KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

EVALUATION OF TIGERNUT (*Cyperus esculentus* L., Brown variety) FLOUR IN THE PRODUCTION OF WHEAT-TIGERNUT COMPOSITE BISCUIT

A THESIS SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILMENT FOR THE AWARD OF THE DEGREE OF (MASTER OF SCIENCE IN FOOD SCIENCE AND TECHNOLOGY)

BY:

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DECLARATION

Candidate's Declaration

I, Elleason Gifty hereby declare that this work, with the exception of the quotations and references contained in published works which have all, to the best of my knowledge, been identified and acknowledged, is entirely my own original work. As far as I know, this work has never been previously published or has it ever been submitted anywhere for a master qualification.

Elleason Gifty Signature..... Date.....

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Supervisors' Declaration

We hereby declare that the preparation and presentation of this dissertation was supervised in accordance with the guidelines on supervision of dissertations laid down by the Kwame Nkrumah University of Science and Technology.

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Prof. (Mrs.) Ibok Oduro Signature..... Date.....

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DEDICATION

I highly dedicate this work to God for giving me strength and knowledge to complete the research. I also dedicate this work to my parent Mr. Joseph Kwame Elleason and Mrs. Celestina Elleason, who have helped me in so many ways to bring me this far. It also goes to my love Paul Arthur, my son Michael Nana Kwame Arthur and my siblings: Linda Elleason, Alfreda Elleason, Isaac Elleason, Joseph Elleason, and Daniel Elleason, as well as my relatives: Daniel Kwaw Mieza, Daniel Darko, Gladys kofi and to all readers.

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ABSTRACT

Tigernut is underutilized crop tuber despite its acclaimed nutrients composition. Biscuits were produced by compositing tigernut flour with wheat flour to explore the effect of tigernut in the product. Brown tigernuts were properly cleaned, dried and milled to obtain the flour. Wheat flour (WF) in the biscuit formulation was replaced at five levels, 10%, 20%, 30%, 40% and 50% with tigernut flour (TF). On a scale of 1 – 9; where 1 = dislike extremely and 9 = like extremely, the sensory attributes (appearance, taste, chewiness, mouthfeel, aroma and aftertaste) of wheat-tigernut biscuits were compared to 100% wheat biscuit (control). Proximate, minerals (Mg, Fe, K, Ca and P), colour and texture were conducted on the most preferred and control biscuit. Generally the biscuits had good consumer preference with the 30% tigernut flour blend being the most preferred with average scale score of 8.02. Incorporation of tigernut flour for the production of 30% wheat-tigernut biscuit resulted in an increase in fibre (1.50-6.20 g), ash (1.04-2.14 g) and (energy 419.90-464.97 kcal) but a decrease in protein content (12.21-9.14 g) as compared to the 100% wheat biscuit. Mineral content (Ca, K and P) for the most preferred formulation increased to (30.01-80.52, 91.50-105.50 and 187.87-198.11 (mg /100 g) as compared to the control biscuit. The tigernut-containing biscuit exhibited dark brown colour as compared to the control biscuit. This can be attributed to the brown colour of tigernut flour in the blend. Measurement of baked biscuits texture showed that hardness and fracturability values decreased as tigernut flour content in the biscuit formulation increased. Differences in hardness and fracturability of the biscuits due to various levels of tigernut flour incorporation might be as a result of differences in protein and carbohydrate contents of the products. Wheat flour contains high amount of gluten and starch which may have contributed to the firmness of the control biscuit as compared to the tigernut flour substituted biscuits since the tigernut flour contains no gluten but high in fibre which may have interfered with the texture of wheat-tigernut biscuits. The Promotion and adoption of wheat-tigernut based biscuits would increase the tigernuts nut utilisation and may drive the chain of production of the tigernuts.

