

Statistical Profiling of Functional, Nutritional and Organoleptic Properties of Improved Tuwo (IT)

Farinde Elizabeth Oluremi^{1,*}, Dauda Taofik Oyedele²

¹Agricultural Value Addition Programme, Institute of Agricultural Research and Training,
Obafemi Awolowo University, PMB 5029, Ibadan, Nigeria

²South West Farming Systems Research and Extension Programme,
Institute of Agricultural Research and Training, Obafemi Awolowo University, PMB 5029, Ibadan, Nigeria

*Corresponding author: osekinat@yahoo.co.uk

Received January 19, 2023; Revised February 25, 2023; Accepted March 06, 2023

Abstract Tuwo, a non-fermented maize dumpling is a popular diet native to northerners of Nigeria. Tuwo is nutritionally and texturally poor. The study aims at improving nutrients and functionalities of tuwo. Blends of Quality protein maize (QPM) and pro-vitamin A maize (flour and starch) and pro-vitamin A cassava starch were processed into improved tuwo. The resultant blends of various combination ratios were evaluated for lysine and carotene content as well as functional properties. The tuwo produced from the blends were subjected to sensory evaluation. General linear model analysis returned significantly different means for bulk density, water absorption capacity, swelling capacity, gelation capacity, gelation temperature, lysine and carotene. The $F_{(8, .0.05)} = 1317.4, 264.2, 23.99, 337.5, 21815.8, 2348.9$ and 445.41 , obtained respectively for bulk density, water absorption capacity, swelling capacity, gelation capacity, gelation temperature, lysine and carotene were significant ($P < 0.05$). Sample T_A (75% Yellow QPM flour + 25% Yellow QPM starch) and sample T_P (75% Vitamin A maize flour + 25% Yellow cassava starch) were highest in lysine and carotene respectively. Samples T_H (75% Yellow quality protein maize +25% yellow cassava starch) and sample T_F (75% white quality protein maize +25% yellow cassava starch) were rated high in the sensory attributes evaluated. Modification of maize tuwo with 25% pro-vitamin A cassava starch improved the nutrients and functionalities of tuwo. Nutritious, functionally stable and acceptable tuwo meal could be produced from quality protein maize and yellow cassava. Further improvement on the functional properties of the tuwo to correlate with the nutrients contents is recommended.

Keywords: Tuwo, lysine, carotene, acceptability, median values, general linear model

Cite This Article: Farinde Elizabeth Oluremi, and Dauda Taofik Oyedele, "Statistical Profiling of Functional, Nutritional and Organoleptic Properties of Improved Tuwo (IT)." *American Journal of Food and Nutrition*, vol. 11, no. 1 (2023): 16-24. doi: 10.12691/ajfn-11-1-3.

1. Introduction

Tuwo, a non-fermented maize dumpling is a popular diet native to Northern Nigeria where it is consumed by different tribes including the Hausas, Fulanis, Kanuri and Nupes. Popularity of Tuwo has increased as Yorubas of the South West Nigeria and some other West African countries including Ghana, Togo, Benin, Mali and Burkina-Faso are now eating Tuwo [1]. Tuwo is usually consumed with different types of soup depending on the taste of the community where it is consumed. Soups such as okro, ogbono, melon and some local vegetable soups such as kubewa, kuka and tafshe which are side dishes also go with tuwo [2]. Tuwo is traditionally prepared by making a slurry of the maize flour and adding the slurry to adequate boiling water on fire, stirring, adding more maize flour and stirring to thicken and form a consistent gel-like dough. Water may be added if the dough is too thick, the

dough is then left on fire to cook for about 10 minutes, and stirred thoroughly to get a uniform consistency of the tuwo meal [3]. Tuwo is faced with limitations in its acceptability due to its poor textural quality [1]. Maize tuwo from local indigenous maize is also low in nutrients, hence there is dire need to improve the nutrients content of tuwo through the use of bio fortified maize and cassava.

Maize (Zeamays) is an important food crop providing about 30% of the calories for approximately 4.5 billion peoples in 94 developing countries [4]. It is one of the most widely utilized cereals in Nigeria and other West African countries due to its high yielding potentials, storability and versatility in processing. Maize is a good source of carbohydrates, fats, proteins and some of the important vitamins as well as minerals. It is also the richest in energy among cereal grains, and this is why it is been referred to as nutria-cereal [4]. One of the main nutritional circumscriptions of maize grains, however, is its deficiency in two important essential amino acids -lysine and tryptophan [5]. Efforts at improving the

protein quality of maize led to the development of quality protein maize (QPM) varieties. QPM kernels contain double the quantity of lysine and tryptophan, balanced ratio of isoleucine to leucine and increased desirable proteins [4]. Nigeria is one of the world class producers of cassava as it is among the top five countries for cassava production including Thailand, Democratic Republic of Congo (DRC), Brazil and Indonesia [6]. Cassava is a carbohydrate food crop containing about 70% starch (amylose and amylopectin). It is very low in proteins, ribofavin, thiamine, niacin and retinol [7]. Nutritional enhancement of cassava has been reported [8,9] particularly on vitamin A (carotenoid) improvement.

