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Storage Stability Studies and Consumer Acceptability of Ready-To-Consume*kunun Gyada* Powder

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Abstract: *The shelf stability of ready-to-consumekunun gyada powder samples were evaluated for 9 months by analyzing changes in water activity, colour, development of peroxides and rancidity, microbiological changes and consumer acceptability of the product stored at 24°C±2 and relative humidity of 41±2%. Results showed stability in the water activity (aw) with a range between 0.37and 0.61. The peroxide value (PV) range between 0.19-0.52 meq/kg, KGP5 had the lowest peroxide value 0.19 meq/kg. The thiobarbituric acid value (TBA) of the product was low during the 9 months storage period.Values range between 0.21-0.38 MAE/kg. The kunun gyada powder had no mold, yeast, bacteria and coliform growth during the storage period. The colour of the product in terms of whiteness (L^*) range between 85.47% - 72.22%,sensory attributes (colour, appearance, texture and overall acceptability) of the product evaluated base on a 5 point hedonic scale showed that colour of the product was acceptable after 9 months of storage, the texture and appearance of the product was stable during the storage period.The overall acceptability score showed that the KGP2 was more acceptable over the other products.*

Key words: *Kunun gyada, peroxide value, thiobarbituric acid value, consumer acceptability and microbiological changes*

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I. Introduction

Kunun gyada is a cereal-based Nigerian porridge which is usually prepared from cereal flour in combination with groundnut milk1.It is mostly taken as breakfast meal and used extensively during the fasting period of Ramadan. The product is also used as a weaning food.The product kunun gyada which is traditionally prepared can easily go bad when stored unrefrigerated. When refrigerated, the product can only be kept for a maximum of four days2. Therefore the product need to be processed into a powder form to extend its shelf life.Kunun gyada production is traditionally carried out on a small scale, the product has not been fully commercialized. The storage stability studies of ready-to-consumekunun gyada powder was investigated for 9 months to ascertain the wholesomeness of the productduring the storage period. Moisture content in a dry powder product plays an important role in shelf-life of a product. A dry powder product may be contaminatedor rancidity spoilage may also occur with high moisture and oil content. Poor package material may also allow moisture absorption and oxygen which will lead to spoilage and subsequent deterioration in quality of the product. Micro-organism cannot strive in food products with low moisture content or water activity3. The product ready-to-consumekunun gyada powder has high oil content due to the addition of ingredients such as groundnut and soybean, the oil may develop rancidity during storage which will consequently shorten the product's shelf-life.

Rancidity is a very important factor to address when it comes to storage stability of the product.Oxidative rancidity of the oil in the product may lead to degradation to such an extent that the shelf-life of the product may be compromised. The oil in the product is dispersed during processing and once hydrogen peroxide have been formed, which can further break down into aldehyde and ketones a product which have the flavours and aromas associated with oxidative rancidity then the product's shelf-life will shorten[4]. Incorporating antioxidants into foods is one of the most effective means of retarding lipid oxidation.The use of natural antioxidant has been encouraged by researchers to replace the synthetic ones[5,6,7]. Natural antioxidants are seen to be natural and play a dual role when used in foods.They can suppress oxidation and also add to the nutritive value of the food. A good example is sesame seed,Sesame seed oil has higher oxidation stability than other vegetable oils[8]. Its inherent tocopherols and browning substances generated from the maillard reaction also contribute to their antioxidant ability. The brown substances generated during sesame roasting have antioxidant activity, synergistic action with other ingredients and impact on the aroma of sesame oil. [8] also reported that the optimum roasting time and temperature for sesame seed to obtain the most antioxidants and total phenolic, flavonoids and other contents is 150°C for 90 min.

Microbial spoilage is seen to be associated with unhygienic practices during processing which will lead to recontamination of the finished product, strict hygiene practices is very vital when considering handling from raw material up to the finished product. Good packaging material should be considered.A package that does not allow the penetration of moisture and diffusion of oxygen. [9] recommended a strict hygiene practices during processing of laboratory produced weaning food formulations from pearl millet and the avoidance of recontamination. [3] also reported storage stability due to low moisture content which prevented microbial growth, and low water activity which is not safe for spoilage microbes. This shows that a product with high moisture content may be susceptible to microbial spoilage.The storage stability studies of the *kunun gyada* powder has therefore become important to ascertain the wholesomeness of the product (low microbial load), consumers acceptability of the product over a period of time, effectiveness of the package material against penetration of solar radiation, moisture absorption and diffusion of oxygen to keep the product in good condition during the period of storage without developing rancidity. This study will enhance the commercial production of ready-to-consume*kunun gyada*powder.

II. Materials and Methods

The samples for the storage studies were obtained after production of the *kunun gyada* powder in the Faculty of Food Science and Technology, UPM laboratories.Aluminum laminated polyethylene (ALP) pouches (18×9 cm) with thickness of 86 µm purchased from Good and Well Sdn. Bhd. (Selangor, Malaysia). Vertical continuous band sealer (GW-FRB-980II, Good and Well, Selangor, Malaysia).

Formulation

The formulations used to prepare ready-to-consume*kunun gyada*powder is shown in Table 1. A slurry of each formulation was made by adding distilled water (1:5 w/v) to composite flour and after gentle mixing, the slurry was drum dried at 100 ^{o}C, pressure of 3 barsand drum rotation of 2 rotations per minutes. After cooling the dry flakes were ground into powder using a home blender.It was then sieved (0.5 mm mesh size) and 50 g of the powder were placed in aluminum laminated polyethylene (ALP) pouches (18×9 cm) with thickness of 86 µm purchased from Good and Well Sdn. Bhd. (Selangor, Malaysia). This was followed by flushing the powder with nitrogen gas before heat-sealing at 150 ± 1^{o}C using a vertical continuous band sealer (GW-FRB-980II, Good and Well, Selangor, Malaysia). The samples were stored at room temperature 24^{o}C±2 and relative humidity of 41±2%.

