Original Research Article

Effect of Drying Methods on the Chemical and Storage Properties of '*Daddawa*' Powder from *Parkia biglobosa* Seeds

ABSTRACT

The study investigated effect of different drying methods on the chemical and storage properties of '*daddawa*' powder produced from African locust bean (*Parkia biglobosa*) seeds. The study provided valuable insights into the drying methods that will help in optimizing the process of drying fermented 'daddawa' vis-à-vis nutritional and other quality properties of the product. The seeds were processed using slight modification of the traditional method. Fermented seeds were divided into four portions, three parts were dried using cabinet, oven and sun giving samples CB1, OC2 and SD3 respectively. Dried samples were comminuted using attrition mill and packaged. The fermented undried seeds (UA0 - control) was milled into paste and refrigerated before analysis. The samples were subjected to chemical analysis using standard procedures. Results of proximate composition revealed that moisture content of CB1 (13.04^{b}±0.00), OC2 (12.64^{bc}±0.47) and SD3 (12.03^{c}±0.00) were within range of flour (10-14%). Protein content showed that SD3 (25.17^{a}±0.09) was significantly ($P<0.05$) different to the rest samples. The result of vitamin content of '*daddawa*' powder shows that SD3 (8.88^{a}±0.00) was highest in vitamin B1 followed by UA0 (8.67^{a}±0.15) with no significant ($P<0.05$) difference. The results show an array of mineral content including calcium, potassium, iron, magnesium, phosphorus, zinc, manganese and sodium. pH value was highest in OC2 (6.9) and SD3 (6.9) and least in CB1 (6.2). The study revealed that cabinet dried samples could be more stable owing to its lowered pH value and color thus proving its advantage over the others. Also, both water activity and microbial counts of bacteria and fungi increased with storage time. It is recommended that further studies should be carried out to determine the *invitro* and *invivo* digestibility of the protein for both the dried and undried (control) samples. Also, to ameliorate losses of nutrients during drying, lower temperature should be adopted.

Keywords: *Daddawa; drying methods; chemical qualities; powder; microbial; Parkia biglobosa.*

1. INTRODUCTION

Daddawa is an alkaline fermented condiment which is processed from the seeds of the African locust bean and has a final pH above 7 [1]. African locust bean (*Parkia biglobosa*) and other oil seeds such as melon seed, castor seed, soy-bean etc. are fermented to produce condiments [2]. Fermented locust bean is a well-known condiment with characteristic ammoniacal odour and flavor which enhance the taste of traditional soups and

sauces especially those used as accompaniments to starchy foods. It is generally added to soups as low cost meat substitute by low income families in parts of Nigeria and is known to contribute to the caloric and protein intake [3]. *Daddawa* is common with the Hausa tribe in the northern part of Nigeria and the Middle belt. Fermented or local seasonings are good source of nutrients and could be used to produce complementary food supplements. Local seasonings can also add extra nutrients such as vitamins B due to traditional processes which they undergo.

Fermented products remain a thing of interest since they do not require refrigeration during distribution and storage. Traditionally, fermented locust beans are molded into paste and sundried [4]. According to [5], various methods have been adopted to add value and extend the shelf life of fermented locust beans such as salting, drying, processing the seed into powdered condiment (locust beans powder) and improvements involving addition of small portion of solid fat (such as hydrogenated oil), salt and seasonings, and shaping it to small cubes. Drying is a cheap method that will help to alleviate the high incidence of spoilage and thus reduce protein malnutrition in low-income earners. Drying also decreases the moisture content, thus discouraging microbial growth and food spoilage. [6] recommended that good post fermentation technique is necessary to protect, prolong shelve life and to present the condiment in an acceptable form. Such techniques include drying, packaging and storage. Traditionally, storage of dried 'daddawa' cubes is done by packaging in overwrap such as polythene or leaves and placed inside plastic or glass containers for safe keeping. However, some factors limit their production and acceptability by the generality of the people. As observed by [7], the traditional condiments have not attained commercial status due to the very short shelf-life, objectionable packaging materials, stickiness and the characteristics putrid odour.