This study is justified from the need to improve the functional, nutritional and organoleptic properties of the tuwo flour. This would enhance increase in its consumption beyond the known current shore of consumption (Northern Nigeria). Similarly, the increase in its consumption would consequently translate into increase in the demand for quality protein maize and pro-vitamin A cassava. The objectives of the study are thus to improve the nutrients content of tuwo through the use of bio fortified maize and cassava as well as to guesstimate the functional, nutritional and organoleptic properties of the improved Tuwo flour.

2. Materials and Methods

2.1. Source of Materials and Processing

White quality protein maize (ART-98-SW6-OB-SR-W), Yellow quality protein maize (ART-98-SW1-Y) and Pro-vitamin A maize (PRO-VIT-A-SYN-2) were obtained from the seed store of Institute of Agricultural Research and Training, Moor plantation, Ibadan, Nigeria. The pro-vitamin A cassava (IBA-070593) was obtained from International Institute of Tropical Agriculture, Ibadan, Nigeria.

2.1.1. Maize Flour, Maize Starch and Cassava Starch Processing

Maize (Quality protein maize and Vitamin A maize) were processed into flour following the method described by [10]. Maize starch and cassava starch were processed using the methods described by [11,12] respectively.

2.1.2. Formulation of Tuo Blends

Composite Flour blends of Maize flour and maize starch or Maize flour and cassava starch were mixed in appropriate proportion as shown in Table 1. The composite flours were mixed at a speed of 100 rpm for 2

minutes in Kenwood mixer (MC-HM-163). The resulting flour mix was cooled and packed in airtight plastic container and labelled appropriately.

2.1.3. Processing of Tuwo Meal

Tuwo meal was prepared following standard and optimized method of [13] with slight modification. The tuwo blend flour mix was made into slurry by mixing 200 g of the tuwo flour with 600 ml of water (1:3w/v). The slurry was added to boiling water (1300 ml) twice its quantity off burner. The mixture was stirred in the boiled water, additional 500g flour mix was added bit by bit and stirred continuously until a stiff gel consistency was formed. The gel was placed on a gas burner and cooked for about 3 minutes, water 300 ml was then added to the gel, gel lifted with stirrer to allow water to sink to the bottom of the gel. The gel was covered and allowed to cook without stirring for about 5 minutes. The cooked gel was then stirred very well to form smooth dough (tuwo meal).

2.2. Laboratory Analysis

2.2.1. Determination of lysine and Carotene

Lysine content and carotene content in the tuwo flour blends samples were determined following the methods used by [14,15] respectively.

2.2.2. Determination of Functional Properties

Bulk density of the tuwo flour samples was determined using [16] method. The method described by [17] was used to determine water absorption capacity (WAC). Swelling capacity was determined using the methods described by [18] while Gelation capacity and Gelation temperature were determined following the method described by [19].

2.2.3. Sensory Evaluation

Tuwo meal samples from different flour mixture were freshly prepared and subjected to sensory evaluation. The samples were coded and presented to 15 semi trained panel of judges who are members of staff of Institute of Agricultural research and Training and who are familiar with the food product (tuwo). The panelists were provided with a scoring sheet and were asked to score the samples for colour, flavour, appearance, texture, taste, and overall acceptability using 9 point hedonic scale where 9 represent like extremely and 1 represent dislike extremely [20]. The panelists were provided with water for mouth rinsing after each tasting.

Table 1. Flour Proportion Mix for the Tuwo Samples

Sample	Yellow QPM flour (g)	White QPM flour (g)	Pro-vitamin A maize flour (g)	Yellow QPM starch (g)	Pro-vitamin A cassava starch (g)
T _A	75	-	-	25	-
T _C	-	-	75	25	-
T _F	-	75	-	-	25
T _H	75	-	-	-	25
T _J	-	-	100	-	-
T _K	-	75	-	25	-
T _O	100	-	-	-	-
T _P	-	-	75	-	25
T _T	-	100	-	-	-

2.3. Statistical Analysis

Data analysis was done using descriptive statistics (mean $\pm$ standard error and variance), correlation analysis and general linear model analysis. Means were separated using Duncan Multiple Range Test. Variable clustering (VARCLUS) of the functional properties was done using Mahalanobis distance. The goal of cluster analysis is to quantitatively discover natural grouping of the variable of the Tuo flours. The measures of similarities may be distance, correlation, cosine similarity depending on the context of the problem. The present work adopted distance (Mahalanobis distance). The Mahalanobis distance between 2 objects is defined by [21] as;

$$d_m = \left[(x_B - x_A)^T C^{-1} (x_B - x_A) \right]^{0.5} \quad (1)$$

x_A and x_B = Pair of objects and C is the sample covariance matrix.

The organoleptic analysis of the samples were computed using Kruskal Wallis (KW) statistics. KW test,

$$H = \frac{12}{N(N+1)} \sum_{i=1}^k \frac{R_i^2}{n_i} - 3(N+1) \quad (2)$$

We reject the H_0 if $H > \chi^2$ while we fail to reject the null hypothesis (H_0) if $H < \chi^2$.