Table 1: Formulation of ingredients for ready-to-consume*kunun gyada*powder

Ingredients (%)	KGP1 (Control)	KGP2	KGP3	KGP4	KGP5
Groundnut paste	60	60	60	60	60
Rice flour	40	30	30	25	25
Germinated soybean flour	0	5	10	10	15
Sesame flour	0	5	0	5	0

KGP1 (control) = 60:40(Groundnut paste& Rice flour), KGP2 = 60:30:5:5(Groundnut paste, Rice flour, germinated soy bean flour and roasted sesame flour), KGP3 = 60:30:10(Groundnut paste, Rice flour and germinated soy bean flour), KGP4 = 60:25:10:5(Groundnut paste, Rice flour, germinated soy bean flour and roasted sesame flour) and KGP5 = 60:25:15(Groundnut paste, Rice flour and germinated soy bean flour)

The ready-to-consume*kunun gyada* powder samples used for the analysis were randomly picked from the stored product after every month for the period of storage (9 months). Analysis conducted include: water activity, colour, changes in peroxide value (PV), Thiobarbituric acid (TBA), microbiological changes and consumer acceptability by sensory evaluation.

Water activity (a_W)

The water activity (a_w) of the ready-to-consume *kunun gyada* powders was determined using a water activity analyzer (Model TE8309, Aqua Lab, USA). The instrument was first turned on to warm for about 1 hour, then calibrated using calibration standard solution of sodium chloride (NaCl) to obtain an a_w of 0.76 and potassium chloride (KCl) to obtain an a_w of 0.85. One gram (1 g) of dry powder was placed in the sample dish with a sample capacity of 7.5 ml and inserted into the water activity meter. The machine automatically read the water activity of the sample. The reading was displayed on the screen and expressed as (a_w) measured at a temperature of 25 ± 2 ^{o}C.

Peroxide value

The peroxide value was determined by the method described by [10], 5 g of powered sample after production was weight into a conical flask containing 30 ml of acetic acid-chloroform solution (3:2 v/v) and swirled to dissolve the sample. 0.5 ml of saturated potassium iodide solution (KI) was then added and allowed to stand with occasional shaking for 1 minute, followed by addition of 30ml distilled water. The preparation was then titrated with 0.1 N sodium thiosulfate with constant agitation until the yellow iodine colour has almost disappeared, then 0.5 ml of starch indicator solution is added, the titration was continued drop-wise until the blue grey colour disappears indicating the titration end point. Blank test was also conducted and the Peroxide value was calculated using:

PV= $\frac{(Vs - Vb)\ N \times 1000}{W}$, express in meq/kg

Where Vs = volume (ml) of sodium thiosulfate used in titration of sample, V_b = volume (ml) of sodium thiosulfate used for the blank titration, W = weight of sample used and N = normality of the sodium thiosulfate.

Thiobarbituric acid (TBA)

The TBA value was determined was determined by the method described by [11] where 10 g of powder sample was first dissolved in 50 ml distilled water and mixed by vortex for 3 minutes. The mixture was then transferred into a distillation flask with additional 47.5 ml distilled water followed by addition of 2.5 ml of HCL solution (1 part conc. HCL to 2 parts distilled water) to adjust the pH to 1.5. This was followed by addition of some glass beads to prevent bumping. The distillation apparatus was fixed and the mixture was heated on an electric heating element to boil, 5 ml of the distillate was pipetted into a stoppered glass bottle. This was followed by addition of 5 ml TBA reagent (0.2883 g/100ml of 90 % glacial acetic acid) and stoppered. It was then vortexed and the mixture was heated in boiling water bath for 35 minutes, a blank was also prepared similarly using 5 ml distilled water added to 5 ml TBA reagent. After heating the mixtures in boiling water bath, it was cooled under a running tap for 10 minutes and the absorbance was measured against the blank at 538 nm. The TBA value was calculated by multiplying the resulting absorbance by the factor 7.8 to convert to mg of malonaldehyde per kg sample.

Total plate count (TPC)

The total plate count was determined according to the method described by [12]. One gram of ready-to-consume*kunun gyada* powder was suspended in 10 ml of sterilized distilled water and vortexed to form a homogenous mixture. Then 1ml of the mixture was aseptically diluted through a series of tubes containing 9 ml sterile diluents (sterilized distilled water)up to five dilutions (10^{-5}). One ml each of the diluent was inoculated on standard method Agar ([plate count Agar] BD. Becton, Dickinson and company, Sparks USA) in triplicate and incubated for 48 hours at 35 ^{o}C. Plates with colonies were expressed as colony forming units per gram (CFU/g).

Yeast and mold count

The yeast and mold count was determined using potato dextrose agar (Merck, Darmstadt, Germany) according to the method described by [12]. One gram each of the *kunun gyada* powder samples were suspended in 10 ml sterilized distilled water and vortexed. Then 1 ml of the resultant homogenous mixture was serially diluted through a series of tubes containing 9 ml sterile diluents (sterilized distilled water) up to five dilutions (10^{-5}). One ml each of the diluent was also inoculated on potato dextrose agar in triplicate and incubated for 72 hours at 35 ^{o}C. Plates with colonies were expressed as colony forming units per gram (CFU/g).

Colour

The color of the ready-to-consume *kunun gyada* powder was determined using a Minolta CR-410 chromo meter (Model B8408908) coupled with a Minolta DP-400 data processor (Model B2014888 Konica Minolta, Japan). The instrument was calibrated prior to measurement with a white standard tile. Three grams of the *kunun gyada* powder was filled into a sample cup and the measuring head was placed horizontally on the sample cup with a pulsed xenon arc lamp which emits uniform light on the sample and the resultant reflecting light was read. Results were express as percent of L^* (whiteness/darkness), a^*(redness/greenness) and b^*(yellowness/blueness).