Keywords: Tigernut flour, Biscuits, Sensory evaluation, Parameters, Colour and Texture analysis

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APPENDICES

APPENDIX 1 – FORMULAE USED FOR CALCULATIONS

a) % moisture = $\frac{W2- W3}{W2-W1} \times 100$

Where: W1 = Weight of crucible
W2 = W eight of crucible + sample
W3 = Weight of crucible + dry sample

b) % Ash = $\frac{W3- W1}{W2- W1} \times 100$

% Total nitrogen (%N) = $\frac{X \text{ moles} \times (Vs- Vb) \text{ cm3} \times 14g}{1000cm3} \times 100$

c) % Fat = $\frac{W2- W1}{W3} \times 100$

d) Energy (Kcal) = $\frac{(\text{Protein} \times 17 + \text{fat} \times 37 + \text{carbohydrates} \times 17)}{4.186}$

e) % Carbohydrate = 100 – (% moisture + % ash + % crude protein + % crude fat + % crude fibre)

Browning index formula

$$BI = \frac{[100 \times (a^* + 1.79 L^*)- 0.31]}{\frac{5.645 (L^*) + a^* - (3.012b^*)}{0.17}}$$

Where
a* = degree of redness
L* = degree of lightness
b* = degree of yellowness

APPENDIX 2A: QUESTIONNAIRE FOR SENSORY EVALUATION OF WHEAT AND WHEAT-TIGERNUT BISCUITS

ACCEPTABILITY TEST

Age…… Date……

INSTRUCTION: You have been provided with six different coded samples of biscuits. Please write the code of sample you test. Use the scale below to rate each attribute across the 6 samples indicating your level of acceptability of each product tested.

1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Neitherlike nor dislike
6. Like slightly
7. Like moderately
8. Like very much
9. Like extremely

NB: Wash your mouth with water provided after each test.

SAMPLE CODE	SENSORY ATTRIBUTES TEST FOR BISCUITS							
	Appearance	Colour	Taste	Chewiness	Mouth feel	Aroma	After taste	Overall acceptability

Comment or suggestion

.....

.....

.....

APPENDIX 2B: TABLE FOR MEAN VALUES AND STANDARD DEVIATION OF SENSORY ATTRIBUTES

Sample Code	App	Col	Tas	Chew	Mtf	Arom	Aft	Overall
0%TF	6.84^{a} (1.30)	6.94^{a} (1.22)	6.78^{a} (0.93)	6.40^{a} (1.07)	6.24^{a} (1.26)	6.14^{a} (1.18)	6.76^{a} (1.13)	6.78^{a} (0.91)
10%TF	7.16^{ab} (1.33)	7.12^{ab} (1.26)	6.76^{a} (0.96)	6.40^{a} (1.03)	6.34^{a} (1.24)	7.16^{b} (1.06)	6.28^{b} (0.93)	6.72^{a} (1.23)
20%TF	7.38^{bc} (1.24)	7.54^{bc} (1.27)	6.36^{b} (1.01)	6.20^{a} (1.18)	5.90^{a} (1.25)	7.52^{b} (0.89)	6.06^{b} (1.28)	6.50^{a} (1.28)
30%TF	7.86^{c} (1.05)	7.88^{c} (1.02)	7.76^{c} (0.82)	5.60^{b} (0.81)	7.46^{b} (0.89)	7.98^{c} (0.78)	7.64^{c} (1.01)	8.02^{b} (0.92)
40%TF	6.94^{b} (1.32)	7.04^{a} (1.09)	5.46^{d} (1.01)	5.12^{c} (1.17)	4.90^{c} (1.31)	7.78^{c} (0.91)	5.14^{d} (1.14)	5.54^{c} (1.47)
50%TF	6.32^{d} (1.67)	6.12^{d} (1.86)	3.96^{e} (1.21)	3.58^{d} (1.05)	3.40^{d} (1.43)	8.10^{c} (0.86)	3.78^{e} (1.22)	4.42^{d} (1.62)

Numbers in columns followed by different letters are significantly different ($p \leq 0.05$)

Numbers in parentheses represent the standard deviation of the mean.

App – Appearance, Col – C olour, Tas – Taste, Chew – Chewiness, Mtf – Mouthfeel, Aro – Aroma, Aft – Aftertaste, Overall – Overall acceptability.