Most foods are highly perishable because of high moisture contents which make them susceptible to biochemical reactions and microbial spoilage, thereby requiring preservation in one way or the other [8]. Among the common methods used in preserving food products are minimal processing, refrigeration, smoking and dehydration or drying [9, 10, 11, 12]. Drying has been used as a method of reducing post-harvest losses in many agricultural produce for a long time [13] and as well as improving their commercial value. Drying of foods reduces the moisture contents to preserve the foods and prolong their storage life so that the dried products could be made available at locations where they are not produced and all year round. Apart from reduction in bulkiness and weight, drying also reduces the costs of packaging, handling and transportation [13]. However, the drying of foods could also lead to physical, sensory, nutritional and microbiological quality changes.

Drying methods are broadly divided into two namely, natural and artificial drying methods. The natural drying method uses the solar energy to remove moisture from food products. This method depends on variability of weather conditions which makes it highly unreliable [14]. On the other hand, artificial drying method is more preferred than natural method of drying because of faster drying rate and efficiency and effectiveness in removing large amount of moisture from produce which result into better quality dried products [14]. In addition, there is better control of various factors involved in the drying process such as temperature, drying air flux and time of drying. In artificial drying effectiveness and efficiency of drying operation could be improved through the use of mechanical or electrical equipment such as fans [8].

One of the constraints to utilization of *daddawa* is the poor quality, short shelf life and high putrid odour which affect its acceptability and storage stability [6]. Hence, the condiment has remained localized. Consequently, converting *daddawa* into powder will not only extend its shelf life but also reduce the high offensive odour associated with the product thereby improving the acceptability. Also, significant contributions have been made on local condiments from both legumes and wild trees, however, little or no knowledge is available on the impact of drying on the quality characteristics of *daddawa* powder.

The study was aimed at evaluating the chemical, sensory and storage properties of powdered *daddawa* produced from African locust bean (*Parkia biglobosa*) seeds using oven, cabinet and sundrying methods.

2. METHODOLOGY

2.1 Material

Processing raw materials such as African locust bean (*Parkia biglobosa*) ("*kalwa*" in Hausa) was purchased at Muda Lawal market in Bauchi metropolis, Bauchi State, Nigeria. Drying machines such as cabinet (APV MITCHELL DRYERS CARLISLE ENGLAND ORDER NO. 5213/82) and oven (PROLABO NO. 35349) dryers were sourced from the Department of Food Science and Technology, Federal Polytechnic Bauchi, Bauchi State, Nigeria where processing and analysis was carried out. Sundrying was done outside the Food Processing Workshop of the Department, where product was placed on cleaned stainless steel tables.

2.2 Formulation of samples and production process

The traditional method was adopted for the production of *daddawa* with slight modification (Fig.1) [15]. Fermented *daddawa* was divided into four portions, three parts were dried using cabinet (80^0C), oven (80^0C) and sun (ambient) giving samples CB1, OC2 and SD3 respectively. The dried 'daddawa' was comminuted using attrition milling machine to get samples of powdered *daddawa*. The fermented undried seeds (UA0 - control) was milled into paste and refrigerated to prevent spoilage before analysis. Three samples of 'daddawa' powder including control (UA0) were subjected to chemical analysis which included proximate composition, vitamin content, mineral content, pH and titratable acidity, water activity, and color determination using standard analytical methods [16].

African locust bean seeds
↓
Cleaning
↓
Sorting
↓
Boiling using traditional iron pot (overnight)
↓
Cooling (40^0C)
↓
Dehulling (by hand pressing)
↓
Pressing and washing
↓
Reboiling (for about 6 hours with addition of "*kaun*")
↓
Re-washing
↓
Draining (plastic basket sieve)
↓
Wrapping in brown paper and placing in trays
↓
Fermentation (4 days at 27^0C)
↓

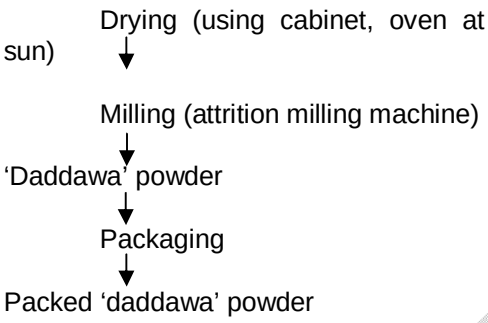

Figure 1: Flow chart for powdered 'daddawa' production from Africa locust bean seeds (*Parkia biglobosa*) with modification [15].

