European Journal of Food Science and Technology
Vol.9, No.3, pp.35-52, 2021
Print ISSN: ISSN 2056-5798(Print)
Online ISSN: ISSN 2056-5801(online)

# QUALITY EVALUATION OF COOKIES MADE FROM WHEAT FLOUR FORTIFIED WITH TIGER NUT FLOUR AND DATE PALM FRUIT

**M.O. Jimoh**

Department of Chemical and Food Sciences, Bells University of Technology, Ota, Nigeria

**ABSTRACT:** *Cookies are baked food that is typically small, flat and sweet. It usually contains flour, sugar and other ingredients. Tiger nut is globally recognized for its nutritional, functional and medicinal properties that are suitable for children, grownups and sport men. However, it is highly underutilized. The inclusion of date palm fruit in the production of cookies from wheat flour fortified with tiger nut flour enhances good sensory attributes and reduces the risk of diabetics associated with consumption of granulated sugar as sweeteners. The samples were formulated as 75%, 15% and 10%; 70%, 20% and 10%; 65%, 20% and 15%; 60%, 15% and 25%; and 50%, 30% and 20% of wheat flour, tiger nut flour and date palm fruit respectively. Pasting properties of composite flour, proximate and microbial analyses of the products were determined. Pasting properties showed that peak viscosity (2093 – 2792) RVU; trough viscosity (1480 – 2031) RVU; breakdown viscosity (434 – 759) RVU; final viscosity (3016 – 3258) RVU; setback viscosity (1210 – 1536) RVU; pasting temperature (68.20 - 71.55)$^{o}$C; and pasting time (8.77 - 9.31) minutes. Proximate analysis showed that crude protein (11.33 – 11.99)%; crude fat (1.25 – 2.36)%; crude fibre (1.88 – 2.40)%; total ash (1.68 – 1.89)%; moisture content (10.83 – 12.63)%; and carbohydrate (68.48 – 70.89)%. Microbial count of the cookies showed that at week 0, there was no growth both in the nutrient agar plates and in the potato dextrose agar plate. From week 1 to week 3, total viable count in cookies stored at ambient condition was found to be higher than those stored in the refrigeration and freezing condition. However, bacterial count was found to be higher in week 1, 2 and 3 for each storage condition. At $p<0.5$ level of significance, there was no significant difference in most sensory attributes considered. Overall acceptability of cookies were rated high between like slightly and like extremely. This is an indication that apart from additional nutritional benefit, organoleptic quality and suitability of the food satisfied consumer's perception.*

**KEYWORDS**: quality, pasting, proximate, microbial, sensory, flour

## INTRODUCTION

Cookies have been identified as the simplest best-known fast snack (Farheena *et al.,* 2015). Cookies are described as nourishing snacks created from unpleasant dough, reworked into savory product through the application of heat in an oven (Olaoye *et al.,* 2007). They are common samples of bakeshop product of ready-to-eat snack that possess many engaging options as well as wide consumption, characterized with long shelf-life and function for vital nutrient (Ajibola *et al.,* 2015). They are baked flour confectionery dried to low moisture content. Cookies contain many of the same ingredients as cakes except that they have a lower proportion of liquid with a higher proportion of sugar and fat (Hazzouri *et al.,* 2015). Recipes for cookies are probably more variable


https://doi.org/10.37745/ejfst.2013

than those for any other type of bakery products (Adeleke and Odedeji, 2010). Cookies have currently become adored nutritional snack for all ages; it is easy to hold regardless of size, tasty to eat, cholesterol-free, containing organic process and dietary principles of importance and fairly low cost (Farheena *et al.,* 2015). The major ingredients are flour, fat, sugar, salt and water. These are mixed beside alternative minor ingredients (baking powder, milk, surfactant and sodium metabisulphite) to make dough containing a protein network Tiwari *et al., (*2008). The alternative ingredients are to fortify major ingredients in the production of cookies so as to fulfill specific biological process or therapeutic desires of customers (Ajibola *et al.,* 2015). Harasym and Oladzki (2014) noted that cookies are known for low water content and relatively free from microbial spoilage.

