the low-income populace and therefore not seen as a significant food. However, Aletor and Ojelabi[3] reported that this snack could serve as a substantial protein supplement since it contained high crude protein and crude fat similar to its parent material, groundnut. Notwithstanding the long history of consumption of *Kulikuli* among the popular food items in the low-income populace, there exists a piece of draft information on the effects of the processing condition on the proximate and sensory attributes of the product.

Thus, there are a need to optimize the processing conditions that can guarantee adequate combinations. The Taguchi orthogonal array is a unique statistical experimental design approach that greatly improves the productivity of food processing[4]. Taguchi suggests the production processes needed to be applied at optimum levels with minimum variation in its functional attributes. The signal-to-noise(S/N) ratio represents quality characteristics for the observed data in the Taguchi method[5]. This study, therefore, employs the Taguchi technique to evaluate the effects of the processing conditions on the proximate and sensory qualities of *Kulikuli*.

MATERIALS AND METHODS

Study area: The study was carried out at Department of Food Science and Technology, Laboratory of Food Processing, Modibbo Adama University, Yola, from October, 2017 to December, 2020.

Source of materials: Groundnut (*Arachis hypogaea* L.) seeds varieties were purchased from the local market in Hong, Adamawa State. They were taken to the Department of Crops and Horticulture for confirmation of their varieties. The reagents and chemicals used were sourced from the analytical laboratory of the Department of Food Science and Technology, Modibbo Adama University, Yola and were of analytical standard.

Experimental design: The experimental design technique of Genichi Taguchi that was devised specifically to improve the quality of Japanese manufactured goods in the post-war period in conjunction with Analysis of Variance (ANOVA) was used. The Taguchi orthogonal array was designed using Minitab version 16 software (Minitab, Inc. Coventry, UK) for three factors at three levels, having an array of L_9 (3×3) based on the outcome of the preliminary trial experiment. Table 1 shows the outline of Taguchi experimental design L_9 (3×3) which gave nine experimental runs to evaluate the responses of the production of *Kulikuli*.

Table 1: Outline of Taguchi experimental design L_9 (3×3) for *Kulikuli* production

	Independent variables in coded form			Experimental variables in their natural units		
Experimental runs	A	B	C	Groundnut variety	Temperature (°C)	Time (min)
1	1	1	1	KA	160	3
2	1	2	2	KA	165	2
3	1	3	3	KA	170	1
4	2	1	2	KW	160	2
5	2	2	3	KW	165	1
6	2	3	1	KW	170	3
7	3	1	3	GK	160	1
8	3	2	1	GK	165	3
9	3	3	2	GK	170	2

KA: *Kampala* variety of groundnut, KW: *Kwanyamili* variety of groundnut and GK: *GogoKampala* variety of groundnut

Sample preparation and production of *Kulikuli*: The production of *kulikuli* was done as described by Emelike and Akusu[1] with slight modification. The groundnut seeds were sorted to select wholesome ones and then milled into a smooth paste. Groundnut paste and additives were weighed using an electronic balance (10 kg×1 g digital kitchen electronic scale). The smooth paste of 100 g was weighed into mixing bowls, with 0.5 g of powdered dry pepper and 0.3 g of salt added as seasoning. They were thoroughly mixed in the bowl and transferred to a properly clean chopping board. Vigorous kneading was applied then, extracting the oil from it[1]. The mixture gradually became harder and sticky during the kneading process, continually extracting oil. After which, the paste was moulded into flat round shapes (1 cm diameter and 5 cm length) and fried using the oil extracted to a somewhat brown colour under controlled temperature. The procedure was repeated for the other blends of groundnut paste following the experimental layout in Table 1. The produced *kulikuli* samples were cooled at room temperature (25±1°C) for about 15-20 min and then kept in an air-tight container until further analysis.