Biscuit Treatment: 0%TF = Control (100% wheat)
10%TF = 10% tigernut flour substitution
20%TF = 20% tigernut flour substitution
30%TF = 30% tigernut flour substitution
40%TF = 40% tigernut flour substitution
50%TF = 50% tigernut flour substitution

APPENDIX 3A: MINERAL ANALYSIS

Composition of reagent 'A' and 'B'

"Reagent A" was prepared by dissolving an amount of 1.056 g of L-Ascorbic acid in 200 ml of "Reagent B" and made to mix well.

With "Reagent B", 12.0 g of Ammonium molybdate was weighed and dissolved in about 250 ml distilled water. An amount of 0.2908 g of Antimony potassium tartrate was also weighed and dissolved in about 100 ml distilled water. Both of the dissolved reagents were added to a litre of 5 N H_2SO_4 (135.98 ml conc. H_2SO_4/litre). The reagents were mixed thoroughly and made to 2 L. The prepared reagent was then stored in Pyrex glass bottle in dark, cool compartment.

Formulae for calculating amount of minerals;

$$\text{Mineral element} = \text{conc. of element (mg/L)} \times \frac{\text{Total volume used (L)}}{\text{Weight of sample (kg)}}$$

Where; total volume used = 250 ml = 0.25 L

Weight of sample = 1.0 g = 0.001 kg

The values in mg/kg were converted to percentage by dividing the mg/kg value by 10,000. The values in mg/kg were again converted to mg/g by multiplying the mg/kg value by 1000.

$$\text{Phosphorus (mg/g)} = (\text{Absorbance (nm)}/\text{Graph factor}) \times \text{Dilution factor} \times \frac{\text{Total volume used (ml)}}{\text{Weight of sample (g)}}$$

Where; Absorbance = readings on the spectrophotometer measured in (nm)

$$\text{Graph factor} = \frac{\text{Sum of Absorbance readings of P standards}}{\text{Sum of concentrations of P standards}}$$

$$\text{Dilution factor} = \frac{\text{volumetric flask used for aliquot (25 ml)}}{\text{Volume of aliquot used (1 ml)}}$$

Total volume used after digestion = 250 ml

Weight of sample = 2.0 g

APPENDIX 3B: TEXTURE ANALYSER MODEL SETTINGS

Mode: measures force in compression
Option: return to start
Pre-test speed: 1.5 mm/s
Test speed: 2.0 m/s
Post-test speed: 10.0 mm/s
Distance: 5 mm
Trigger force: auto- 25 g
Tare mode: auto
Data acquisition rate: 400 pps

APPENDIX 4: CORRELATION BETWEEN SENSORY ATTRIBUTE AND INSTRUMENTAL TEXTURE ANALYSIS

Correlations

		appearance	colour	taste	chewiness	mouthfeel	aroma	aftertaste	OA	Hardness	fracturability
appearance	Pearson Correlation	1	.983**	.867*	.894*	.882*	.140	.783	.893*	.328	.353
	Sig. (2-tailed)		.000	.025	.016	.020	.791	.065	.016	.525	.493
	N	6	6	6	6	6	6	6	6	6	6
Colour	Pearson Correlation	.983**	1	.874*	.900*	.882*	.044	.815*	.885*	.408	.431
	Sig. (2-tailed)	.000		.023	.014	.020	.934	.048	.019	.421	.393
	N	6	6	6	6	6	6	6	6	6	6
Taste	Pearson Correlation	.867*	.874*	1	.998**	.999**	-.331	.983**	.992**	.695	.701
	Sig. (2-tailed)	.025	.023		.000	.000	.522	.000	.000	.126	.121
	N	6	6	6	6	6	6	6	6	6	6
chewiness	Pearson Correlation	.894*	.900*	.998**	1	.998**	-.287	.976**	.995**	.666	.674
	Sig. (2-tailed)	.016	.014	.000		.000	.581	.001	.000	.149	.142
	N	6	6	6	6	6	6	6	6	6	6
mouthfeel	Pearson Correlation	.882*	.882*	.999**	.998**	1	-.295	.975**	.995**	.669	.676
	Sig. (2-tailed)	.020	.020	.000	.000		.571	.001	.000	.146	.140
	N	6	6	6	6	6	6	6	6	6	6

