Table 4: Economics of Supplementing Elephant Grass (*Pennisetum purpureum)* with Three Different Types of Protein Sources.

Parameters	**Diets**		
	CCM/MB (I)	**CSC/MB (II)**	**SBW/MB (III)**
Total feed intake (kg)	1.18	1.13	1.48
Feed cost /Kg (₦)	75.92	102.69	69.72
Cost of feed consumed (₦)	89.59	116.04	103.19
Total weight gain (Kg)	0.72	0.91	1.11
Feed cost / Kg gain (₦)	124.42	127.52	92.96

CCM/MB = Coconut meal/Maize bran, CSC/MB = Cottonseed cake/Maize bran, SBW/MB = Soyabean waste/Maize bran, SEM = Standard error of the mean,

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Rheological Modification of Donkwa (Ground Cake Snacks) Using Food Gel

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Abstract

Donkwa is a common snack that is commonly taken in the northern part of Nigeria and it is prepared from roasted groundnut (peanut) mixed with roasted cereal (maize) flour and spiced with ginger and pepper, and sugar are added to taste. The mixture were pounded and moulded into balls that can be eaten without further processing. The need to optimize donkwa to meet the daily nutrient need of the malnourished were made by improvement of the textural and /or pasting properties of donkwa using food gels. The compositional effects of major ingredients on donkwa textural properties were also determined. Samples of groundnut, maize, and sorghum were obtained locally from Kure modern market, minna, Niger state. The groundnut were cleaned, sorted and roasted. The maize were cleaned, sorted and ground into powdered and sieved. The sorghum were cleaned, sorted and soaked in cleaned water for 24hours. The wet sorghum was milled to paste and 4litres of water were added to the paste and allowed to settled and sieved. The pastes were sun dried, and used as gelling agent (Binder). The roasted groundnut were mixed with the maize powder and milled to paste for the three ratio (G80-M20, G70-M30, G60-M40) with varied proportion of binder (food gel), 2%, 4%, and 6% respectively. These specified ratio of groundnut paste,(x_1) maize powder(x_2) and binder(x_3) were mixed *accordingly. The mixture were constituted differently into a number of experimental treatments with 0.000053g of Sugar, 0.0000025g of Salt, and 0.0000012g of pepper as ingredients proportion for each run. The mixture were allowed to cool and settle, and moulded into various shapes and sizes. A three variables three levels factorial design matrix ($N=3^3$) were used to analysed the sensory data. The results were subjected to data analysis using SPSS 16.0, 2010 version. Analysis of variance was used to check if there were significant differences between the treatments and Student-Newman-Keuls Multiple range test (SNK) was used to separate means that were significantly different. The results showed that out of the 27 experimental treatments, treatment 2 with 70% groundnut, 20% maize and 2% binder gave the highest qualities in terms of adhesiveness, firmness, chewiness, textural hardness and cohesiveness. Therefore, it was recommended as the best formulation for high quality donkwa preparation.*

Keywords: *rheological, modification, donkwa, foodgels.*

Introduction

The original constituent of donkwa is a combination of roasted maize and groundnut to form a paste. To improve the rheology, taste and flavor of the product, ginger, sugar, spices and paper in a given proportion were added to it. The mixture is pounded and moulded into balls that can be eaten without further processing (Abdurrahman *et al.*, 2003). A standard ratio for donkwa production has been reported to be either in the ratio of 40:60 of maize to groundnut or 50:50 of maize to groundnut because at these levels, the mineral content are significantly high (Ahmad, 2010).The need to optimize local food products to meet the daily nutrient need of the malnourished population in Africa has been advanced in different research activities, resulting in several high-energy-protein foods (Sanni, 1997; Gilbert, *et al*., 2000; Jideani*et al*., 2001). Concerted efforts were needed to achieve high quality, wholesome and safe products in the snacks food industry.

MATERIAL AND METHODS

Experimental materials;

Samples of groundnut, maize, and sorghum were obtained locally from kure modern market, minna, Niger state. The groundnut was cleaned, sorted and roasted. The maize was cleaned, sorted and ground into powdered and sieved. The sorghum was cleaned, sorted and soaked in cleaned water for 24hours. The wet sorghum was milled to paste and 4litres of water were added to the paste and allowed to settled and sieved. The sieved powdered were subjected to sun dried, and used as gelling effects (Binder).

Composite formulation

The roasted groundnut were mixed with the maize powder and milled to paste for the three ratio with varied proportion of binder (food gel), 2%, 4%, and 6% respectively. Specified percentages of groundnut paste, maize powder and binder were mixed as indicated in the Table of design matrix. The milled mixtures were pounded differently into a number of experimental treatments with 0.000053g of Sugar, 0.0000025g of Salt, and 0.0000012g of Pepper as ingredient proportion for each run. The Mixture was allowed to cool and settle, and moulded into various shapes and sizes.