Determination of proximate compositions of *Kulikuli*: The moisture, protein, crude fats, ash and crude fibre of the produced *Kulikuli* samples were determined using the standard methods of AOAC[1]. The determination of the carbohydrate content was done by finding the difference between 100 and the total sum of the percentage of moisture, protein, fat, fibre and ash. The total caloric content was determined by calculation, using the following expression:

$$\text{Total caloric (Kcal/100 g)} = (\text{protein content}\times 2.44)+(\text{fat content}\times 8.37)+(\text{carbohydrate content}\times 3.57)$$

Determination of sensory qualities of *Kulikuli*: The organoleptic properties of the produced *Kulikuli* were carried out by fifty semi-trained panellists consisting of staff and students of the Department of Food Science and Technology, Modibbo Adama University of Technology, Yola, Adamawa State. The criteria for selecting the panellists are, interest and willingness to serve, above 16 years of age, regular consumers of *Kulikuli*, availability for the entire period of evaluation and neither sick nor allergic to the products[6]. The containers with the samples were coded and kept far apart to avoid crowding and for independent judgment. The panellists were asked to rank the *Kulikuli* based on their quality attributes (appearance, taste, aroma, toughness, crispiness, tooth packing, chewability and overall acceptability) using 9 points hedonic scale, where, 1 = 'dislike extremely' and 9 = 'like extremely'. Meanwhile, all necessary precautions were taken to prevent the carryover of flavour and overlap feeling during the evaluations. This was achieved by ensuring that the panellists rinsed their mouths with fresh room temperature water before and after each stage of evaluations.

Process optimization using Taguchi technique: Taguchi's optimization technique suggested that the production process or combination having the smallest variability is the optimal or best condition. This variability is determined by the signal-to-noise (S/N) ratio which represents quality characteristics for the observed data in the Taguchi method. The signal-to-noise ratio is used as an index to evaluate the quality of the production processes. The 'signal' represents the desired value, the 'noise' represents the undesirable value and the signal to noise ratio expresses the scatter around the desired values. The experimental results obtained were then transformed into two types of S/N ratios namely, smaller-the-better, nominal-the-best and larger-the-better as shown in Eq. 1 and 2[5].

Smaller is the better characteristic:

$$\frac{S}{N} = -10\log\frac{1}{n}\left(\sum y^2\right) \quad (1)$$

Larger is the better characteristic:

$$\frac{S}{N} = -10\log\frac{1}{n}\left(\sum \frac{1}{y^2}\right) \quad (2)$$

Where:

$\bar{y}$ = Average response data
Sy^2 = Variation of y and n in the number of treatments
y = Response data

For each type of the characteristics of the above S/N ratio transformation, the average mean of the response for each level of the factors as shown in the experimental table was calculated. Also, the average signal to noise ratio (S/N ratio) was calculated for each level of all the factors. The smaller the better equation was used for calculating the signal to noise ratio of moisture contents, fat contents while the larger the better equation was used for calculating the signal to noise ratio of protein, ash, crude fibre, carbohydrate and energy value.

Statistical analysis: The experimental data obtained were analyzed using a statistical package for social sciences (SPSS) software (SPSS 20.0 for Windows, SPSS Inc., Chicago, IL, USA) and the results were expressed as Means±Standard Error (SE). The significance of the difference between the means was determined using Duncan's Multiple Range Test and the differences were considered to be significant at $p<0.05$.

RESULTS AND DISCUSSION

Effect of the processing conditions on the proximate compositions of *Kulikuli* using Taguchi techniques: The influence of the processing conditions on the proximate compositions of *Kulikuli* is presented in Table 2 and 3. The moisture content of the *Kulikuli* samples ranged from 5.77-6.99% which showed that experimental run 4 (KW, 160°C, 2 min) had the least value while experimental run 3 (KA, 170°C, 1 min) had the highest value. The moisture contents were slightly significant ($p<0.05$) from each other which were observed to be due to the processing conditions. They were also not being too high, which is less than 13% recommended by FAO/WHO[7]. This is predisposing them to fungal and bacterial attacks and they can also be stored for a long period of storage time.

The effect of each processing factor on the moisture content of *Kulikuli* was established by calculating the S/N ratio of the desired factor levels. The response means S/N ratio for each level of the controlling factors is shown in Table 4. The response table includes ranks based on delta value (highest minus lowest). Rank 1st is assigned to the parameter with the highest delta value, rank 2nd to second highest delta value and rank 3rd to the least delta value. Based on the analysis, the groundnut variety has the highest delta value thus rank 1st is assigned to it follow by frying time (rank 2nd) and temperature of frying (rank 3rd). This shows that the groundnut variety is the most significant processing parameter controlling the moisture content of *Kulikuli* sample. While the time and temperature of frying follow, respectively.