2.2 Determination of Chemical properties of powdered '*daddawa*'

Proximate composition, vitamin content, mineral content, Titratable acidity, pH, water activity and color were determined using standard chemical methods [16].

2.3 Sensory Evaluation of '*Daddawa'* Samples

Sensory evaluation was determined using 15 untrained panellists randomly selected with the 9-point hedonic scale [17].

2.5 Determination of Total Microbial Count

The Total Microbial Count (TMC) also known as the Total Viable Count (TVC) was determined using the procedure [18]. 23.4g of potato dextrose agar was weighed and dissolved in 300ml of distilled water in a conical flask. 5.6g of nutrient agar was also weighed and dissolved in 200ml of distilled water. 9ml of distilled water was pipetted into 5 test tubes each for the samples, and plucked with cotton wool. The prepared agars, distilled water, petri-dishes and pipettes was sterilized in the autoclave (Model: YX-280A. GULFEX MEDICAL AND SCIENTIFIC ENGLAND) at 121^{0}C for 15 minutes at 15psi. After sterilizing, the test tubes was labelled 10^{-1} to 10^{-5} and the petri-dishes was also labelled appropriately. 10g of each sample was weighed into a homogenate containing 50ml of distilled water in a beaker. This was stirred using a stirrer to a homogenous solution which was later filtered to get a clear solution. 1ml of the homogenate was serially diluted into the 9ml of test tubes labelled 10^{-1}. After homogenizing, 1ml was taken from here and transferred to the 10^{-2} and continued up to the 10^{-5} dilution for each sample. 0.1ml aliquot from the 10^{-5} dilution was transferred into labelled petri-dishes in duplicate for each sample. The potato dextrose agar and nutrient agar were allowed to cool, after which each was poured into the petri-dish containing 0.1ml aliquot for each sample. The petri-dishes were rocked gently and allowed to solidify. The plate was then incubated by placing the nutrient agar plate inside the incubator (M'^{c} Jefferson – UK) at 37^{0}C for 24 hours and the potato dextrose agar plate was put on the shelf at room temperature for 72 hours. At the end of the incubation period, the colonies on each plate was counted with a colony counter (J-2 Colony Meter PEC MEDICAL USA) and results calculated as colony forming units (CFU) per ml. The following equation was used to calculate the colony forming unit of the microbial counts:

$c = n/vd$

Where c is the colony forming unit per ml (cfu/ml)
n is the number of colonies
d is the dilution blank factor
v is the volume transferred to plate

2.6 Statistical Analysis

Results were presented as mean ± standard deviations of duplicate determinations. The data obtained from the various determinations were subjected to analysis of variance using the GenStat Statistical Software, Seventeenth Edition (17.1). One way analysis of variance

(ANOVA) was used for the comparison of the means. Differences between means was considered to be significant at ($P<0.05$) using the Tukey multiple range test.

3. RESULTS AND DISCUSSION

3.1 Proximate composition of 'daddawa' powder

The proximate composition of 'daddawa' powder presented in "Table 1" showed that the control sample UA0 ($23.38^{a}\pm0.06$) is significantly different to samples CB1 ($13.04^{b}\pm0.00$), OC2 ($12.64^{bc}\pm0.47$) and SD3 ($12.03^{c}\pm0.00$) in moisture content at 5% confidence level. Whereas CB1 and SD3 shows significant difference ($P<0.05$), OC2 appeared same with others in their moisture content. This result unarguably appears under range of moisture content of flour (10-14%) which makes it ideal for safe keeping. The result is equally lower than that reported for moisture content (26.61%) by [19]. Expectedly, protein, fat, ash, crude fibre and carbohydrate contents expressed higher values in the dried samples than the undried (control); with SD3 ($25.17^{a}\pm0.09$) being the highest and UA0 ($19.71^{c}\pm0.38$) as the least in protein value. Proximate composition result in general ranged from $2.94^{c}\pm0.07$ (UA0) to $41.79^{a}\pm0.44$ (OC2) representing ash and carbohydrate respectively. The protein and carbohydrate contents were way above that reported by [19] which were given as 16.98% and 22.28% respectively. It can be deduced that drying help to condense the nutrient values especially the non-volatile ones. Crude fibre content of all samples expressed higher values than that reported by [20] for fermented *parkia biglobosa* seeds (1.71%), likewise variables like protein (20.23%) and carbohydrate (33.84%). This could further portray the advantage of drying and conversion to powder in concentrating the nutrients.