***Experimental Design Method**:*

A three variables, three levels factorial design ($N=3^3$) provides the frame work for the experimental runs. Data were subjected to statistical analysis using SPSS 16.0, 2010 version. Analysis of variance was used to check if there were significant differences between the treatments and Student-Newman-Keuls Multiple range test (SNK) was used to separate means that were significantly different.

PLATE 1

CONTROL SAMPLES

PLATE 2

IMPROVED SAMPLES

RESULTS

ANALYSIS RESULT OF DONKWA ADHESIVENESS

The mean scores for adhesiveness of the 27 different donkwa treatments were as shown in table 3.1

Table 3.1: Analysis result of Donkwa Adhesiveness

Treatments	Mean	± standard deviation
Control	4.13^{ab}	1.48
1	3.96^{ab}	1.32
2	4.33^{ab}	0.89
3	4.50^{ab}	1.15
4	3.71^{ab}	0.58
5	3.79^{ab}	0.81
6	4.25^{ab}	0.40
7	3.54^{b}	0.86
8	3.71^{ab}	1.21
9	3.71^{ab}	0.86
10	4.00^{ab}	1.33
11	4.29^{ab}	0.92
12	3.92^{ab}	0.76

13	4.96^{a}	0.81
14	4.04^{ab}	0.72
15	3.67^{ab}	1.21
16	3.54^{b}	0.86
17	3.58^{ab}	0.93
18	4.04^{ab}	1.21
19	4.17^{ab}	0.44
20	4.50^{ab}	0.93
21	4.38^{ab}	0.48
22	3.58^{ab}	0.79
23	4.29^{ab}	0.66
24	4.38^{ab}	0.43
25	4.03^{ab}	0.68
26	4.75^{ab}	0.78
27	4.25^{ab}	0.89

Mean on the same column with different superscript are significantly different ($P<0.05$)

Range: 1.00 – 6.00

ANALYSIS RESULT OF DONKWA CHEWINESS

The mean scores for chewiness of the 27 different donkwa treatments were as shown in table 3.3

Table 3.3:Analysis result of Donkwa chewiness

Treatments	Mean	±standard deviation
Control	3.75^{a}	1.54
1	4.08^{a}	1.08
2	4.58^{a}	0.87
3	4.96^{a}	0.81
4	4.96^{a}	0.62
5	3.71^{a}	1.64
6	4.63^{a}	0.96
7	4.38^{a}	1.13
8	4.08^{a}	1.53

9	4.33[a]	1.25
10	4.13[a]	1.54
11	4.00 [a]	1.35
12	3.92 [a]	1.29
13	4.63[ac]	1.23
14	4.29[a]	1.37
15	4.33[a]	1.21
16	4.29[a]	1.16
17	4.46[a]	1.25
18	4.17[a]	1.45
19	4.08[a]	1.46
20	4.29[a]	1.18
21	4.67[a]	1.05
22	4.33[a]	1.21
23	4.50[a]	1.07
24	4.71[a]	0.89
25	4.63[a]	1.13
26	5.08[a]	0.36
27	5.25[a]	0.34

Means are not significantly different from each other ($p > 0.05$)
Range: 1.00 – 6.00

ANALYSIS RESULT OF DONKWA FIRMNESS

The mean scores for firmness of the 27 different donkwa treatments were as shown in table 3.4

Table 3.4: analysis result of Donkwa firmness

Treatments	Mean	± standard deviation
Control	3.25[ab]	1.60
1	3.83[ab]	1.34
2	3.96[ab]	1.36
3	3.17[ab]	1.34
4	4.83[a]	0.94
5	4.13[ab]	1.42

6	3.38^{ab}	1.11
7	3.42^{ab}	0.97
8	3.13^{ab}	0.80
9	3.08^{ab}	1.24
10	3.25^{ab}	1.60
11	4.04^{ab}	0.72
12	4.00^{ab}	1.11
13	4.17^{ab}	1.56
14	3.13^{ab}	1.23
15	3.13^{ab}	0.64
16	2.58^{b}	0.87
17	3.63^{ab}	0.43
18	3.04^{b}	0.69
19	3.42^{ab}	1.04
20	3.00^{b}	0.93
21	3.25^{ab}	1.39
22	2.83^{b}	1.05
23	3.46^{ab}	0.86
24	3.25^{ab}	1.54
25	3.2^{ab}	0.78
26	3.17^{ab}	1.53
27	4.33^{ab}	1.68

Mean on the same column with different superscript are significantly different (P<0.05)

Range: 1.00 – 6.00

ANALYSIS RESULT OF DONKWA TEXTURAL HARDNESS

The mean scores for textural hardness of the 27 different donkwa treatments were as shown in table 3.5

.Table 3.5: Analysis result of Donkwa textural hardness.