The lower the S/N ratio the better was considered to optimize the moisture content of the *Kulikuli* produced. The highest S/N ratio (-15.22) was obtained for the KW variety along with a 2 min frying time at 160°C frying temperature. This shows that the use of KW variety along with 2 min frying time at 160°C frying temperature is the best processing combination to reduce the moisture content of *Kulikuli* to the barest minimum within the experimental domain considered in the present study. On an average basis, the moisture content of the KW variety (5.77-6.03%) was the lowest followed by the GK variety (5.96-6.02%) while the KA variety (6.30-6.99%) was the highest. The highest moisture content was also reported by Sarkiyayi and Kanu[8] for *Kulikuli* produced from Kampala to Munch variety.

The crude protein content of the *Kulikuli* samples ranged from 29.57-35.98% which showed that experimental run 4 (KW, 160°C, 2 min) had the least value while experimental run 3 (KA, 160°C, 3 min) had the highest value. The protein contents were significant ($p<0.05$) from each other which were observed to be due to the processing conditions and varieties used. On an average base, the crude protein content

Table 2: Effect of the processing conditions on the proximate compositions (moisture, crude protein and crude fat) of *Kulikuli* using Taguchi techniques

Experimental runs	Moisture contents	S/N moisture contents	Crude protein	S/N crude protein	Crude fat	S/N crude fat
KA, 160°C, 3 min	6.56 ± 0.03^{b}	-16.34	35.98 ± 0.11^{a}	31.12	10.62 ± 0.04^{h}	-20.52
KA, 165°C, 2 min	6.30 ± 0.03^{c}	-15.98	35.10 ± 0.05^{b}	30.91	13.91 ± 0.10^{g}	-22.86
KA, 170°C, 1 min	6.99 ± 0.04^{a}	-16.89	35.07 ± 0.02^{b}	30.90	13.68 ± 0.18^{g}	-22.72
KW, 160°C, 2 min	5.77 ± 0.01^{e}	-15.22	29.57 ± 0.04^{g}	29.42	20.38 ± 0.02^{c}	-26.18
KW, 165°C, 1 min	6.03 ± 0.01^{d}	-15.60	31.76 ± 0.01^{f}	30.04	22.55 ± 0.10^{a}	-27.06
KW, 170°C, 3 min	5.91 ± 0.04^{d}	-15.43	34.24 ± 0.11^{c}	30.69	18.59 ± 0.04^{d}	-25.38
GK, 160°C, 1 min	5.96 ± 0.06^{d}	-15.50	33.78 ± 0.01^{e}	30.57	17.80 ± 0.02^{f}	-25.01
GK, 165°C, 3 min	6.02 ± 0.01^{d}	-15.59	34.05 ± 0.03^{d}	30.64	18.22 ± 0.04^{e}	-25.21
GK, 170°C, 2 min	5.99 ± 0.05^{d}	-15.54	31.65 ± 0.01^{f}	30.01	22.07 ± 0.07^{b}	-26.88

Mean values in the same columns bearing the same superscript are not significantly different ($p<0.05$). KA = *Kampala* variety of groundnut, KW: *Kwanyamili* variety of groundnut and GK = *GogoKampala* variety of groundnut

Table 3: Effect of the processing conditions on the proximate composition (crude ash, crude fibre and carbohydrate) of *Kulikuli* using Taguchi techniques

Experimental runs	Crude ash	S/N crude ash	Crude fibre	S/N crude fibre	Carbohydrate	S/N carbohydrate
KA, 160°C, 3 min	5.20 ± 0.05^{cd}	14.32	2.26 ± 0.03^{abc}	7.06	39.39 ± 0.19^{a}	31.91
KA, 165°C, 2 min	4.93 ± 0.08^{d}	13.85	2.16 ± 0.11^{abc}	6.67	37.63 ± 0.31^{b}	31.51
KA, 170°C, 1 min	8.44 ± 0.05^{a}	18.52	2.12 ± 0.05^{abc}	6.51	33.71 ± 0.24^{c}	30.56
KW, 160°C, 2 min	4.82 ± 0.02^{d}	13.66	1.78 ± 0.02^{c}	4.98	37.80 ± 0.02^{b}	31.55
KW, 165°C, 1 min	7.37 ± 0.01^{b}	17.35	1.17 ± 0.02^{d}	1.36	31.13 ± 0.12^{d}	29.86
KW, 170°C, 3 min	5.08 ± 0.08^{d}	14.12	2.02 ± 0.05^{bc}	6.09	34.17 ± 0.10^{c}	30.67
GK, 160°C, 1 min	8.74 ± 0.28^{a}	18.83	2.56 ± 0.42^{a}	8.17	31.17 ± 0.63^{d}	29.87
GK, 165°C, 3 min	5.50 ± 0.03^{c}	14.8	2.36 ± 0.05^{ab}	7.44	33.87 ± 0.05^{c}	30.50
GK, 170°C, 2 min	7.45 ± 0.17^{b}	17.44	1.21 ± 0.07^{d}	1.62	31.64 ± 0.23^{d}	30.01