Table 1: Results of Proximate Composition of Powdered "Daddawa" Samples

Parameter	UA0	CB1	OC2	SD3
Proximate composition (% 100g sample)				
Moisture	$23.38^{a}\pm0.06$	$13.04^{b}\pm0.00$	$12.64^{bc}\pm0.47$	$12.03^{c}\pm0.00$
Protein	$19.71^{c}\pm0.38$	$24.26^{b}\pm0.06$	$23.80^{b}\pm0.04$	$25.17^{a}\pm0.09$
Crude fat	$9.50^{d}\pm0.08$	$24.26^{b}\pm0.06$	$12.04^{c}\pm0.05$	$12.93^{a}\pm0.02$
Ash	$2.94^{c}\pm0.07$	$4.53^{a}\pm0.59$	$3.28^{bc}\pm0.07$	$3.89^{ab}\pm0.01$
Crude fibre	$4.93^{d}\pm0.01$	$6.16^{b}\pm0.04$	$6.44^{a}\pm0.01$	$5.20^{c}\pm0.02$
Carbohydrate	$39.54^{b}\pm0.44$	$39.63^{b}\pm0.48$	$41.79^{a}\pm0.44$	$40.79^{a}\pm0.13$

Values are means ± standard deviations of duplicate determinations. Means in same row with different superscript are significantly ($P<0.05$) different.

Key: UA0 = Undried fermented 'daddawa' seeds
CB1 = Cabinet dried 'daddawa' powder
OC2 = Oven dried 'daddawa' powder
SD3 = Sundried 'daddawa' powder

3.2 Vitamin content of 'daddawa' powder

The result of vitamin content of 'daddawa' powder "Figure 2" showed that SD3 ($8.88^{a}\pm0.00$) was highest in vitamin B1 followed by UA0 ($8.67^{a}\pm0.15$) with no significant difference ($P<0.05$) and the least was expressed in CB1 ($7.17^{b}\pm0.02$) which has no significant difference ($P<0.05$) to OC2 ($7.29^{b}\pm0.08$). 'Daddawa' powder showed highest value in vitamin D content, with UA0 ($87.98^{a}\pm1.92$) being significantly different ($P<0.05$) to the rest of the samples. While vitamin E expressed least values in vitamin contents of samples, sample UA0 ($2.18^{a}\pm0.23$) is significantly different ($P<0.05$) to the rest of the samples. Vitamins B1 and D expressed values higher than that reported by [21] which were 0.77mg/100g and

0.29mg/100g respectively. However, the same author reported a value for vitamin E (23.34mg/100g) which was higher than that obtained for the experimental samples.