Aroma	Pearson Correlation	.140	.044	-.331	-.287	-.295	1	-.485	-.251	-.872*	-.850*
	Sig. (2-tailed)	.791	.934	.522	.581	.571		.330	.631	.023	.032
	N	6	6	6	6	6	6	6	6	6	6
aftertaste	Pearson Correlation	.783	.815*	.983**	.976**	.975**	-.485	1	.963**	.795	.796
	Sig. (2-tailed)	.065	.048	.000	.001	.001	.330		.002	.059	.058
	N	6	6	6	6	6	6	6	6	6	6
OA	Pearson Correlation	.893*	.885*	.992**	.995**	.995**	-.251	.963**	1	.621	.627
	Sig. (2-tailed)	.016	.019	.000	.000	.000	.631	.002		.188	.183
	N	6	6	6	6	6	6	6	6	6	6
Hardness	Pearson Correlation	.328	.408	.695	.666	.669	-.872*	.795	.621	1	.998**
	Sig. (2-tailed)	.525	.421	.126	.149	.146	.023	.059	.188		.000
	N	6	6	6	6	6	6	6	6	6	6
fracturability	Pearson Correlation	.353	.431	.701	.674	.676	-.850*	.796	.627	.998**	1
	Sig. (2-tailed)	.493	.393	.121	.142	.140	.032	.058	.183	.000	
	N	6	6	6	6	6	6	6	6	6	6

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 5: PROXIMATE COMPOSITION AND MINERAL ELEMENTS OF SAMPLES

Table 4.1: The Proximate Composition of Tigernut flour, Wheat flour, Control biscuit and cceptable biscuit

SAMPLE	PARAMETER						
	MOISTURE (g/100g)	ASH (g/100g)	CRUDE FAT (g/100g)	CRUDE PROTEIN (g/100g)	CRUDE FIBRE (g/100g)	CARBOHYDRATE (g/100g)	ENERGY (Kcal/100g)
TF	6.90 ± 0.11^{a}	1.50 ± 0.01^{a}	15.10 ± 0.14^{a}	5.83 ± 0.01^{a}	5.92 ± 0.03^{a}	64.75 ± 0.07^{a}	420.11 ± 0.94^{b}
WF	10.01 ± 0.01^{b}	1.14 ± 0.01^{b}	1.62 ± 0.03^{b}	10.15 ± 0.07^{b}	0.87 ± 0.00^{b}	76.21 ± 0.07^{b}	365.04 ± 0.25^{a}
WB	6.30 ± 0.01^{c}	1.04 ± 0.02^{c}	10.40 ± 0.02^{c}	12.21 ± 0.01^{c}	1.50 ± 0.01^{c}	68.55 ± 0.06^{c}	419.90 ± 0.01^{b}
W-TB(30%TF)	6.11 ± 0.04^{d}	2.14 ± 0.03^{d}	24.60 ± 0.28^{d}	9.14 ± 0.03^{d}	6.20 ± 0.01^{d}	51.81 ± 0.20^{d}	464.97 ± 1.55^{c}

*Values are means and standard deviations of two determinations. Values in same column with different letters are significantly different at $p<0.05$.
TF = Tigernut flour, WF = Wheat flour, WB = Wheat biscuit and W-TB = Wheat-tigernut biscuit

Table 4.2: Some Essential Mineral Elements of Samples

Sample	Mineral Element				
	Calcium	Iron	Phosphorus	Potassium	Magnesium
TF	49.79 ± 0.16^{b}	4.74 ± 0.01^{c}	172.45 ± 0.03^{b}	190.50 ± 2.12^{a}	54.03 ± 0.01^{a}
WF	30.09 ± 0.18^{a}	2.13 ± 0.01^{a}	154.01 ± 1.93^{a}	85.34 ± 1.82^{b}	60.09 ± 0.18^{b}
WB	30.01 ± 0.04^{a}	2.33 ± 0.04^{a}	187.87 ± 0.18^{a}	91.50 ± 2.12^{c}	90.01 ± 0.00^{c}
W-TB	80.52 ± 0.01^{c}	2.60 ± 0.14^{b}	198.11 ± 0.04^{c}	105.50 ± 2.12^{d}	90.01 ± 0.01^{c}