Consumer acceptability (Sensory attributes for *Kunun gyada* powder)

The sensory attributes for the *kunun gyada* powder was evaluated based on a 5 point hedonic scale. Panelists were required to score the samples from 1 (Dislike Extremely) to 5 (Like Extremely). Thirty untrained panelists (Nigerian postgraduate students in UPM) who were familiar with the product for over 20 years were each given five different *kunun gyada* powder. The samples were coded using 3-digit random numbers and randomly served to assess for colour, appearance, texture and overall acceptability. The sensory attribute assessment was done in a sensory Laboratory at the Faculty of Food Science and Technology, Universiti Putra Malaysia.

Statistical analysis

All measurements were done in triplicate and values were presented as mean ± standard deviation of triplicate determination. One-way analysis of variance (ANOVA) was used to identify the significant differences among the means of different samples and Turkey test was also used to compare the means of the obtained values. The statistical analysis was carried out using Minitab version 17 (Minitab Pty Ltd, Sydney). Probability level of P < 0.05 (95 % confident level) was identified as significant.

III. Results

Effect of storage on the water activity (a_W) of *kunun gyada* instant powder

Table 1 shows the effect of nine months storage at 25 ^oC ± 2 and 41± 2 % RH on the water activity of ready-to-consume*kunun gyada* powder. Results obtained show that the water activity between the products ranged between 0.37 at 8 month storage time for KGP2 to 0.61 at initial storage for KGP1to 0.45, KGP2 from o.55-0.39, KGP3 0.54-0.40, KGP4 0.55-0.38 and KGP5 from 0.55-0.39, respectively.

Table 1: Changes in water activity of ready-to-consume *kunun gyada* powder during storage

Months of storage	KGP1	KGP2	KGP3	KGP4	KGP5
0	$0.61±0.01^{aA}$	$0.55±0.01^{bA}$	$0.54±0.01^{bA}$	$0.55±0.01^{bA}$	$0.55±0.01^{bA}$
1	$0.60±0.01^{aA}$	$0.54±0.01^{bA}$	$0.54±0.01^{bA}$	$0.55±0.01^{bA}$	$0.54±0.00^{bAB}$
2	$0.60±0.02^{aA}$	$0.52±0.01^{cB}$	$0.54±0.01^{bcA}$	$0.54±0.01^{bA}$	$0.52±0.01^{cB}$
3	$0.48±0.01^{aB}$	$0.41±0.01^{cC}$	$0.47±0.02^{abB}$	$0.41±0.04^{cB}$	$0.42±0.01^{bcC}$
4	$0.46±0.00^{aBC}$	$0.40±0.01^{dCD}$	$0.41±0.01^{bcC}$	$0.41±0.00^{cdB}$	$0.42±0.01^{bC}$
5	$0.45±0.01^{aC}$	$0.40±0.00^{bCD}$	$0.40±0.01^{bC}$	$0.40±0.00^{bBC}$	$0.40±0.01^{bCD}$
6	$0.46±0.00^{aBC}$	$0.40±0.01^{bCD}$	$0.40±0.00^{bC}$	$0.40±0.01^{bBC}$	$0.40±0.01^{bCD}$
7	$0.44±0.00^{aC}$	$0.38±0.00^{dEF}$	$0.41±0.00^{bC}$	$0.40±0.01^{bcBC}$	$0.38±0.01^{cdD}$
8	$0.45±0.00^{aC}$	$0.37±0.02^{bF}$	$0.40±0.02^{bC}$	$0.39±0.00^{bCD}$	$0.40±0.00^{bCD}$
9	$0.45±0.01^{aC}$	$0.39±0.00^{bDE}$	$0.40±0.02^{bC}$	$0.38±0.02^{bD}$	$0.39±0.01^{bD}$

Mean values within each raw followed different superscript letters (a, b, c or d) are significantly (P≤0.05) different. Mean values within each column followed by different superscript letters (A, B, C, D etc) are significantly (P < 0.05) different

Effect of storage on peroxide value of *kunun gyada* powder

Table 2 presents the peroxide value ofready-to-consume*kunun gyada* powder for the storage period of 9 months. The results obtained indicate that the peroxide value was low during the period of storage and ranged between 0.19-0.52 meq/kg. However, a slight increase in peroxide value was recorded during the period of storage and the values remains low and were within the acceptable limit (not above 10 meq/kg). KGP1 increased from initial 0.47-0.52 at 9 months, KGP2 from 0.31-0.43, KGP3 0.19-0.33, KGP4 0.25-0.44 and KGP5 from 0.20-0.38 meq/kg, respectively.

Table 2: Changes in peroxide value of *kunun gyada* powder during storage at room temperature (meq/kg)