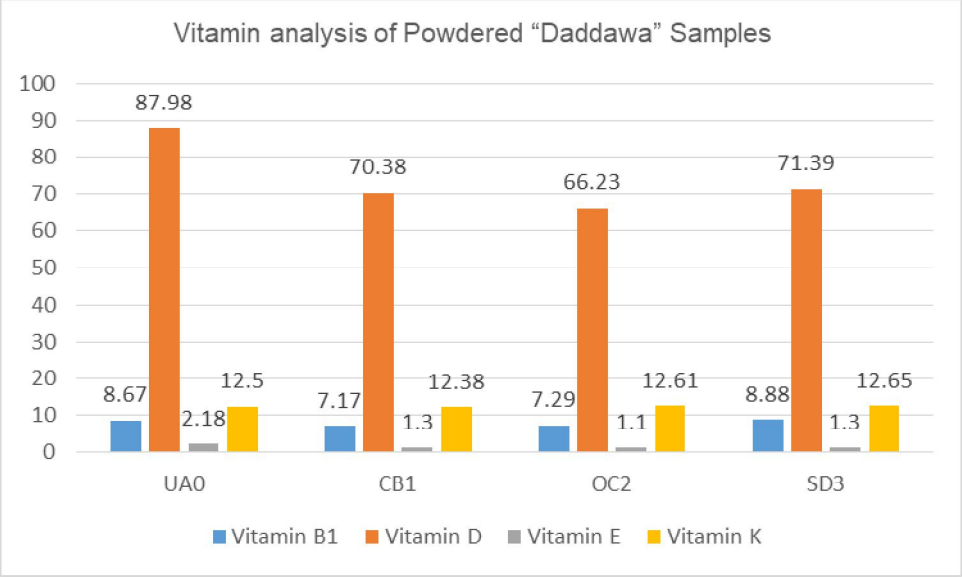

Figure 2: Results of vitamin composition of powdered "daddawa" samples

3.3 Mineral content of 'daddawa' powder

The 'daddawa' powder samples showed an array of mineral content "Table 2" including calcium, potassium, iron, magnesium, phosphorus, zinc, manganese and sodium. Potassium had the highest value with SD3 ($174.90^{a}\pm2.22$) being significantly different ($P<0.05$) to the other samples including the control as seen in "Table 2". Calcium followed in the amount expressed by minerals and then magnesium. In calcium content UA0 ($123.60^{a}\pm0.08$) was significantly different ($P<0.05$) to other samples. Iron was least expressed with no significant difference ($P<0.05$) among the samples. All mineral values for the samples were higher than those reported by [21] for fermented oven dried *Parkia biglobosa* seeds except iron which was 14.13±0.01 mg/100g. [22] reported the following values for sodium, potassium, calcium, magnesium and phosphorus: 60.80mg/kg, 5566.60mg/kg, 1.30mg/kg, 0.40mg/kg, 4.70mg/kg respectively for locally fermented *parkia biglobosa*. However, the expressed results for these minerals by samples UA0, CB1, OC2 and SD3 exceeded the above stated results. This could be consequent of the methods of production and drying processes employed which has proven more advantageous.

Table 2: Results of Mineral analysis of Powdered "Daddawa" Samples

Parameter	UA0	CB1	OC2	SD3
Mineral content (mg/100g)				
Calcium	$123.60^{a}\pm0.08$	$119.10^{b}\pm1.27$	$106.80^{c}\pm0.78$	$105.30^{c}\pm0.78$
Potassium	$139.80^{c}\pm2.14$	$150.80^{b}\pm0.70$	$122.20^{d}\pm0.00$	$174.90^{a}\pm2.22$
Iron	$1.08^{a}\pm0.09$	$1.15^{a}\pm0.06$	$1.10^{a}\pm0.01$	$1.23^{a}\pm0.02$
Magnesium	$103.00^{b}\pm0.56$	$102.30^{b}\pm0.00$	$100.60^{c}\pm0.53$	$108.60^{a}\pm0.71$
Phosphorus	$32.95^{c}\pm0.56$	$40.40^{b}\pm0.08$	$40.50^{b}\pm0.86$	$42.38^{a}\pm0.07$
Zinc	$4.40^{c}\pm0.05$	$4.65^{b}\pm0.02$	$4.63^{b}\pm0.00$	$4.75^{a}\pm0.00$
Manganese	$4.29^{b}\pm0.07$	$4.89^{a}\pm0.01$	$4.07^{b}\pm0.02$	$4.73^{a}\pm0.15$
Sodium	$56.32^{a}\pm0.62$	$56.51^{a}\pm0.08$	$57.16^{a}\pm1.16$	$56.56^{a}\pm0.16$

Values are means ± standard deviations of duplicate determinations. Means in same row with different superscript are significantly (P<0.05) different.

Key: UA0 = Undried fermented 'daddawa' seeds
CB1 = Cabinet dried 'daddawa' powder
OC2 = Oven dried 'daddawa' powder
SD3 = Sundried 'daddawa' powder

3.4 pH Content and Titratable acidity of 'Daddawa' Powder

The pH values expressed by the powdered 'daddawa' samples "Table 3" showed a similar range between the samples, except CB1 with a slightly lower value. While UA0, OC2 and SD3 had 6.8, 6.9, 6.9; CB1 was least with 6.2 respectively. This indicate that CB1 was more slightly acidic than the others. It also suggest that the sample could be more stable in terms of microbial activity during storage. During fermentation, the pH of fermented food and beverage products decreases as the amount of organic acid increases [23].This could be accounted to microbial activities, especially of lactic acid bacteria that convert carbohydrates into different organic acids such as lactic acid, acetic acid, and butyric acid [24, 25, 26].

Titratable acidity value also shown in "Table 3" was highest in CB1 (3.72%) and lowest in SD3 (2.30%). This indicate a little variation in the palmitic value of the samples. The pH result agrees with the titratable acidity content of the samples. As observed, CB1 with highest acidity value had lower pH value indicating a more slightly acidic content.