Mean values in the same columns bearing the same superscript are not significantly different ($p<0.05$). KA: *Kampala* variety of groundnut, KW: *Kwanyamili* variety of groundnut and GK: *GogoKampala* variety of groundnut

Table 4: Response table for means signal to noise (S/N) ratio for the proximate compositions of *Kulikuli* using Taguchi techniques

	Groundnut variety	Frying temperature	Frying time
Moisture contents (smaller is better)			
Level 1	-16.40	-15.58	-16.00
Level 2	-15.42	-15.72	-15.58
Level 3	-15.54	-15.95	-15.79
Delta	0.99	0.27	0.42
Rank	1st	3rd	2nd
Crude protein (larger is better)			
Level 1	30.97	30.37	30.50
Level 2	30.97	30.53	30.11
Level 3	30.41	30.53	30.82
Delta	0.93	0.16	0.71
Rank	1st	3rd	2nd
Crude fat (smaller is better)			
Level 1	-22.03	-23.90	-24.93
Level 2	-26.21	-25.04	-25.31
Level 3	-25.70	-24.99	-23.70
Delta	4.18	1.14	1.60
Rank	1st	3rd	2nd
Ash (larger is better)			
Level 1	15.56	15.60	18.23
Level 2	15.04	15.33	14.98
Level 3	17.02	16.69	14.41
Delta	1.98	1.36	3.82
Rank	2nd	3rd	1st
Crude fibre (larger is better)			
Level 1	6.746	6.737	5.345
Level 2	4.144	5.157	4.424
Level 3	5.741	4.737	6.863
Delta	2.602	2.000	2.439
Rank	1st	3rd	2nd
Carbohydrate (larger is better)			
Level 1	31.32	31.11	30.10
Level 2	30.69	30.66	31.02
Level 3	30.16	30.41	31.06
Delta	1.17	0.70	0.96
Rank	1st	3rd	2nd

Level 1: *Kampala* variety, 160°C frying temperature and 3 min frying time, Level 2: *Kwanyamili* variety, 165°C frying temperature and 2 min frying time, Level 3: *GogoKampala* variety and 170°C frying temperature and 1 min frying time

of the KA variety was the highest followed by the GK variety while the KW variety was the lowest. However, the high protein values recorded for *Kulikuli* produced with these experimental runs is an indication that they are a good source of protein in snack foods. These high protein levels will also provide the daily allowance recommendation of protein (23.0-36.0 g/100 g) for school-age children reported by Emelike and Akusu[1].

The effect of each processing factor on the crude protein content of *Kulikuli* was established by calculating the S/N ratio of the desired factor levels. The response means S/N ratio for each level of the controlling factors is shown in Table 4. From the response mean S/N ratio, rank 1st is assigned to groundnut variety as the highest delta value follow by frying time (rank 2nd) and temperature of frying (rank 3rd) which is the lowest delta value. This shows that the groundnut variety is the most significant processing parameter controlling the crude protein content of *Kulikuli* sample. While the time and temperature of frying follow, respectively.

The higher the S/N ratio the better was considered to optimize the crude protein content of the *Kulikuli* produced. The highest S/N ratio (31.12) was obtained for KA variety along with a 3 min frying time at 160°C frying temperature. This shows that the use of KA variety along with 3 min frying time at 160°C frying temperature is the best processing combination to preserve the crude protein content of *Kulikuli* samples within the experimental domain considered in the present study. Notwithstanding, the presence of high crude protein content in all the *Kulikuli* samples suggested that are good sources of protein. Sarkiyayi and Kanu[8] reported that dietary proteins are needed for the synthesis of the new cell wall, repair of worn-out tissues, hormones, enzymes, antibodies and other substances required for healthy functioning and development of the body and its protection and also for the treatment of protein-energy malnutrition.