Months of storage	KGP1	KGP2	KGP3	KGP4	KGP5
0	$0.47±0.02^{aC}$	$0.31±0.02^{bD}$	$0.19±0.01^{dF}$	$0.25±0.02^{cE}$	$0.20±0.01^{dD}$
1	$0.48±0.02^{aBC}$	$0.32±0.02^{bD}$	$0.20±0.01^{dEF}$	$0.26±0.02^{cDE}$	$0.21±0.01^{dD}$
2	$0.48±0.02^{aBC}$	$0.38±0.02^{bC}$	$0.22±0.01^{dDE}$	$0.28±0.02^{cCD}$	$0.21±0.02^{dD}$
3	$0.48±0.02^{aBC}$	$0.39±0.03^{bBC}$	$0.24±0.01^{dD}$	$0.29±0.01^{cC}$	$0.21±0.02^{dD}$
4	$0.50±0.01^{aAB}$	$0.41±0.00b^{aAB}$	$0.30±0.02^{cBC}$	$0.40±0.02^{bB}$	$0.26±0.06^{cC}$
5	$0.51±0.00^{aA}$	$0.41±0.01^{bAB}$	$0.28±0.06^{cC}$	$0.42±0.02^{bAB}$	$0.25±0.04^{cC}$
6	$0.51±0.01^{aA}$	$0.41±0.01^{bAB}$	$0.31±0.02^{cAB}$	$0.42±0.01^{bAB}$	$0.32±0.01^{cB}$
7	$0.50±0.00^{aAB}$	$0.42±0.00^{bA}$	$0.32±0.01^{cAB}$	$0.43±0.02^{bA}$	$0.33±0.02^{cB}$
8	$0.51±0.02^{aA}$	$0.43±0.01^{bA}$	$0.31±0.01^{dAB}$	$0.44±0.02^{bA}$	$0.36±0.02^{cA}$
9	$0.52±0.02^{aA}$	$0.43±0.01^{bA}$	$0.33±0.00^{dA}$	$0.44±0.01^{bA}$	$0.38±0.01^{cA}$

Mean values within each raw followed different superscript letters (a, b, c or d) are significantly (P≤0.05) different. Mean values within each column followed by different superscript letters (A, B, C, D etc) are significantly (P < 0.05) different

Effect of storage on Thiobarbituric acid value (TBA) of ready-to-consume*kunun gyada* powder

The TBA results for the ready-to-consume*kunun gyada* powder is presented in Table 3. The results obtain show that KGP5 had the lowest TBA value of 0.26 MAE/kg at 9 months, followed by KGP4 0.27 MAE/kg. The values for the TBA range between 0.21 for KGP5 at initial storage-0.41 MAE/kg for KGP2 at 9 months.

Table 3: Changes in thiobarbituric acid (TBA) of ready-to-consume kunun gyada powder during 9 months storage (MAE/kg)

Parameters	Months of storage	KGP1	KGP2	KGP3	KGP4	KGP5
Thiobarbituric acid (TBA)	0	0.25 ± 0.01^{abD}	0.28 ± 0.01^{aG}	0.23 ± 0.02^{bcD}	0.22 ± 0.02^{bcC}	0.21 ± 0.01^{cD}
	1	0.25 ± 0.01^{bD}	0.38 ± 0.02^{aBC}	0.24 ± 0.01^{bCD}	0.21 ± 0.01^{cC}	0.21 ± 0.01^{cD}
	2	0.24 ± 0.02^{bD}	0.30 ± 0.01^{aFG}	0.24 ± 0.02^{bCD}	0.21 ± 0.01^{bC}	0.23 ± 0.01^{bBCD}
	3	0.25 ± 0.02^{bD}	0.32 ± 0.02^{aEF}	0.24 ± 0.01^{bCD}	0.22 ± 0.02^{bC}	0.22 ± 0.02^{bCD}
	4	0.26 ± 0.01^{bCD}	0.32 ± 0.03^{aEF}	0.25 ± 0.01^{bBCD}	0.22 ± 0.02^{bC}	0.24 ± 0.01^{bABC}
	5	0.28 ± 0.01^{bBC}	0.34 ± 0.01^{aDE}	0.24 ± 0.01^{cCD}	0.22 ± 0.01^{cC}	0.23 ± 0.01^{cBCD}
	6	0.28 ± 0.02^{bBC}	0.36 ± 0.01^{aCD}	0.26 ± 0.03^{bABC}	0.26 ± 0.01^{bB}	0.24 ± 0.01^{bABC}
	7	0.30 ± 0.02^{bAB}	0.37 ± 0.01^{aBC}	0.27 ± 0.01^{bcAB}	0.27 ± 0.01^{bcA}	0.25 ± 0.02^{cAB}
	8	0.31 ± 0.02^{bA}	0.39 ± 0.01^{aAB}	0.28 ± 0.02^{bcA}	0.27 ± 0.01^{bcA}	0.25 ± 0.01^{cAB}
	9	0.31 ± 0.01^{bA}	0.41 ± 0.01^{aA}	0.28 ± 0.01^{bcA}	0.27 ± 0.01^{bcA}	0.26 ± 0.03^{cA}

Mean values within each raw followed different superscript letters (a, b or c) are significantly ($P\leq0.05$) different. Mean valueswithin each column followed by different superscript letters (A, B, C, D etc) are significantly ($P < 0.05$) different.

Effect of storage on microbial stability of ready-to-consume*kunun gyada* powder

The microbial analysis of the *kunun gyada* powder indicated that there was no growth in the product during the period of storage period as shown in Figure 1.