Table 3: Results of Chemical Property of Powdered "Daddawa" Samples

Parameter	**UA0**	**CB1**	**OC2**	**SD3**
pH	6.8	6.2	6.9	6.9
Titratable acidity (% palmitic acid)	2.72	3.52	2.43	2.30

Values are means ± standard deviations of duplicate determinations. Means in same row with different superscript are significantly (P<0.05) different.

Key: UA0 = Undried fermented 'daddawa' seeds
CB1 = Cabinet dried 'daddawa' powder
OC2 = Oven dried 'daddawa' powder
SD3 = Sundried 'daddawa' powder

3.5 Sensory evaluation of powdered 'daddawa' samples

The result of sensory evaluation is presented in "Table 4". The result showed that the mean values for the parameters of taste, smell, and general acceptability were: 8.53, 8.27, 7.60, 7.80; 8.07, 7.73, 7.60, 7.93; 8.07, 7.93, 7.93, 8.07 and 8.20, 7.87, 8.00, 7.47 for UA0, CB1. OC2 and SD3 respectively.

The result showed that there was significant difference (P<0.05) among the samples only in taste, and it is between the control sample UA0 and OC2 as observed in "Table 4". There was no significant difference (P<0.05) between UA0, CB1, OC2 and SD3 in the parameters of smell, colour and general acceptability. Overall, the test panelist preferred UA0 based on taste.

Table 4: Result of sensory evaluation

Sample	Taste	Smell	Colour	General acceptability
UA0	8.53^{a}±0.74	8.07^{a}±0.96	8.07^{a}±1.09	8.20^{a}±0.94
CB1	8.27^{ab}±0.70	7.73^{a}±0.96	7.93^{a}±0.96	7.87^{a}±1.13
OC2	7.60^{b}±0.99	7.60^{a}±0.99	7.93^{a}±0.96	8.00^{a}±0.76
SD3	7.80^{ab}±0.94	7.93^{a}±1.09	8.07^{a}±0.88	7.47^{a}±1.06

Mean values along a column with different letter superscript are significantly different (P<0.05)

Key: UA0 = Undried fermented 'daddawa' seeds

CB1 = Cabinet dried 'daddawa' powder
OC2 = Oven dried 'daddawa' powder
SD3 = Sundried 'daddawa' powder

3.6 Water activity (a_w) of powdered 'daddawa' samples

The result of water activity of 'daddawa' powder samples presented in "Figure 3" indicate values obtained during three months storage period. In month one, CB1, OC2 and SD3 had 0.81, 0.80 and 0.89 water activity values respectively. In month two, the values increased as follows: 0.89, 0.87 and 0.91 for CB1, OC2 and SD3 respectively. In month three, the values obtained were 0.90, 0.90 and 0.945 for CB1, OC2 and SD3 respectively.

The result showed that there is significant difference ($P<0.05$) between CB1 (0.81a) and SD3 (0.89b) and OC2 (0.80a) and SD3 (0.89b) in month one. There was no significant difference ($P<0.05$) among the samples in month two, although the values increased significantly than that of month one. There was also slight increase in water activity of samples from month two to three of storage.

The result of water activity of the samples were slightly lower than the water activity requirement for bacteria growth which is 0.91 [27] with only sample SD3 expressing a value above this in month three. The increasing trend of the values with increase in storage time reflect a possible increase in microbial load with time. Water activity is a measure of water in a material that is available to react with or attach itself to other material; it is also called "free" water while the unavailable water is called "bound" water. Fungi require a water activity of at least 0.6 [12].