Treatments	Mean	±standard deviation
Control	3.67^{abc}	1.25
1	3.91^{abc}	1.62
2	5.08^{ab}	0.56

3	2.91^{d}	1.51
4	4.67^{ab}	0.65
5	4.58^{abc}	1.49
6	4.54^{abc}	1.41
7	4.29^{abc}	1.57
8	4.54^{abc}	1.53
9	4.46^{abc}	1.10
10	4.33^{abc}	0.89
11	3.33^{cd}	1.60
12	4.75^{ab}	0.66
13	3.42^{cd}	1.83
14	4.50^{abc}	1.00
15	4.41^{abc}	0.93
16	4.75^{ab}	0.62
17	5.25^{a}	0.45
18	4.92^{ab}	0.70
19	4.46^{abc}	0.84
20	4.71^{ab}	0.45
21	4.21^{abc}	1.27
22	4.75^{ab}	0.45
23	4.00^{abc}	1.40
24	4.42^{abc}	0.90
25	4.13^{abc}	1.19
26	4.50^{abc}	1.07
27	3.88^{abc}	1.68

Mean on the same column with different superscript are significantly ($P<0.05$)
Range: 2.00 – 6.00

ANALYSIS RESULT OF DONKWA COHESIVENESS

The mean scores for cohesiveness of the 27 different donkwa treatments were as shown in table 3.6

Table 3.6: analysis result of donkwa textural cohesiveness

Treatments	Mean	±standard deviation
Control	3.58^{abcdef}	1.73

1	3.92^{abcde}	1.16
2	4.68^{a}	.84
3	3.71^{abcdef}	1.25
4	3.63^{abcdef}	1.19
5	3.79^{abcdef}	1.20
6	2.29^{f}	1.23
7	3.75^{abcdef}	1.12
8	3.38^{abcdef}	1.23
9	3.82^{abcdef}	0.90
10	3.46^{abcdef}	1.05
11	4.29^{abc}	1.03
12	3.79^{abcdef}	0.81
13	4.13^{abcd}	1.30
14	3.58^{abcdef}	1.29
15	2.67^{def}	0.78
16	3.50^{abcdef}	1.04
17	2.92^{bcdef}	0.97
18	2.50^{ef}	0.56
19	2.79^{cdef}	0.86
20	2.88^{bcdef}	0.88
21	3.54^{abcdef}	0.89
22	2.71^{def}	0.92
23	3.50^{abcdef}	1.22
24	4.38^{ab}	0.48
25	3.58^{abcdef}	0.36
26	3.71^{abcdef}	0.94
27	3.79^{abcdef}	0.58

Mean on the same column with different superscript are significantly different ($P<0.05$)
Range: 1.00 – 6.00

DISCUSSION

Result of donkwa sensory attributes

The adhesiveness of donkwa of experimental treatments 7, 13 and 16 are insignificantly different from each other but significantly different from the control, while the remaining treatments were not significantly different from each other and the control at ($p<0.05$). There were no significant difference in the chewiness of the 27 experimental treatments with the exception of treatment 13 which is significantly different from the control and other experimental treatments ($p< 0.05$). The experimental treatments 4,16,18,20 and 22 showed significant difference in firmness from the control, but the experimental treatment 4 was significantly different from both the control and others ($p< 0.05$). The treatments 2, 4, 12, 16, 18, 20 and 22 were not significantly different from each other but significantly different from the control in hardness at ($p < 0.05$). The experimental treatments 11 and 13 were not significantly different from each other in textural hardness at ($p < 0.05$). The experimental treatments 3 and 17 were significantly different from each other, from the control and from other treatments ($p < 0.05$). The treatments 1, 5, 6, 7, 8, 9, 10, 14, 15, 19, 23, 24, 25, 26 and 27 were not significantly different from each other and the control at ($p < 0.05$).The experimental treatments of 3, 4, 5, 7, 8, 9, 10, 12, 14, 16, 21, 23, 25, 26 and 27 were not significantly different from each other and from the control at ($p < 0.05$). The treatments 17 and 20 were not significantly different from one another but significantly different from the control at ($p < 0.05$).

Conclusion and Recommendation

Conclusion

The 27 experimental treatments showed that treatment 13 had quality characteristics in terms of adhesiveness, chewiness, firmness and cohesiveness than the control. However, it has lower textural quality characteristics than the control.

The treatment 27 recorded the highest chewiness, high firmness, moderately high textural hardness, high cohesiveness and adhesiveness in comparison with the control. The treatment 7 recorded the highest firmness, high textural hardness, moderately high cohesiveness, low adhesiveness and high chewiness in comparison with the control.

The treatment 2 recorded the highest textural hardness, high cohesiveness, high adhesiveness, high chewiness and high firmness in comparison with the control. The treatment 13 recorded the highest cohesiveness, high adhesiveness, moderately high firmness and low textural hardness in comparison with the control.

Recommendation

From the 27 experimental treatments, the products of treatment 2 recorded the highest of all the five sensory quality characteristics under consideration that is adhesiveness, cohesiveness, textural hardness, firmness and chewiness. Therefore, it was recommended as the best formulation for high quality donkwa preparation.

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