The crude fat content of the *Kulikuli* samples ranged from 10.62-22.07% with experimental run 1 (KA, 160°C, 3 min) having the least value while experimental run 9 (GK, 170°C, 2 min) had the highest value. The fat contents were statistically significant (p<0.05) from each other. On an average basis, the crude fat content of the KW variety (18.59-22.55%) was the highest followed by the GK variety (17.80-20.07%) while the KA variety(10.62-13.91%) was the lowest. The high-fat values recorded for *Kulikuli* produced with these experimental runs were observed to be due to the high-fat content of groundnuts and the processing techniques used which involved the addition of cooking oils and/or deep-frying. While the height value of the KW variety is an indication that they are a good source of fat in snack foods than others. The crude fat values recorded for *Kulikuli* produced with these experimental runs were significantly higher than 6.00% which was the minimum recommendations of FAO/WHO for weaning foods as reported by Msheliza *et al.*[7].

The effect of each processing factor on the crude fat content of *Kulikuli* was established by calculating the S/N ratio of the desired factor levels. The response means S/N ratio for each level of the controlling factors is shown in Table 4. From the response mean S/N ratio, rank 1st is assigned to groundnut variety as the highest delta value follow by frying time (rank 2nd) and temperature of frying (rank 3rd) which is the lowest delta value. This shows that the groundnut variety is the most significant processing parameter controlling the crude fat content of *Kulikuli* sample. While the time and temperature of frying follow, respectively.

The smaller the S/N ratio the better was considered to optimize the crude fat content of the *Kulikuli* produced. The highest S/N ratio (-20.52) was obtained for KA variety along with a 3 min frying time at 160°C frying temperature. This shows that the use of KA variety along with 3 min frying time at 160°C frying temperature is the best processing combination to reduce the crude fat content of *Kulikuli* samples within the experimental domain considered in the present study. The high-fat contents of the *Kulikuli* samples showed that they supply strong energy which helps in the transportation of fat-soluble vitamins such as vitamin A, D, E and K and also contribute substantially to the energy value of foods as well as provide essential fatty acids for optimal neurological, immunological and functional development in children[8]. However, high-fat foods are susceptible to both hydrolytic and oxidative/enzymatic rancidity which is responsible for off flavour and this affects both the general acceptability and storage stability of the products[7].

Ash content is the remaining residue after the original matter in the food sample has been burnt away and it indicates the minerals level of the food samples. The ash content of the *Kulikuli* samples ranged from 4.82-8.74% with experimental run 4 (KW, 160°C, 2 min) having the least value while experimental run 7 (GK, 160°C, 1 min) had the highest value shown in Table 3. The ash contents were statistically significant (p<0.05) from each other. The ash values recorded for *Kulikuli* produced with these experimental runs were relatively higher than the 2.80-4.60% range reported by Ezekiel *et al.*[9] and 6.0 g/100 g DM reported by Aletor and Ojelabi[3]. The variations in the results were observed to be due to differences in groundnuts varieties and the processing techniques used.

The effect of each processing factor on the ash content of *Kulikuli* was established by calculating the S/N ratio of the desired factor levels. The response means S/N ratio for each level of the controlling factors is shown in Table 4. From the response mean S/N ratio, rank 1st is assigned to frying time as the highest delta value follow by groundnut variety (rank 2nd) and temperature of frying (rank 3rd) which is the lowest delta value. This shows that the frying time is the most significant processing parameter controlling the ash content of *Kulikuli* sample. While the groundnut variety and temperature of frying follow, respectively. The larger the S/N ratio the better was considered to optimize the crude fat content of the *Kulikuli* produced. The highest S/N ratio (18.86) was obtained for the GK variety along with a 1 min frying time at 160°C frying temperature. This shows that the use of GK variety along with 1 min frying time at 160°C frying temperature is the best processing combination to preserve the ash content of *Kulikuli* samples within the experimental domain considered in the present study. The high ash contents of the *Kulikuli* samples is an indication that they are good sources of minerals.

The crude fibre content of the *Kulikuli* samples ranged from 1.17-2.56% with experimental run 5 (KW, 165°C, 1 min) having the least value while experimental run 7 (GK, 160°C, 1 min) had the highest value. The crude fibre contents on an average base showed that KA variety was the highest followed by GK variety while the KW variety was the lowest. Notwithstanding the varieties and processing conditions differences in the experimental runs, the ash and crude fibre contents values obtained were within the recommended FAO/WHO value of less than 5% for crude fibre and less than 10% for ash contents[7].