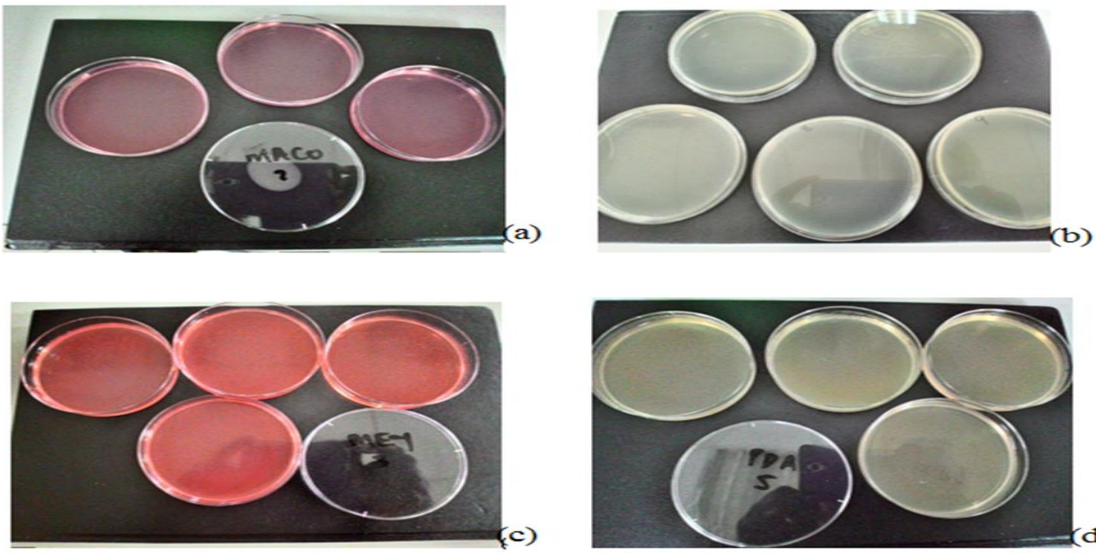

Fig 1: Different media used were (a) MacConkey Agar, (b) Mueller-Hinton Agar, (c) Standard method Agar and (d) Potato dextrose Agar

Effect of storage on whiteness colour (L^*) of ready-to-consume*kunun gyada* powder

The colour of the *kunun gyada* powder in terms of whiteness (L^*) is presented in table 4. Comparing the 9 month storage value for L^* with the 0 month values, KGP1 had 3.46% decrease in whiteness, similarly KGP2 reduced by 2.43%, KGP3 by 1.51%, KGP4 3.52% and KGP5 decreased by 6.1% which was the maximum decreased in whiteness after 9 months of storage. There is a significant difference for L^* between the products, and values range between 85.47% KGP1 (control) – 72.22% for KGP4.

Table 4: Changes in colour (L*) of ready-to-consume *kunun gyada* powder during 9 months storage

Parameters	Months of storage	KGP1	KGP2	KGP3	KGP4	KGP5
(L*)	0	85.47 ± 0.47^{aC}	76.94 ± 0.35^{bA}	76.52 ± 0.13^{bA}	72.22 ± 0.09^{cA}	72.36 ± 0.04^{cA}
	1	85.38 ± 0.01^{aD}	76.06 ± 0.01^{cD}	76.48 ± 0.02^{bB}	72.57 ± 0.02^{dAB}	72.35 ± 0.01^{eA}
	2	86.01 ± 0.01^{aA}	76.44 ± 0.12^{bB}	76.10 ± 0.02^{cC}	72.23 ± 0.02^{dB}	72.08 ± 0.01^{eB}
	3	85.78 ± 0.01^{aB}	76.22 ± 0.02^{bC}	76.00 ± 0.01^{cD}	70.83 ± 0.02^{eC}	71.49 ± 0.03^{dC}
	4	85.76 ± 0.01^{aB}	75.62 ± 0.00^{bE}	75.83 ± 0.01^{cF}	70.50 ± 0.01^{eCD}	71.10 ± 0.09^{dD}
	5	83.21 ± 0.01^{aE}	75.44 ± 0.01^{cF}	75.85 ± 0.00^{bE}	70.10 ± 0.02^{dD}	68.84 ± 0.03^{eE}
	6	83.13 ± 0.01^{aF}	74.82 ± 0.11^{cG}	75.05 ± 0.05^{bG}	68.72 ± 0.05^{dE}	66.46 ± 0.07^{eF}
	7	83.14 ± 0.01^{aF}	74.68 ± 0.01^{cH}	75.02 ± 0.01^{bH}	68.71 ± 0.01^{dE}	66.38 ± 0.01^{eG}
	8	82.88 ± 0.00^{aG}	74.53 ± 0.01^{cI}	75.00 ± 0.01^{bI}	68.72 ± 0.01^{dE}	66.30 ± 0.01^{eH}

9	82.01 ± 0.01^{aH}	74.51 ± 0.01^{cI}	75.01 ± 0.01^{bHI}	68.70 ± 0.02^{dE}	66.26 ± 0.01^{eI}

Mean values within each raw followed different superscript letters (a, b, c, d or e) are significantly ($P\leq0.05$) different. Mean values within each column followed by different superscript letters (A, B, C, D etc) are significantly ($P < 0.05$) different

Effect of storage on Consumer acceptability of the colour of ready-to-consume *kunun gyada* powder

The effect of 9 months storage on consumer acceptability for colour of *kunun gyada* powder is presented in table 5. The results obtained shows that panelist accepted the colour of product KGP2 with the highest score of 4.12 at (0 month) over the other products. Product KGP5 had the least score of 2.50 at initial storage period. There is a significant difference ($P < 0.05$) in the acceptability scores for colour between the products.

Appearance

The results for the effect of 9 months storage on consumer's acceptability of the appearance of ready-to-consume*kunun gyada* powder showed significant difference between the scores of the product table 5. Sample KGP2 had the highest score 4.22, flowed by KGP1 4.01 at zero month. Product KGP5 had the lowest score of 2.88 at initial storage, same trend was recorded after 9 month of storage but there was no significant difference ($P < 0.05$) between product KGP4 and KGP5 with scores of 3.00 and 3.04, respectively.