Wheat flour (*Triticum aestivum*) is a powder made of grinded wheat suitable for human consumption. There are different kinds of flour and these are distinguished by the quantity of protein they contain, their colour, the elements of the grain used, and also the form of wheat (Al-Harrasi *et al.*, 2014). Protein in the wheat provides food structure. Glutens develop and become additional elastic once the dough is kneaded (Liu, 2007). Date Palm fruit (*Phoenix dactylifera L*) domestically known as *debino* in Northern part of Nigeria, from the family of Palmae is a sweet green groceries (Al-daihan and Bhat 2012). The fruit may be a fruit within which associate outer fleshy half consists of pulp and covering encompassing a shell of arduous stone with a seed within (Farheena *et al.,* 2015). Date fruit contains quite70% sugar chiefly aldohexose and laevulose and thus, high energy food sources (Dada *et al.,* 2012). It provides replacement for sugar (sucrose) within the cookies instruction that is additionally of nice biological process to diabetics and other metabolic health related patients.

Tiger nut will be ingested freshly from the bottom, roasted, boiled, or juiced. Packaged tiger loopy are dried to be shelf-stable; used as tiger nut flour and tiger nut milk. Tiger nut milk prevents heart problems and thrombosis as well as activating blood circulation; it also helps in the prevention and treatment of urinary tract and bacterial infection hence, helps in the reduction of the risk of colon cancer (Elom and Ming, 2017; Adejuyitan et al., 2009). In order to reduce low-density lipoprotein cholesterol, tiger nut oil has been documented to (LDL-C) and raises high-density lipoprotein (HDL-C) cholesterol, thus reducing blood triglyceride levels and the risk of blood clots, thereby avoiding arteriosclerosis reported by Sanchez-Zapata *et al.,* (2012). Cookies produced in recent time have been evaluated by WHO and were found to contain a large amount of sugar and this is known to have an adverse effects on consumers (Nakayama *et al.,* 2011). Jerome-Morais *et al.,* (2011) discovered that refined sugar has been found as the causative agent for diabetics irrespective of the age barrier. Thus, this research is aimed at producing cookies with more nutritional benefits with inclusion of tiger nut known for its high fiber content and replacing the detrimental use of sugar as a sweetener with date palm fruit as natural sweetener.

## MATERIALS AND METHODS

### Material Selection

Dried date Palm Fruit, tiger nut and other ingredients such as; whole wheat, milk, egg, salt, margarine (fat), baking powder, and sugar were purchased at Ota market in Ogun state, Nigeria.



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

Reagents and equipment used were available in the Food Processing Laboratory of the Department of Chemical and Food sciences as well as Central Research Laboratory, Bells University of Technology Ota, Nigeria.

**Preparation of Tiger Nut Flour and Date Palm Fruit Pulp (DPFP)**

The tiger nut flour was obtained by cleaning and sorting of the tiger nut in order to remove unwanted material which can contaminate the flour and washed. After washing, it was then oven dried at 75ºC for 6-8 hours and it was milled using hammer mill or a suitable grinding machine and then sieved using the appropriate mesh size, sieve to obtain fine and homogenized particles. Tiger nut flour was sealed in a cellophane bag and stored at room temperature. The date Palm Fruit pulp (powder) was produced by, washing the date palm fruits with water to remove adhering dirt, followed by removal of seeds of the fruit manually and cut into small pieces with the aid of knife and weighing the dried date palm fruit. The pulp with pericarp was then oven dried at 75ºC for 6 – 8 hours and subsequently milled using milling machine and sieved through a suitable mesh size, sieve to obtain fine homogenized particles . The date palm fruit meal was sealed in a cellophane bag and stored at room temperature. The ratio of whole wheat flour, tiger nut flour and date palm fruit pulp (DPFP) is shown in Table 1 while Figure 1 shows flowchart for the production of cookies.