*Values are means and standard deviations of duplicate determinations (n=2). Values in same column with different letters are significantly different at $p<0.05$. TF = Tigernut flour, WF = Wheat flour, WB = Wheat biscuit and W-TB = Wheat-tigernut biscuit

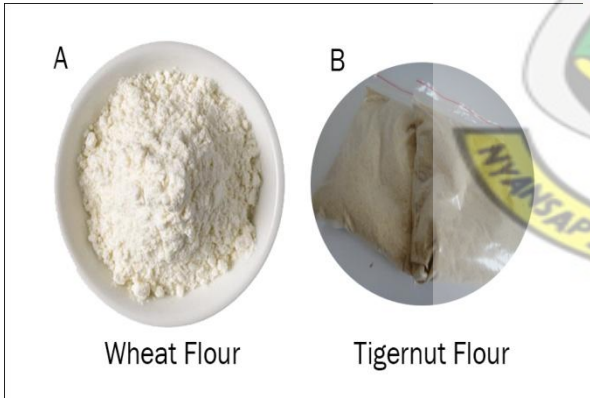
APPENDIX 6: SENSORY SCORES OF BISCUIT PRODUCTS BY PANALISTS

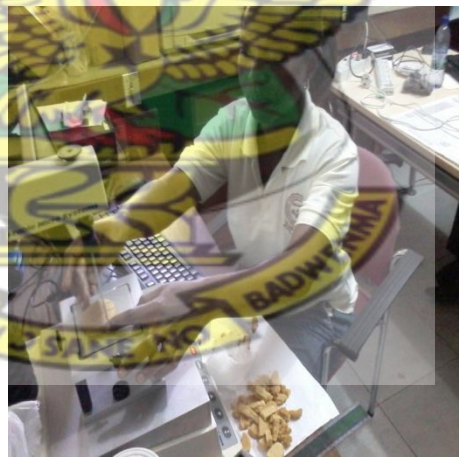
Sample code	Appearance	Colour	Taste	Chewiness	Mouth feel	Aroma	Aftertaste
0% TF	6.84 ± 1.30^{a}	6.94 ± 1.22^{a}	6.78 ± 0.93^{a}	6.40 ± 1.07^{a}	6.24 ± 1.26^{a}	6.14 ± 1.18^{a}	6.76 ± 1.13^{a}
10% TF	7.16 ± 1.33^{ab}	7.12 ± 1.26^{ab}	6.76 ± 0.96^{a}	6.40 ± 1.03^{a}	6.34 ± 1.24^{a}	7.16 ± 1.06^{b}	6.28 ± 0.93^{b}
20% TF	7.38 ± 1.24^{bc}	7.54 ± 1.27^{bc}	6.36 ± 1.01^{b}	6.20 ± 1.18^{a}	5.90 ± 1.25^{a}	7.52 ± 0.89^{b}	6.06 ± 1.28^{b}
30% TF	7.86 ± 1.05^{c}	7.88 ± 1.02^{c}	7.76 ± 0.82^{c}	5.60 ± 0.81^{b}	7.46 ± 0.89^{b}	8.14 ± 0.78^{c}	6.99 ± 1.01^{c}
40% TF	6.94 ± 1.32^{b}	7.04 ± 1.09^{a}	5.46 ± 1.01^{d}	5.12 ± 1.17^{c}	4.90 ± 1.31^{c}	7.98 ± 0.91^{c}	5.14 ± 1.14^{d}
50% TF	6.32 ± 1.67^{d}	6.12 ± 1.86^{d}	3.96 ± 1.21^{e}	3.58 ± 1.05^{d}	3.40 ± 1.43^{d}	8.10 ± 0.86^{c}	3.78 ± 1.22^{e}

*Values are presented as mean ± standard deviation. Values in same column with different letters are significantly different at $p<0.05$. Key: 1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Neither like nor dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much and 9 = Like extremely

Biscuit samples prepared for evaluation

Panellists evaluating biscuit samples





Texture analysis of biscuit samples

Tigernut biscuit