Table 5: Changes in sensory attributes (colour and appearance) of *kunun gyada* powder during 9 months storage

Sensory attributes	Months of storage	KGP1	KGP2	KGP3	KGP4	KGP5
Colour	0	4.01^{bE}	4.12^{aE}	3.61^{cB}	2.88^{dF}	2.50^{eG}
	1	4.09^{aD}	4.20^{aCD}	3.31^{bFG}	3.01^{bE}	3.45^{bA}
	2	4.23^{bA}	4.30^{aA}	4.10^{cA}	3.20^{dB}	3.08^{eD}
	3	4.20^{aB}	4.21^{aBC}	3.40^{bE}	3.31^{cA}	3.09^{dCD}
	4	4.10^{bD}	4.13^{aDE}	3.50^{cC}	3.00^{dE}	2.80^{eF}
	5	4.00^{bE}	4.10^{aE}	3.30^{cG}	3.00^{dE}	3.00^{dE}
	6	4.11^{aCD}	4.11^{aE}	3.42^{bE}	3.05^{cD}	3.00^{cE}
	7	4.00^{aE}	4.04^{aF}	3.45^{bD}	3.15^{cC}	3.10^{dC}
	8	4.13^{bC}	4.20^{aBC}	3.40^{cE}	3.00^{eE}	3.10^{dC}
	9	4.20^{aB}	4.23^{aB}	3.33^{bF}	3.15^{cC}	3.12^{cB}
Appearance	0	4.01^{bCD}	4.22^{aBC}	3.48^{cB}	3.05^{dE}	2.88^{eG}
	1	4.03^{bC}	4.11^{aDE}	3.32^{cE}	3.10^{dD}	3.08^{dD}
	2	3.96^{bF}	4.20^{aC}	4.00^{bA}	3.24^{cC}	3.18^{cC}
	3	4.00^{aDE}	4.00^{aH}	4.00^{aA}	3.23^{bC}	3.16^{cC}
	4	4.00^{aDE}	4.05^{aG}	3.38^{bD}	3.01^{cF}	3.40^{bA}
	5	4.10^{bB}	4.13^{aD}	3.45^{cC}	3.35^{dA}	3.30^{eB}
	6	4.20^{bA}	4.25^{aA}	3.50^{cB}	3.31^{dB}	3.10^{eD}
	7	4.03^{aC}	4.00^{aH}	3.30^{bE}	3.00^{cF}	3.02^{cEF}
	8	4.00^{bCDE}	4.08^{aFG}	3.18^{cG}	3.10^{dD}	3.00^{eF}
	9	3.98^{bEF}	4.05^{aG}	3.20^{cF}	3.00^{dF}	3.04^{dE}

Mean values within each raw followed different superscript letters (a, b, c, d or e) are significantly ($P\leq0.05$) different. Mean values within each column followed by different superscript letters (A, B, C, D etc) are significantly ($P < 0.05$) different.

Texture

Table 6 presents the effect of 9 months storage on the consumer acceptability of the texture of ready-to-consume*kunungyada* powder. There is a significant difference between the score for the acceptability of texture for the products. At 0 month the product KGP1 had a score of 4.42 which was the highest followed by KGP2 (3.73) while product KGP5 had the least score of 3.00. At 9 months of storage KGP1 and KGP2 had the highest score of 4.00 while KGP4 and KGP5 were scored lowest with 3.00, respectively.

Overall acceptability

The overall acceptability assessment of ready-to-consume*kunun gyada* powder by panelist during the 9 months storage period as presented in table 6 showed that at 0 month the product KGP2 had the highest score for overall acceptability 4.31 followed by KGP1 with a score of 3.95. At 9 months, KGP2 had the highest score of 4.02 while KGP5 was scored 3.00. The scores were based on a 5 point hedonic scale.

Table 6: Changes in sensory attributes of ready-to-consume *kunun gyada*powder during 9 month storage

Sensory attributes	Months of storage	KGP1	KGP2	KGP3	KGP4	KGP5
Texture	0	4.42^{aB}	3.73^{bG}	3.67^{cD}	3.15^{dE}	3.00^{eE}
	1	4.41^{aB}	3.82^{bF}	3.11^{cG}	3.11^{cE}	2.93^{dF}
	2	4.01^{bF}	4.11^{aC}	3.82^{cB}	3.24^{dD}	3.22^{eC}
	3	4.12^{aE}	4.11^{aC}	3.73^{bC}	3.51^{cB}	3.31^{dB}
	4	4.21^{aD}	4.01^{bD}	3.71^{cC}	3.50^{dBC}	3.11^{eD}
	5	4.51^{aA}	4.32^{bA}	3.40^{dE}	3.45^{cC}	3.11^{eD}
	6	4.31^{aC}	4.21^{bB}	3.30^{cF}	3.22^{dD}	3.01^{eE}
	7	4.13^{aE}	3.91^{bE}	3.88^{bA}	3.73^{cA}	3.71^{cA}
	8	3.91^{bG}	4.00^{aD}	3.00^{cH}	3.02^{cF}	3.00^{cE}
	9	4.00^{aF}	4.00^{aD}	3.02^{bH}	3.00^{bF}	3.00^{bE}
Overall acceptability	0	3.95^{bC}	4.31^{aA}	3.61^{cB}	3.09^{dDE}	2.78^{eG}
	1	4.01^{bB}	4.25^{aB}	3.08^{dF}	3.11^{dCD}	3.87^{cA}
	2	4.15^{bA}	4.24^{aB}	3.41^{cD}	3.10^{dCDE}	3.01^{eF}
	3	4.14^{aA}	4.15^{aD}	3.41^{bD}	3.33^{cA}	3.32^{cB}
	4	4.01^{bB}	4.11^{aE}	3.41^{cD}	3.20^{dB}	3.01^{eF}
	5	4.15^{bA}	4.21^{aC}	3.20^{cE}	3.12^{eC}	3.15^{dC}
	6	4.00^{aB}	4.00^{aG}	3.21^{bE}	3.21^{bB}	3.11^{cD}
	7	4.00^{aB}	4.05^{aF}	3.50^{bC}	3.00^{cF}	3.04^{cE}
	8	3.85^{bD}	4.10^{aE}	4.08^{aA}	2.88^{dG}	3.02^{cEF}
	9	3.80^{bE}	4.02^{aG}	3.40^{cD}	3.08^{dE}	3.00^{eF}

Mean values within each raw followed different superscript letters (a, b, c, d or e) are significantly ($P \leq 0.05$) different. Mean values within each column followed by different superscript letters (A, B, C, D etc) are significantly ($P < 0.05$) different.