3. Results

3.1. Summary Statistics, Correlation and Cluster Analysis for the Tuwo Flour Samples

The results of the summary statistics of the variables indicated that sample T_F has the highest mean bulk density of 0.925 (± 0.001) while sample T_J has the least bulk density of 0.421 (± 0.004 - Table 2). Highest mean water absorption capacity (WAC) and swelling capacity, SC (4.6 ± 0.05 and 80.3 ± 0.2) were obtained for sample T_K while the least of both WAC and SC (3.2 ± 0 and 55.8 ± 0.3) were also obtained for sample T_J (Table 2). The variability

Analysis of the bulk density of the different tuwo flour returned almost constant value for all tuwo flour except for both sample T_H (0.000018) and sample T_J (0.00003). The variability of the WAC ranged between zero (0) for samples (T_F , T_J , T_K , T_O and T_P) and 0.00405 for sample T_A (Table 2). The variances of SC fall between zero for both samples T_C and T_T on one side and 18 for sample T_O on the other hand (Table 2). Highest mean gelation capacity (GC) of 56.35 ± 0.15 was obtained for sample T_P While the least GC of 40.25 ± 0.15 was obtained for sample T_J . The variance ranged between 0.005 for sample T_O , T_F and T_C on one hand and 0.5 for sample T_H on the other hand (Table 2). Mean gelation temperatures fall between 60.7 $\pm 0.1^\circ\text{C}$ for sample T_K and 81.55 $\pm 0.05^\circ\text{C}$ for sample T_J while the variance ranged from zero for sample T_C and 0.02 for both sample T_F and T_K . Sample T_P (Figure 1) that returned the highest carotene (2.707) had the least lysine (2.473). The highest lysine (3.86) was obtained in sample T_A .

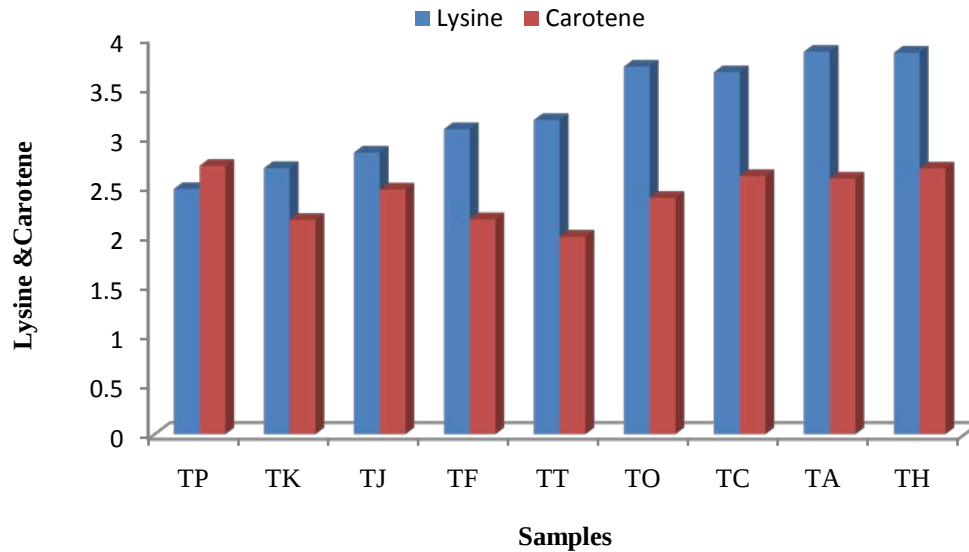
The results of bivariate correlation analysis indicated that bivariate variables, $\rho_{x,y}$ ranged between -0.902 for $\rho_{x,y}$ of water absorption capacity with gelation temperature and 0.824 for $\rho_{x,y}$ of water absorption capacity with swelling capacity (Table 3). The results also depict that 38% of the $\rho_{x,y}$ were significant while the remaining 62% were not significant. Some of the bivariate variables $\rho_{x,y}$ (43%) were inversely related including correlation between WAC and gelation capacity (-0.902), correlation between gelation capacity and gelation temperature (-0.865), correlation between swelling capacity and gelation temperature (-0.727) among others. The remaining bivariate variables $\rho_{x,y}$ (57%) on the other hand were directly correlated (Table 3).

The goal of the cluster analysis in our present study is to partition the data into distinct sub-group (cluster) such that each group has very similar or homogenous observation while observations belonging to dissimilar groups are heterogenous or different. Two (2) sample pairs (sample T_C and T_P as well as sample T_F and T_H) were found fusing together at different agglomeration distances. The cluster dendrogram (Figure 2) indicated that sample T_C and T_P agglomerate at the earliest distance (1.70955) while sample T_F and T_H agglomerate at mahalanobis distance of 2.0526.