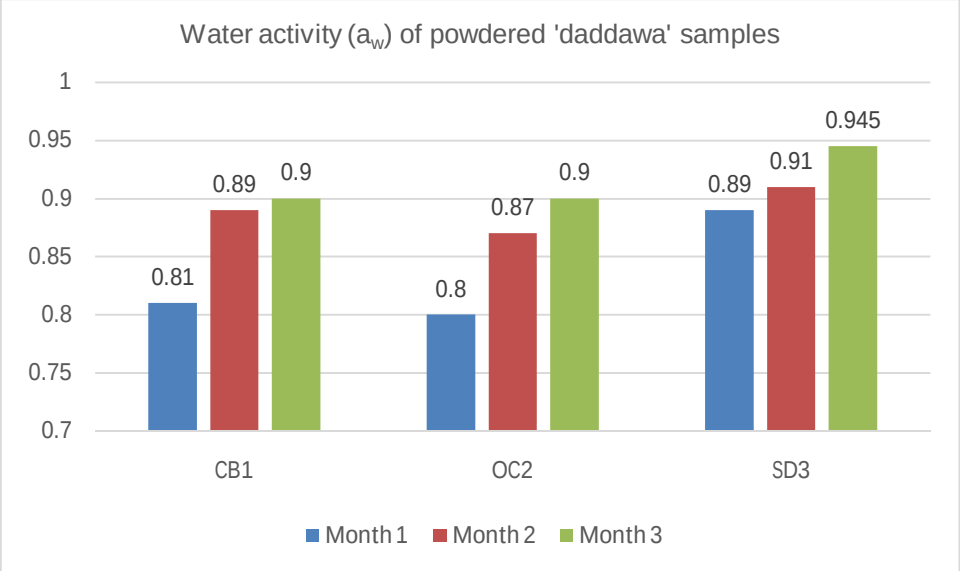

Figure 3: Results of water activity of powdered 'daddawa' samples

3.7 Microbial analysis of powdered 'daddawa' samples

The result of microbial analysis of 'daddawa' samples are presented in "Table 5". The results shows values of total viable counts (TVC) and fungi counts obtained after production (zero month) and during period of storage (1-3 months). In zero month, UA0 expressed highest value of total viable count (TVC) and fungi count (FC) (4.7×10^4cfu/ml and 4.8×10^1cfu/ml) respectively than CB1, OC2 and SD3 as observed in Table 5. While fungi count had higher values than total viable count, during the storage period, both results are within safety limits.

In month one, SD3 showed the highest value of TVC (7.1×10^1cfu/ml) while OC2 (1.0×10^1cfu/ml) was least. There is no significant difference between the samples. Similarly,

there is no significant difference ($P<0.05$) between the samples in FC values but OC2 (2.05×10^{1}cfu/ml) was slightly higher.

There was no significant counts of the samples in TVC in month two but there was significant increase in TVC of samples in month three as CB1, OC2 and SD3 had 1.3×10^{3}cfu/ml, $1,1\times10^{3}$cfu/ml and 1.3×10^{3}cfu/ml respectively. Also, FC gradually increased in month three as CB1, OC2 and SD3 had 1.9×10^{1}cfu/ml, 2.4×10^{1}cfu/ml and 2.4×10^{1}cfu/ml respectively.

The total viable counts (TVC) of the powdered '*daddawa'* samples during the storage period were less than that reported by [28] for locust bean-condiment powder produced in plastic (5.03×10^{2} $\log_{10}$ cfu/mL) and locust bean–condiment powder produced in calabash (4.74×10^{2} $\log_{10}$ cfu/mL).

Overall, the microbial results showed that both TVC and FC are within safety limit at 3 months of storage, as all the results were below minimum limit of standard (1.0×10^{6}cfu/ml). It indicates that the products can keep for longer time on the shelf, being a dried product.

Table 5: Results of microbial analysis (Month 0-3)

Sample	Month 0		Month 1		Month 2		Month 3	
	TVC*	FC*	TVC	FC	TVC	FC	TVC	FC
UA0	$4.7\times10^{4a}\pm8485.25$	$4.85\times10^{1a}\pm53.50$	-	-	-	-	-	-
CB1	$1.2\times10^{1b}\pm0.00$	$2.85\times10^{1a}\pm7.78$	$1.2\times10^{1a}\pm0.00$	$1.9\times10^{1a}\pm0.00$	$1.3\times10^{1a}\pm0.00$	$2.0\times10^{1a}\pm0.00$	$1.3\times10^{3a}\pm0.00$	$1.9\times10^{1a}\pm0.00$
OC2	$1.0\times10^{1b}\pm0.00$	$2.25\times10^{1a}\pm0.71$	$1.0\times10^{1a}\pm0.00$	$2.05\times10^{1a}\pm0.71$	$1.0\times10^{1a}\pm0.00$	$2.25\times10^{1b}\pm0.71$	$1.1\times10^{3a}\pm0.00$	$2.4\times10^{1a}\pm0.00$
SD3	$1.95\times10^{1b}\pm2.12$	$3.25\times10^{1a}\pm2.12$	$7.1\times10^{1a}\pm83.44$	$2.0\times10^{1a}\pm0.00$	$1.3\times10^{1a}\pm0.00$	$2.3\times10^{1b}\pm0.00$	$1.3\times10^{3a}\pm0.00$	$2.4\times10^{1a}\pm0.00$

Values are mean ± standard deviation of duplicate determinations. Mean values along a column with different letter superscripts are significantly different ($P<0.05$).