The effect of each processing factor on the crude fibre content of *Kulikuli* was established by calculating the S/N ratio of the desired factor levels. The response means S/N ratio for each level of the controlling factors is shown in Table 4. From the response mean S/N ratio, rank 1st is assigned to groundnut variety as the highest delta value follow by frying time (rank 2nd) and temperature of frying (rank 3rd) which is the lowest delta value. This shows that the groundnut variety is the most significant processing parameter controlling the crude fat content of *Kulikuli* sample. While the time and temperature of frying follow, respectively.

The larger the S/N ratio the better was considered to optimize the crude fibre content of the *Kulikuli* produced. The highest S/N ratio (8.17) was obtained for the GK variety along with a 1 min frying time at 160°C frying temperature. This shows that the use of GK variety along with 1 min frying time at 160°C frying temperature is the best processing combination to reserve the crude fibre content of *Kulikuli* samples within the experimental domain considered in the present study. The high fibre content of these *Kulikuli* samples is an indication that it will aid fast metabolism in the gastrointestinal tract. Also, high crude fibre content is an important dietary component in preventing overweight, constipation, cardiovascular disease, diabetes and colon cancer[10].

The carbohydrate content of the *Kulikuli* samples ranged from 31.13-39.39% with experimental run 5 (KW, 165°C, 1 min) having the least value while experimental run 1 (KA, 160°C, 3 min) had the highest value. The carbohydrate contents on an average basis showed that the KA variety was the highest followed by the KW variety while the GK variety was the lowest. Notwithstanding the varieties and processing conditions differences in the experimental runs, the *Kulikuli* samples produced are nutrient-dense since they are high in energy due to their high protein and carbohydrate content[1]. The carbohydrate values corroborated with the findings of Oko *et al*.[11].

The effect of each processing factor on the carbohydrate content of *Kulikuli* was established by calculating the S/N ratio of the desired factor levels. The response means S/N ratio for each level of the controlling factors is shown in Table 4. From the response mean S/N ratio, rank 1st is assigned to groundnut variety as the highest delta value follow by frying time (rank 2nd) and temperature of frying (rank 3rd) which is the lowest delta value. This shows that the groundnut variety is the most significant processing parameter controlling the carbohydrate content of *Kulikuli* sample. While the time and temperature of frying follow, respectively.

The larger the S/N ratio the better was considered to optimize the carbohydrate content of the *Kulikuli* produced. The highest S/N ratio (31.91) was obtained for KA variety along with 3 min frying time at 160°C frying temperature. This shows that the use of KA variety along with 3 min frying time at 160°C frying temperature is the best processing combination to reserve the carbohydrate content of *Kulikuli* samples within the experimental domain considered in the present study. The high carbohydrate content of these *Kulikuli* samples is an indication that they are good sources of carbohydrates. However, this high carbohydrate content might make this product not good for patients with diabetes and other related health problems. The energy value ranged from 317.30-377.68 Kcal. These values are within the recommended minimum daily requirement of 380-425 kcal as recommended by FAO/WHO[7].

Effect of the processing conditions on the sensory qualities of *Kulikuli*: The effect of the processing conditions on the organoleptic properties of the *Kulikuli* produced is presented in the spider chart in Fig. 1. The *Kulikuli* samples were significantly different ($p \geq 0.05$) from each other. The experimental run 7 (GK, 160°C, 1 min) had the highest rating and the experimental run 3 (KW, 170°C, 1 min) had the lowest rating in terms of appearance, taste, colour, aroma, crispiness, tooth packing, chewing ability and overall acceptability. However, experimental run 8 (GK, 165°C, 3 min) had the highest rating and experimental run 3 (KW, 170°C, 1 min) had the lowest rating in terms of toughness. The result obtained showed that with the increase in the frying temperature lowered the scores for all the sensory qualities of *Kulikuli* samples evaluated. Also, out of the three groundnut varieties, *Kulikuli* samples produced from the GK variety were preferable to others. This indicates that frying at higher temperatures adversely affects the organoleptic properties of *Kulikuli*. A similar result was observed by Gernah *et al*.[12] in *Zogale* a snack food produced from peanut cake and boiled moringa leaves.

Generally, the acceptance of the *Kulikuli* seems to be dependent on the appearance, taste, colour, aroma, toughness, crispiness, tooth packing, chewability since the pattern of overall acceptance was similar to these tests qualities. Bakare *et al*.[13] reported that the appearance taste, colour, aroma, toughness, crispiness, tooth packing, chewability are important parameters in judging properly fried foods that not only reflect the suitable raw materials used for the preparation but also provide information about the formulation and quality of the products. Therefore, since all the panellists used in this sensory evaluation are semi-trained and familiar with the qualities of *Kulikuli*, then it could be concluded that the GK variety with 1-2 min frying time for not less than 165°C frying temperature is an appropriate processing combination.