Table 2. Summary Statistics Analysis for the Variables

Samples	BD		WAC		SC		GC		GT	
	Mean $\pm$ SE	Variance	Mean $\pm$ SE	Variance	Mean $\pm$ SE	variance	Mean $\pm$ SE	Variance	Mean $\pm$ SE	variance
TA	0.500 $\pm$ 0	0	4.505 $\pm$.005	0.0001	64.3 $\pm$ 0.2	0.08	51.25 $\pm$ 0.25	0.125	61.475 $\pm$ 0.025	0.00125
TC	0.667 $\pm$ 0	0	3.85 $\pm$ 0.05	0.005	60.5 $\pm$ 0	0	47.45 $\pm$ 0.05	0.005	75.5 $\pm$ 0	0
TF	0.925 $\pm$ 0.001	0	3.905 $\pm$.005	0	62.500 $\pm$ 0.1	0.02	51.25 $\pm$ 0.05	0.005	64.60 $\pm$ 0.100	0.02
TH	0.923 $\pm$ 0.003	0.000018	3.855 $\pm$ 0.04	0.00405	61.95 $\pm$ 0.45	0.00405	49.7 $\pm$ 0.5	0.5	74.425 $\pm$ 0.025	0.00125
TJ	0.421 $\pm$ 0.004	0.00003	3.2 $\pm$ 0	0	55.8 $\pm$ 0.3	0.18	40.25 $\pm$ 0.15	0.045	81.55 $\pm$ 0.05	0.005
TK	0.9095 $\pm$.0005	0	4.65 $\pm$ 0.05	0	80.3 $\pm$ 0.2	0.08	51.3 $\pm$ 0.1	0.02	60.7 $\pm$ 0.1	0.02
TO	0.557 $\pm$ 0.001	0	3.5 $\pm$ 0	0	59.4 $\pm$ 3	18	43.45 $\pm$ 0.05	0.005	81.525 $\pm$ 0.025	0.00125
TP	0.8455 $\pm$.0015	0	3.805 $\pm$.005	0	61.15 $\pm$ 2.95	17.405	56.35 $\pm$ 0.15	0.045	78.575 $\pm$ 0.025	0.00125
TT	0.5 $\pm$ 0	0	3.605 $\pm$.005	0.00005	60 $\pm$ 0	0	46.25 $\pm$ 0.15	0.045	80.375 $\pm$ 0.075	0.01125

T_A = 75% Yellow QPM flour + 25% Yellow QPM starch, T_C = 75% Vitamin A maize flour + 25% Yellow QPM starch, T_F = 75% White QPM flour + 25% Yellow cassava starch, T_H = 75% Yellow QPM flour + 25% Yellow cassava starch, T_J = 100% Vitamin A maize flour, T_K = 75% White QPM flour + 25% Yellow QPM starch, T_O = 100% Yellow QPM flour, T_P = 75% Vitamin A maize flour + 25% Yellow cassava starch, T_T = 100% White QPM flour.



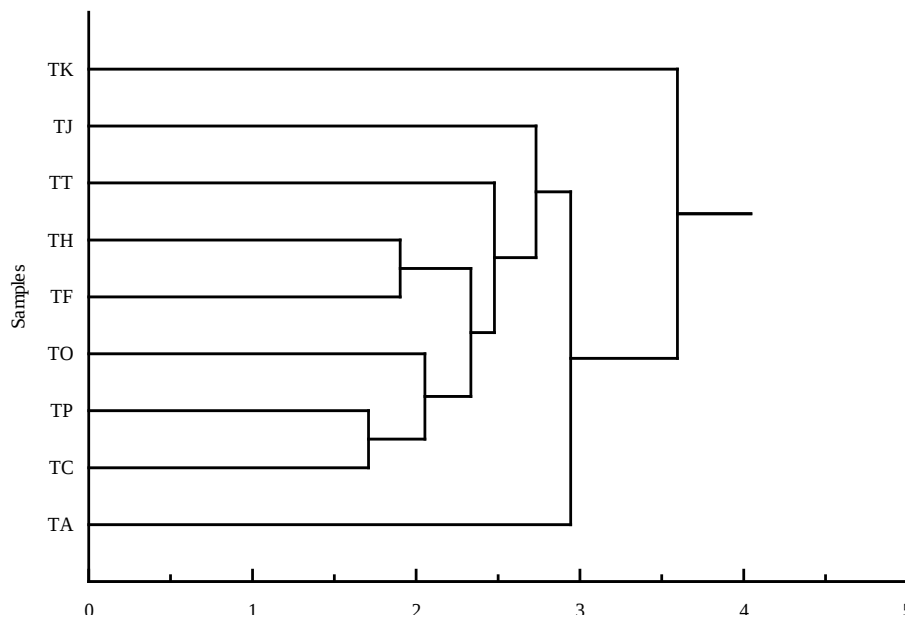
T_A = 75% Yellow QPM flour + 25% Yellow QPM starch, T_C = 75% Vitamin A maize flour + 25% Yellow QPM starch, T_F = 75% White QPM flour + 25% Yellow cassava starch, T_H = 75% Yellow QPM flour + 25% Yellow cassava starch, T_J = 100% Vitamin A maize flour, T_K = 75% White QPM flour + 25% Yellow QPM starch, T_O = 100% Yellow QPM flour, T_P = 75% Vitamin A maize flour + 25% Yellow cassava starch, T_T = 100% White QPM flour

Figure 1. Lysine and Carotene Content of Different Tuwo flour blends

Table 3. Correlation Matrix Tables for the Variances before the Convention

	BD	WAC	SC	GC	GT	Lysine	Carotene
BD	1	0.428	.504*	.633**	-0.432	-0.003	0.116
WAC		1	0.824**	0.859**	-0.902**	0.088	-0.237
SC			1	0.635**	-0.727**	0.209	0.1
GC				1	-0.865**	-0.276	-0.257
GT					1	-0.016	0.249
Lysine						1	0.307
Carotene							1

Note – BD = Bulk Density, WAC = Water absorption capacity, SC = swelling capacity, GC = gelation capacity, GT = gelation Temperature.