IV. Discussion

Water activity (a_W)

Water activity is an important determinant factor to assess the amount of available moisture for biochemical processes and also for the growth of molds, yeast and bacteria in foods. The ready-to-consume*kunun gyada* powder under study recorded rather a significant reduction in water activity after three months of storage and gradual decrease until the end of the storage period. The product maintained a relatively low water activity which could be attributed to the effectiveness of the package material used in preventing the product from absorbing moisture. The water activity values obtained in this study was lower than the values reported by [3] for stored flaked breakfast meal formulated from sorghum and pigeon pea which range between 0.44–0.79. The low water activity values of the *kunun gyada* powder could be attributed to the method of drying used (drum drying), and the packaging material was effective by not allowing moisture absorption. The values for water activity obtain was in agreement and within the range of values reported by [13] for snack chip made from germinated soybean flour (0.40–69).Higher relative humidity may increase water activity of stored powders as reported by [14], they observed that absorption of moisture by stored mango powder from the environment with high relative humidity has contributed to increase in the water activity of the mango powder from 0.226–0.668 after 105 days of storage at 90 % RH. Similarly, [15] observed an increase in the water activity of biscuits particularly at 40 days of storage from 0.03–0.55 and attributed the increase to the ability of the product to bind water which could be due to water sorption by the starch-based components of the biscuit matrix. In this study there was no absorption of moisture and water activity remain low.

Peroxide value

It is important to monitor peroxide value in stored products which contain some amount of oil, peroxide value measures the hydroperoxides content which are used as an indicator of lipid oxidation[16]. An oil is considered rancid at a peroxide value above 10 meq/kg [17]. The highest value of 0.52 meq/kg was recorded after 9 months of storage for the control KGP1. This value is lower than the value reported by [18] for stored maize-groundnut composite flours (0-0.88 meq/kg). They concluded that the values were within the acceptable limit. The low peroxide value of the ready-to-consume*kunun gyada* powder is an indication of the stability of the product to oxidation and could also be attributed to the effectiveness of the package material which did not allow moisture, light or oxygen into the package. The package acted as a barrier to uptake of oxygen by the product which if allowed, may have initiated rancidity. Flushing of the product with nitrogen before sealing the package may also have been an added advantage for the products stability.

Thiobarbituric acid value (TBA)

[3] reported TBA values of 0.043-0.48 for stored samples of breakfast flak made from blends of sorghum and pigeon pea. The TBA value was slightly higher than the values obtained for theready-to-consume *kunun*

gyada powder. The breakfast flak was packaged in aluminum foil and carton, stored for 3 months at 25 $^oC \pm 2$. They reported that the product was stable and attributed the low TBA value to be due to the packaging material which prevented lipid peroxidation as evident by the absence of Malone aldehyde. The TBA values recorded for the *kunun gyada* powder was also lower and could also be attributed to the type of package material used and flushing of the product with nitrogen gas before sealing. KGP5 despite having a higher crude fat content of 24.97 % when compared to the other products was stable. The stability and low TBA of KGP4 and KGP5 may be attributed to packaging material used, introduction of nitrogen gas before sealing the package and the addition of 5 % roasted sesame flour in the formulation of KGP4 and KGP5. It was reported by [19] that Sesame is a good source of antioxidant and can be used to improve the shelf stability and sensory characteristics of food products.[20] also reported that methanolic extract of white roasted sesame seed has high anti-lipid peroxidation activity. Roasting of sesame seeds have been shown to increase antioxidant activity. During roasting sesamolin is converted to sesamol [21]. [22] studied the effect of roasting temperature and time on antioxidant properties of sesame seeds, they observed that sesame is a good source of natural antioxidant after roasting at 150 ^oC for 90 minutes. The antioxidant activity, total phenolic and flavonoid improved. Sesamol is a potent phenolic antioxidant and effective in maintaining the oxidative stability of oil than (α, γ and δ) tocopherols [21]. [8] showed that stability of sesame seed oil against autoxidation has been attributed to sesamin, sesamolin and tocopherols. Also to browning reaction products generated when sesame seeds are roasted. The TBA values obtained for the *kunun gyada* powder were also lower than the TBA values reported by [18] for stored maize-groundnut composite flours which ranges between 0.26-4.52 MAE/kg.

Microbial stability

There was no microbial growth during the storage period of the product. This could be attributed to the low moisture content ranging between 4.47-6.50 % and water activity between 0.37-0.61 throughout the storage period. The package material was also adequate enough to prevent moisture absorption by the product which could have encouraged microbial proliferation[23,24]. [3]reported that there was no growth of yeast or bacterial after 3 months storage of breakfast flake produce from blends of sorghum and pigeon pea. They attributed the microbial stability of the product to good package material, low moisture and water activity which range from 0.43-0.78. The values obtained for water activity by this authors was slightly higher than the values obtained for the *kunun gyada* powder during the period of storage (0.37-0.61).[25] also reported microbial stability of instant breakfast cereals made from pearl millet, red and white sorghum stored for 18 weeks at 25 ^oC. They reported that there was no mold and yeast growth from 0-10 weeks, however they observed growth of yeast and molds from 12 weeks which range between 0.12-0.40 logs CFU/ml. The package material used by this researchers was a transparent polyethylene bag which could have allowed the product to absorb moisture and this may have favoured the growth of microbes. The aluminum-laminated polyethylene (ALP) pouches used in this study for the *kunun gyada* powder was more effective to prevent the product from absorbing moisture. There was also no growth of yeast and molds in the product during the storage period as shown in the plates inoculated on potato dextrose agar (PDA) (Figure 1). This could also be because the *kunun gyada* powder had low moisture content and was properly sealed in a good packaging material.