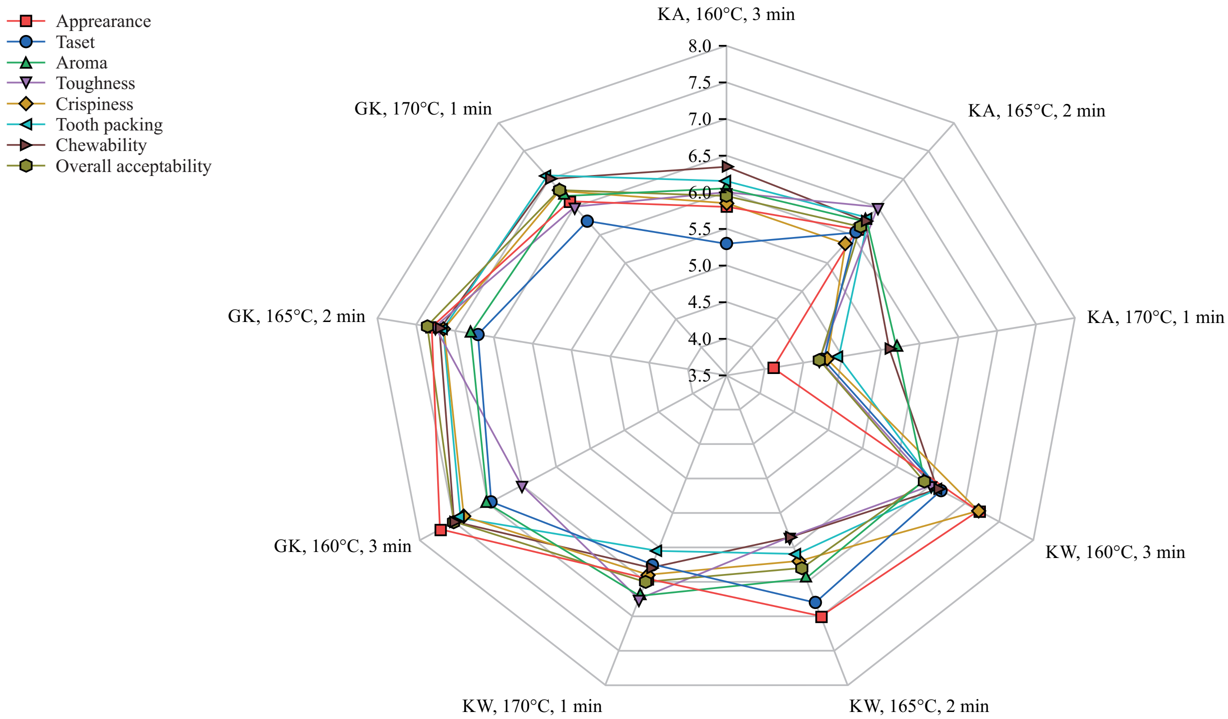

Fig. 1: Effect of the processing conditions on the sensory qualities of *Kulikuli*
KA: *Kampala*, KW: *Kwanyamili* and GK: *Gogo kampala*

CONCLUSION

Proximate analysis showed that *Kulikuli* with high nutritional value in terms of protein, fibre and carbohydrate was produced with KA variety, fried at 160°C for 3 min. However, the result showed a good balance of all the nutrients evaluated in the samples. The sensory result revealed that samples produced from GK varieties, fried at 160°C for 3 min and fried at 165°C for 2 min were the most preferred by the panellists. The study, therefore, provides an insight on the effects of processing conditions on the proximate and sensory qualities of *Kulikuli*.

SIGNIFICANCE STATEMENT

This study discovers the processing combination that significantly affected the proximate and sensory qualities of *Kulikuli* samples. The results provided an insight into the processing combinations that yield nutrients dense and organoleptically accepted *Kulikuli* pieces. This study will help the researcher uncover the critical areas of the processing combination that affected the proximate and sensory qualities of the *Kulikuli* samples that many researchers could not explore. Thus a new theory on the processing variables as affected proximate and sensory attributes of *Kulikuli* may be arrived at.

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