T_A = 75% Yellow QPM flour + 25% Yellow QPM starch, T_C = 75% Vitamin A maize flour + 25% Yellow QPM starch, T_F = 75% White QPM flour + 25% Yellow cassava starch, T_H = 75% Yellow QPM flour + 25% Yellow cassava starch, T_J = 100% Vitamin A maize flour, T_K = 75% White QPM flour + 25% Yellow QPM starch, T_O = 100% Yellow QPM flour, T_P = 75% Vitamin A maize flour + 25% Yellow cassava starch, T_T = 100% White QPM flour

Figure 2. Dendrogram of the Vaulust (Variables cluster) Analysis of the Functional Properties of the Tuwo Flours Blends

No two samples pairs returned the same mahalanobis distance. All other samples joined the clusters at different mahalanobis distances and the farthest agglomeration distance of 3.5951 was obtained for sample T_A and T_K as follows;

$$\begin{aligned}x_{2,8} &= 1.70952: (x_2, x_8) \\x_{3,4} &= 1.90154: (x_2, x_8)(x_3, x_4) \\x_{2,7} &= 2.05255: (x_2, x_7, x_8)(x_3, x_4) \\x_{2,3} &= 2.3347: (x_2, x_3, x_4, x_7, x_8) \\x_{2,9} &= 2.4775: (x_2, x_3, x_4, x_7, x_8, x_9) \\x_{2,5} &= 2.7319: (x_2, x_3, x_4, x_5, x_7, x_8, x_9) \\x_{1,2} &= 2.9442: (x_1, x_2, x_3, x_4, x_5, x_7, x_8, x_9) \\x_{1,6} &= 3.5951: (x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9)\end{aligned}$$

Agglomeration distances of the different clustering variables using Mahalanobis Distance.

x_1 = T_A (75% Yellow QPM flour + 25% Yellow QPM starch), x_2 = T_C (75% Vitamin A maize flour + 25% Yellow QPM starch), x_3 = T_F (75% White QPM flour + 25% Yellow cassava starch), x_4 = T_H (75% Yellow QPM flour + 25% Yellow cassava starch), x_5 = T_J (100% Vitamin A maize flour), x_6 = T_K (75% White QPM flour + 25% Yellow QPM starch), x_7 = T_O (100% Yellow QPM flour), x_8 = T_P (75% Vitamin A maize flour + 25% Yellow cassava starch), x_9 = T_T (100% White QPM flour).

3.2. General Linear Model and Mean Separation of the Tuwo Flour Properties

The results of the general linear model analysis returned significantly different means for bulk density, water absorption capacity, swelling capacity, gelation capacity, gelation temperature lysine and carotene. The $F_{(8, .05)} = 1317.4, 264.2, 23.99, 337.5, 21815.8$ obtained respectively for bulk density, water absorption capacity, swelling capacity, gelation capacity and gelation temperature were significant ($P < 0.05$). Similarly, $F_{(8, .05)} = 2348.9$ and 445.41 obtained for both lysine and carotene were significant ($P < 0.05$ - Table 4). Mean bulk density were partitioned into seven significantly different classes. Mean bulk density obtained for both T_F (0.925) and T_H (0.923)

which falls in the same class were significantly the highest and different from mean bulk density obtained for T_K (0.91). Mean bulk density obtained for sample T_J (0.421) was significantly the least and less than the means bulk density obtained for both sample T_T and T_A (0.500 - Table 4) Sample T_K has the highest significantly different water absorption capacity (4.65) and was followed by mean water absorption capacity for sample T_A (4.505). Sample T_J has the least significant different water absorption capacity of 3.20 and it is significantly lesser than mean water absorption capacity obtained for sample T_O (3.500 - Table 4). Sample T_K returned the highest significantly different swelling capacity (80.300) and it is significantly higher than swelling capacity obtained for sample T_F (62.5) sample T_H (61.950) and sample T_P (61.150). Sample T_J has the least significantly different swelling capacity (55.800) while other samples form intermediate class between the least significantly different class and immediate higher class. Mean gelation capacity was partitioned into six significantly different classes. Mean gelation capacity obtained by sample T_K (51.300) which is greater than that of both sample T_A and T_F (51.250) fall in the highest significantly different class. This (class) was significantly higher than mean gelation capacity obtained for sample T_H (49.700). Sample T_J returned the least significantly different gelation capacity (40.250) and it is significantly less than that obtained for sample T_O (40.250 - Table 4). Sample T_J and sample T_O have the highest significantly different gelation temperature of 81.550°C and 81.520°C and were both significantly higher than that of sample T_T (80.375). Sample T_K however has the least significantly different gelation temperature (60.7°C - Table 4).

The trend of lysine (%) returned for the samples follow the order - Sample T_A (3.860) and T_H (3.800) > sample T_O (3.750) > sample T_C (3.653) and sample T_T (3.170) > Sample T_F (3.077) > sample T_J (2.84) > sample T_K (2.683) > sample T_P (2.47). Sample T_P and T_H have significantly highest carotene (2.707 and 2.680 (ug/g) respectively, followed by mean carotene obtained for both sample T_C (2.603). The least significant mean carotene (1.990) was obtained for sample T_T and it is significantly lesser than mean carotene obtained for both sample T_F (2.167) and sample T_K (2.160-Table 4).