Key: *TVC = Total viable count. FC = Fungi count

UA0 = Undried fermented 'daddawa' seeds

CB1 = Cabinet dried 'daddawa' powder

OC2 = Oven dried 'daddawa' powder

SD3 = Sundried 'daddawa' powde

3.8 Color determination of 'daddawa' samples

The result of color determination of 'daddawa' samples is presented in "Table 6". It was determined using the L* a* b* color measurements. The result showed a significant difference ($P<0.05$) in L* (values) between samples UA0, CB1, OC2 and SD3 as expressed: 20.77^{c}, 23.51^{b}, 18.17^{d} and 28.50^{a} respectively. The values ranged from 18.17-28.50 with OC2 being the least and SD3 being the highest respectively. As shown in the table, a* also expressed significant difference ($P<0.05$) among the samples and ranged from 2.45-6.00 (SD3 and UA0) respectively. The values expressed for b* by the samples is zero except SD3 with -1. The value of b* obviously influenced the DC* and Hue outcome as seen in the table.

L* values (also called value) indicate degree of lightness from black to white (range = 0 – 100). Negative b* is blue, positive b* is yellow; negative a* is green and positive a* is red. Both a* and b* values range from -127 to 127 [29]. As observed in the table, the values of L* for all the samples is closely quarter away from black indicating that the product could be darker in colour. It was also observed from the results that the products leans towards red and yellow except for SD3 (b* = -1.00).

The Hue values of zero degrees obtained for samples UA0, CB1 and OC2 indicate a red hue direction for the product and a probability of a darker product as the hue moves from red to yellow. This analysis could suggest a depiction of the colour of 'daddawa' powder which is red-brown. The dark red-brown colour of the powdered samples was stable during the three months storage period. Colour is a sensory attribute of food that can be used to determine its quality and consumer acceptability. Colour evaluation in foods is an important aspect of safety and marketability in the food industry. It is so influential that it can greatly affect consumers' rating of food quality, taste and acceptability [28].

Table 6: Result of Color Determination of 'Daddawa' samples

Sample	L*	a*	a*	DC*	Hue (^{o})
UA0	20.77^{c}±0.46	6.00^{a}±0.00	0.00	6.00	0.00
CB1	23.51^{b}±0.66	3.10^{c}±0.00	0.00	3.10	0.00
OC2	18.17^{d}±0.08	4.00^{b}±0.00	0.00	4.00	0.00
SD3	28.50^{a}±0.52	2.45^{d}±0.07	-1.00	2.65	-22.21

Values are means ± standard deviations of duplicate determinations. Means in same column with different superscript are significantly ($P<0.05$) different.

Key: UA0 = Undried fermented 'daddawa' seeds
CB1 = Cabinet dried 'daddawa' powder
OC2 = Oven dried 'daddawa' powder
SD3 = Sundried 'daddawa' powder

4. CONCLUSION

The study revealed that 'daddawa' powder dried by various methods expressed better quality in proximate composition than the control. However, drying affected the various vitamins analyzed but with little significant difference. Also, drying had no much effect on the minerals except calcium with much significant difference between the control and the rest. It also revealed that cabinet dried samples could be more stable owing to its lowered pH value. Either of the methods of drying could possibly give a nutritionally stable 'daddawa' powder as both methods compared favorably in the quality indices analyzed. Also, both water activity (a_w) and microbial counts of bacteria and fungi increased with storage time. The study indicated color stability during storage, however, sundried sample had a brighter color than the rest. Additionally, the findings have implications for optimizing drying techniques to preserve nutritional and microbial qualities, making the study relevant for food scientists and technologists working on sustainable food preservation.

Disclaimer (Artificial intelligence)

Option 1: Yes, option 1 is accepted because no AI was employed in the writing and editing of the manuscript.

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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