White colour (L^*)

The values of L^* obtained after 9 months storage period shows that the whiteness of the product was maintained up to four months of storage. A significant reduction in the whiteness was recorded from 5 month of storage, this reduction in whiteness was gradual until the end of 9 months. Only a slight decrease in the colour was observed (less than 7 %). The decrease in whiteness can be explained by the formulation of the product. The products with low L^* values had more soybean and roasted sesame flour added which cause the decrease in the whiteness. The control had no soybean or sesame flour added and had the highest value of whiteness (L^*). [26] observed a similar decrease in whiteness (L^*) of spaghetti made from a composite blend of rice and defatted soybean flours, the L^* value decrease from 62.3 – 49.6 when soybean flour was added (15g/100g).

Consumer acceptability of the colour of *kunun gyada* powder

The low acceptance of KGP5 may be attributed to the product having more quantity of soy flour (15%) than the other products and rice flour was also lower in the formulation (25%). Addition of soybean flour has been shown to decrease whiteness (L^*) and increase brownness (a^*), as observed by [26] when 15% defatted soy flour was added to rice flour, this finding is in agreement with the product KGP5 which also had 15% soy flour in the formulation. It was observed that the colour of KGP2 was more acceptable to the panelist after 9 months storage period.There was no significant difference between KGP2 and KGP1 with scores of 4.23 and 4.20 respectively. This could be due to the fact that KGP2 had the lowest quantity of soy flour (5%) and 30% rice flour in the formulation which did not significantly affect the white colour of the product. Generally base on 5 points score, the product's colour was still acceptable to panelist after a storage period of 9 months. The colour of a product is an important sensory attribute that attracts a consumer to the product [27].

Appearance

The product's colour has affected the appearance as was concluded by [28], that a product's appearance includes the product's colour and other appearance properties such as physical form (shape, size and surface texture). Therefore appearance as a sensory attribute affects the colour a consumer perceives, example apparent roughness of the surface of the product. The whiteness colour of KGP4 and KGP5 decreased due to the addition of soy bean flour, KGP4 had 10% soy and 5% roasted sesame flour in the formulation which may have contributed to the decrease in the whiteness of the product as observed also in product KGP5. This findings is in agreement with the observation of [26] in the formulation of rice and defatted soy flour. KGP4 was also oilier and the oiliness may have also contributed to the product's low score.

Texture

The texture of the product was generally acceptable base on 5 points score, normally texture deals with visual and touch properties of a product.It is a complex aspect of food that relates to physical condition of the product and structure which is visually identified. The difference in the acceptability of the texture by the panelist could be as a result of the variation in the product's formulation, the control had no soy flour added while KGP5 had the highest soy flour (15%) and the lowest quantity of rice flour (25%). The reduction in the quantity of rice flour and an increase in soy flour may have affected the physical texture of KGP5 and was scored low, however during reconstitution of the powder into porridge KGP5 reconstituted faster (18.33 seconds) when compared to the other products and had a low water absorption capacity. This is an indication that the product has more soy flour and the quantity of rice flour was also low. Germination of soy bean seeds has the advantage of improving the functional, textural and nutritional quality of soybean [29]. The control KGP1 had the highest value of water absorption capacity (WAC) of 3.47g/g, the control absorbs more water than the other samples, and high WAC is related to the extent of starch gelatinization.Gelatinize starch imbibes water readily than the soy flour.

Overall acceptability

The highest score recorded by KGP2 could have resulted from the golden brown colour of product which may be due to the addition of 5% soy and 5% sesame flours in the formulation. This may have attracted the panelist.The appearance was scored high (4.22). However, the low quantity of soy flour (5%) was not significantly effective to have improved the physical texture of the product.This is evident in texture acceptability results in which KGP1 had the highest score of 4.42. The results showed that the products were generally acceptable to the panelist after the storage period base on 5 points score. [30] reported the overall acceptability of instant weaning food formulated from blends of maize, pawpaw, red beans and mackerel fish meal with overall acceptability score ranging from 5.50-5.82, based on 9 point hedonic scale.They attributed the acceptability to the colour, texture, taste and flavour of the product. The colour and appearance of the *kunun gyada* powder was maintained during the storage period and could be attributed to the package material which did not allow light, gases and moisture as evident in the results for colour acceptability after the storage period.The score range from 4.23-3.12, the panelist still found the product acceptable after 9 months of storage. [31] observed that aluminum package material has a good barrier properties not to allow moisture, gases and light into the package.

V. Conclusion

The evaluation of the storage stability of ready-to-consume*kunun gyada* powder showed that the product was stable during the storage period.With low water activity 0.37-0.61, peroxide and TBA values the product did not go rancid. This shows that the packaging material used was very effective for the period of storage by not allowing absorption of moisture or penetration of oxygen.Flushing with nitrogen could be an added advantage to the package material which is reflected by the oxidative stability of the product. There was no growth of mold, yeast or coliform during the period of storage which is an indication that the method of processing used to produced ready-to-consume*kunun gyada*powder was effective in addition to a good packaging material.This method may be adopted by *kunun gyada* processors to extend the shelf life of this product. Furthermore the product was still acceptable throughout the storage period.This studyshows the possibility of extending the shelf-life of the traditional *kunun gyada*product if processed into powder at a moisture content between 4.47-6.50% and storage temperature of $24^{o}C\pm2$ with relative humidity of 41±2%. It is recommended that further studies be conducted on storage at refrigeration and higher temperatures.

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