Table 4. General Linear Model Analysis and Mean Separation of the Functional Properties and Nutrient Characteristics of Tuwo Flour

Parameters	Functional Properties					Nutrients	
	BD (g/ml)	WAC (g/g)	SC (%)	GC (%)	GT (°C)	Lysine (%)	Carotene (ug/g)
F-statistics	13137.4**	264.2**	23.99**	337.5**	21815.8**	2348.9**	445.41**
Df	8	8	8	8	8	8	8
T_A	0.500 ^f	4.505 ^b	64.300 ^b	51.250 ^a	61.475 ^g	3.860 ^a	2.467 ^c
T_C	0.667 ^d	3.850 ^{cd}	60.500 ^{bc}	47.450 ^c	75.500 ^d	3.653 ^c	2.603 ^b
T_F	0.925 ^a	3.905 ^c	62.500 ^b	51.250 ^a	64.600 ^f	3.077 ^d	2.167 ^e
T_H	0.923 ^a	3.855 ^{cd}	61.950 ^b	49.700 ^b	74.425 ^e	3.800 ^a	2.680 ^a
T_J	0.421 ^g	3.200 ^g	55.800 ^c	40.250 ^f	81.550 ^a	2.840 ^e	2.577 ^b
T_K	0.91 ^b	4.650 ^a	80.300 ^a	51.300 ^a	60.700 ^b	2.683 ^f	2.160 ^e
T_O	0.557 ^e	3.500 ^f	59.400 ^{bc}	43.450 ^e	81.520 ^a	3.750 ^b	2.383 ^d
T_P	0.846 ^c	3.805 ^{cd}	61.150 ^b	46.350 ^d	78.575 ^c	2.473 ^g	2.707 ^a
T_T	0.500 ^f	3.605 ^e	60.000 ^{bc}	46.250 ^d	80.375 ^b	3.170 ^c	1.990 ^f

T_A=75% Yellow QPM flour + 25% Yellow QPM starch, T_C = 75% Vitamin A maize flour + 25% Yellow QPM starch, T_F = 75% White QPM flour + 25% Yellow cassava starch, T_H = 75% Yellow QPM flour + 25% Yellow cassava starch, T_J = 100% Vitamin A maize flour, T_K = 75% White QPM flour + 25% Yellow QPM starch, T_O = 100% Yellow QPM flour, T_P = 75% Vitamin A maize flour + 25% Yellow cassava starch, T_T = 100% White QPM flour.

3.3. Sensory Analysis of the Tuwo Samples

The organoleptic analysis of the samples indicated that the median of the hedonic test for color ranged from 6 (for both sample T_C and sample T_K) to 8 for sample T_H (Table 5). The Kruska-Wallis (KW) statistics returned results that suggest that the null hypothesis be rejected. This is because KW statistics, $H < \chi^2 = 17.655$ is statistically significant ($P < 0.01$). This implied that there exist significant differences in the median values of the samples with the most attractive sample being sample T_H. The frequencies of the respondents skewed more to the right (which is strongly preferred) compared to other samples (Table 5). The median values for the flavor of the samples fall between 5 for sample T_C and 7.5 for sample T_F (Table 5). This results is statistically significant ($P < 0.01$) since $H < \chi^2 = 21.525$. The KW test Showed that sample T_F was the most preferred intern of flavor since the hedonic scores H_i skewed to the right (Strongly preferred) than any other sampled.. The KW Statistical analysis of samples appearance indicated that there exist significant differences in the median values returned for the samples. The KW statistics $H < \chi^2 = 19.124$ is Significant ($P < 0.05$ -Table 5). The median for the appearance ranged from 6 for both sample T_C and sample T_K to 7.5 for both sample T_F and sample T_H. Sample T_F and sample T_H are the most appealing samples while sample T_C and sample T_K were the least appealing (Table 5).

Sample T_K has the least median of 5.5 for texture while both sample T_F and sample T_P have the highest median of 7.5. This results ($H < \chi^2 = 18.592$) is significant ($p < 0.05$ Table 6). The samples taste fall between 5.5 for sample T_C and 8 for sample T_F which is the most preferred taste (Table 6). The KW statistics, $H < \chi^2 = 15.081$ is significant ($P < 0.05$). The overall acceptance of the samples have median varies ranging between 6 for samples T_C and sample T_K as well as sample T_O and 8 for sample T_H. This results has KW-Statistics $H < \chi^2 = 28.209$ and it is significant ($p < 0.01$ -Table 6).

From these Organoleptic analysis result it is noteworthy that;

1. No regular pattern was obtained for all the organoleptic variables.

2. Sample T_H (75% Yellow QPM flour + 25% Yellow cassava starch) was adjudged by assessors to be the best in terms of color, appearance and overall acceptability while Sample T_F (75% White QPM flour + 25% Yellow cassava starch) was distinguished by the assessor as the most preferred in terms of appearance, flavor, texture and taste. Texture of sample T_A (75% Yellow QPM flour + 25% Yellow QPM starch) was also preferred after T_F (75% White QPM flour + 25% Yellow cassava starch).

3. The median values returned for all the organoleptic assessment variables were statistically significant. The implication of this result is that it is advisable to reject the null hypothesis of similarities in the ranking of the samples.

Table 5. Organoleptic (Color, Flavor and Appearance) Analysis of the Samples using Kruskal Wallis Statistics

		H ₁	H ₂	H ₃	H ₄	H ₅	H ₆	H ₇	H ₈	H ₉	Median	chi square
Color	T _A						2	4	4	2	7.5	17.655**
	T _C			1		2	4	3	2		6	
	T _F				2	1	1	2	4	2	7.5	
	T _H						1	4	5	2	8	
	T _J						2	6	3	1	7	
	T _K		1		2	2	3	3		1	6	
	T _O				2		4	3	2	1	6.5	
	T _P					2	2	6	1	1	7	
Flavor	T _T				3		2	3	2	2	7	21.525**
	T _A					1	4	3	2	2	7	
	T _C		1	1	2	5	1		2		5	
	T _F					1	1	4	5	1	7.5	
	T _H				2	2	2	3	2	1	6.5	
	T _J				3	1	3	2	3		6	
	T _K		1		3	1	5	2			6	
	T _O			1	1	4	4	1	1		5.5	
Appearance	T _P			1	2		2	4	2	1	7	19.124*
	T _T				2	2	3	3	1	1	6	
	T _A						2	5	3	2	7	
	T _C			1	1	1	4	4	1		6	
	T _F				1	1	1	3	4	2	7.5	
	T _H							6	4	2	7.5	
	T _J					2	3	5	2		7	
	T _K		1		3		4	3		1	6	
	T _O				3	1	2	3	2	1	6.5	
	T _P				1	1	2	4	3	1	7	
	T _T			1		1	2	4	2	2	7	

T_A=75% Yellow QPM flour + 25% Yellow QPM starch, T_C = 75% Vitamin A maize flour + 25% Yellow QPM starch, T_F = 75% White QPM flour + 25% Yellow cassava starch, T_H = 75% Yellow QPM flour + 25% Yellow cassava starch, T_J = 100% Vitamin A maize flour, T_K = 75% White QPM flour + 25% Yellow QPM starch, T_O = 100% Yellow QPM flour, T_P = 75% Vitamin A maize flour + 25% Yellow cassava starch, T_T = 100% White QPM flour.

Table 6. Organoleptic (Texture, Taste and Overall acceptance) Analysis of the Samples using Kruskal Wallis Statistics

	Samples	1	2	3	4	5	6	7	8	9	Median	chi square
Texture	T _A				1	2	2	2	2	3	7	18.592*
	T _C		1	1	1	1	4	2	2		6	
	T _F		1				2	3	3	3	7.5	
	T _H					1	4	3	3	1	7	
	T _J				1	1	5	4	1		6	
	T _K		2	1	1	2	3	2		1	5.5	
	T _O				2	3	5	1	1		6	
	T _P		1				3	2	3	3	7.5	
Taste	T _T		1	1		2	3	3	2	1	6.5	15.081
	T _A				1	1	3	3	1	3	7	
	T _C		1	2	3	3	3	1	1	1	5.5	
	T _F				1		1	3	5	2	8	
	T _H				2	3	1	3	2	1	6.5	
	T _J			1	2	2	2	2	3		6	
	T _K		1		1	2	6	2			6	
	T _O				1	2	7	1	1		6	
Overall acceptance	T _P		1			2	3	2	3	1	6.5	28.209**
	T _T			2		2	4	2	1	1	6	
	T _A						2	6	2	2	7	
	T _C		1		3	3	5	2	1		6	
	T _F				1	1	1	4	4	2	7.5	
	T _H						2	2	6	2	8	
	T _J				1	1	3	7	1		7	
	T _K		1	2			5	4			6	
	T _O			1	2	2	4	3	2		6	
	T _P				1	1	2	4	3	2	7	
	T _T				2	2	3	4	2	1	7	

T_A = 75% Yellow QPM flour + 25% Yellow QPM starch, T_C = 75% Vitamin A maize flour + 25% Yellow QPM starch, T_F = 75% White QPM flour + 25% Yellow cassava starch, T_H = 75% Yellow QPM flour + 25% Yellow cassava starch, T_J = 100% Vitamin A maize flour, T_K = 75% White QPM flour + 25% Yellow QPM starch, T_O = 100% Yellow QPM flour, T_P = 75% Vitamin A maize flour + 25% Yellow cassava starch, T_T = 100% White QPM flour.

4. Discussion

This study aimed at statistically crayoning the tuwo flour made from different aggregates of maize and cassava. Our study established irregularities in the pattern of means and variability of the studied variables. These irregularities might be due to disparity in the properties of the constituents of each of the samples. This is in concord with [22] that posited that the functional properties of foods and flours are influenced by the components of the food material, or food additives added to the food (flour), as well as the structures of these components. This is also explicit in the report of the Functional properties of Yellow Maize and Beniseed Composite Flour presented by [20]. Water absorption capacity of the tuwo flour blends samples ranged from 3.2 and 4.65(g/g) in TJ (100% Vitamin A maize flour) and TK (75% White QPM flour + 25% Yellow QPM starch) respectively. High water absorption capacity of sample TK might probably be due to its constituents, as it contains quality protein maize flour and quality protein maize starch, both of which are products of polysaccharides and quality protein. Flour with high water absorption capacity may have more hydrophilic constituents such as polysaccharides. Protein has been reported to be both hydrophilic and hydrophobic in nature, and therefore can interact well with water in foods thereby enhancing the water absorption

[23]. Water absorption capacity is referring to the ability of the flour or starch to hold water against gravity. Swelling capacity of the tuwo flour samples ranged from 55.8 and 80.3% in TJ (100% Vitamin A maize flour) and TK (75% White QPM flour + 25% Yellow QPM starch) respectively. Swelling power or swelling capacity (SC) is a measure of degree of interaction (hydration capacity) of starch granules with water [23]. Similarity in water absorption capacity and swelling capacity as established in our present study may be due to effects of water in the process of swelling and this is in agreement with [24,25,26] who reported that swelling capacity is related to the water absorption index of the starch-based flour during heating. Our study is in agreement with this as sample TK which had the highest water absorption capacity recorded the highest swelling capacity. The water absorption capacity and swelling capacity obtained in the present study were higher than those (water absorption and swelling capacity) reported by [3,27]. These dissimilarities may be due to differences in the constituents as well as combination ratio of the composite flour in the studies. The main constituents of the present study were maize and cassava while tigernut and cowpea were the main constituents of product of [27]. Higher water absorption capacity is an advantage as it suggests good products formulation [25].

The bulk density obtained for the tuwo in this study were more than the standard bulk density of corn flour as reported by [28]. This higher bulk density may be linked with the fortification and textural improvement of the tuwo with yellow cassava starch and quality protein maize starch. The different samples for the present study were aggregated using different ratio of QPM (yellow and white) and yellow cassava starch. The emergency of the sample T_K (75% White QPM flour + 25% Yellow QPM starch) portends that appropriate combination ratio would enhance benignant functional properties of tuwo flour as it has the highest water absorption capacity, highest swelling capacity, highest gelation capacity and the least of both gelation temperature and bulk density. This conforms to composite flour made from yellow maize, soybean and Jack fruit reported by [29]. The blending of maize flour types with maize and cassava starch showed a significant effect on the functional properties of the flour blends as well as organoleptic properties of the finished product (Tuwo). This is in agreement with the findings of [28] whose report showed that blending of wheat flour with other types of flour showed a significant effect on the functional properties of the flour blends as well as their finished products.

Lysine content in the tuwo flour blends samples ranged between 2.47 and 3.86 % in sample TP (75% Vitamin A maize flour + 25% Yellow cassava starch) and TA (75% Yellow QPM flour + 25% Yellow QPM starch). Lysine content of flour is a good predictor of protein content of the flour [30] and the recommended daily intake of lysine is estimated to be around 30-64 mg/kg body weight. Lysine content obtained in the present study is higher than the recommended daily intake value. It is also higher than lysine content obtained in lysine fortified wheat bread flour reported by [30]. Sample T_H (75% Yellow quality protein maize flour + 25% yellow cassava starch) contained the second highest lysine and carotene making it the best combination nutritional wise out of all the tuwo flour blends. The highest β -carotene content in this study is found in sample T_P (75% Vitamin A maize flour + 25% Yellow cassava starch) (2.70 $\mu\text{g/g}$). It is however lower than the 6 μg equivalent to 1 μg of retinol, according to the Food and Nutrition Board of the Institute of Medicine, in USA. Carotenoids are class of colorful plant pigments that the body can convert to vitamin A, they are also powerful antioxidants that have been suggested to contribute to the resistance against certain forms of cancer and heart diseases, and also enhance immune response to infections [31]. The significance of the median hedonic ranking in our study indicated that the panelists can discern between the different samples and identify the best among them. Samples with yellow cassava starch inclusion were more accepted by the panelists and rated high in all the sensory attributes tested.

5. Conclusions

Food property is usually characterized by good structure, optimum quality, nutritional value and/or acceptability of a food product. These qualities were adequately established in our present study and the product T_H (75% Yellow QPM flour + 25% Yellow

cassava starch) was identified as rich in the nutrients evaluated, and ranked highest in overall acceptability by the panelists. Sample T_A (75% Yellow QPM flour + 25% Yellow QPM starch) and sample T_P (75% Vitamin A maize flour + 25% Yellow cassava starch) were highest in lysine and carotene respectively. Tuwo is conventionally made from white maize, , the emergency of sample T_F (75% White QPM flour + 25% Yellow cassava starch) as the best in most of the sensory attributes (flavor, appearance, texture and taste) assessment variables depict that the improvement of the tuwo quality with yellow cassava starch enhances its acceptability. Modification of maize Tuwo with 25% yellow cassava starch would therefore be an effective method of quality improvement of Tuwo as well as enhancement in yellow cassava utilization while the sensory qualities and functional attributes are still retained. Nutritious, functionally stable and acceptable tuwo meal could be produced from quality protein maize and yellow cassava. Sample T_K (75% White QPM flour + 25% Yellow QPM starch) which depicts the best functional properties recorded the second least nutrients content. Thus, further improvement on the functional properties of the tuwo to correlate with the nutrients contents is therefore recommended. Further study should also focus on the improvement of carotene content of the tuwo to meet the recommended daily carotene intake as well as packaging of the product for commercialization.

Acknowledgements

The authors appreciate the Institute of Agricultural Research and Training, Obafemi Awolowo University for the sponsorship and support for this Project.

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