**Table 1: Sample ratio**

| Sample | Wheat flour: Tiger nut: Date palm fruit (%) |
|---|---|
| CDT 1 | 75 : 15 : 10 |
| CDT 2 | 70 : 20 : 10 |
| CDT 3 | 65 : 20 : 15 |
| CDT 4 | 60 : 15 : 25 |
| CDT 5 | 50 : 30 : 20 |
| WC | 100 |

**LEGEND**

CDT 1: 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit

CDT 2: 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit

CDT 3: 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit

CDT 4: 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit

CDT 5: 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit

WC: 100% Wheat flour



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

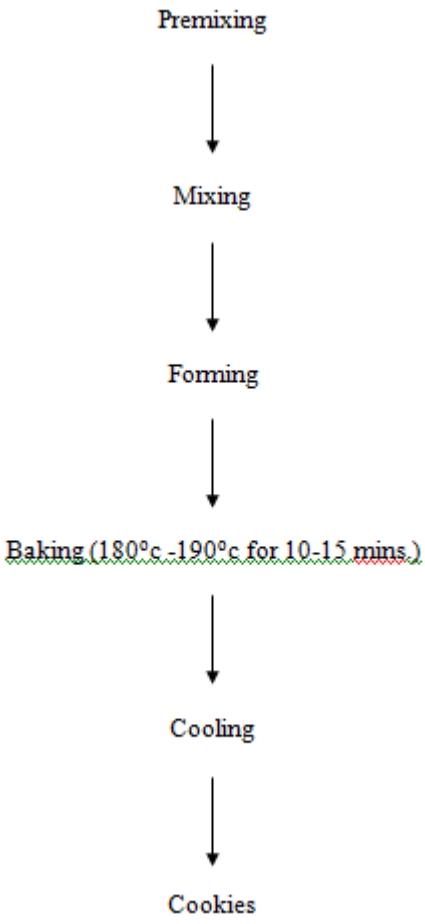


**Figure 1: Flowchart for production of Cookies**

**Proximate Analysis**

Standard methods of the Association of Official Analytical Chemists (AOAC, 2005) were used to determine the crude protein content, total ash, crude fat, crude fibre and moisture content of the samples. Crude protein content (Total nitrogen (%) x 6.25) was determined by Kjedahl method, using 2 g of sample. Crude fat was obtained by exhaustively extracting 5 g of sample in Soxhlet apparatus using n-hexane as the extractor. Ash content was determined by the incineration of 2 g sample in a Muffle furnace maintained at 550 $^{o}$C for 5 hours. Crude fibre was determined by weighing 2 g of sample and added 1.25% $H_2S0_4$, the mixture was boiled under reflux for 30 minutes. The residue was rinsed thoroughly with hot water and 1.25% NaOH was added and boiled to achieve neutral filtrate, oven dried at 100 $^{o}$C for 8 hours. Moisture content was determined by heating 2 g of sample to constant weight in a crucible placed in an oven maintained at 105 $^{o}$C. The total carbohydrate content was calculated by difference in protein, fat, ash, fibre and moisture from 100.



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

**Pasting Properties**

Pasting properties were determined using a Rapid Visco Analyser (RVA) 3C. Three (3) g of the sample was weighed into a weighing vessel while 25ml of distilled water was dispensed into a new canister. The slurry was heated from 50$^{o}$C for 2 minutes holding time. The rates of heating and cooling were done at a constant rate 11.25$^{o}$C/min. Peak viscosity, trough viscosity, break down viscosity, final viscosity, set back viscosity, pasting time and pasting temperature were read from the pasting profile.

**Microbial Analysis**

Microbial analysis on each sample was carried out according to the Official Methods of Analysis of AOAC (1995).

*Total bacteria count:* 1g of the sample was homogenized in 100 ml of distilled water. Dilution was made by mixing 1.0 ml of food homogenate into a test tube containing 9 ml of sterile diluents to obtain 10-1 dilution. The diluent was made up to 10-2 and 10-3. Total viable count of bacteria was determined by enumerating these colonies forming unit (cfu) by pour plating on nutrient agar and cultured at 37$^{o}$C for 48 hours. The number of colony forming unit on each plate was using colony counter and was expressed as cfu/g. This was carried out on each sample at week 0 as well as week 1, 2 and 3 under ambient, refrigeration and freezing temperature.

*Total fungi count:* The total fungi count was determined by pour plating on potato dextrose agar plate supplemented with 1.0% tetracycline to inhibit bacteria growth and was incubated at room temperature $(30 \pm 2)^{o}$C for 2 days. The number of colonies was expressed as cfu/g. This was carried out on each sample at week 0 as well as week 1, 2 and 3 under ambient, refrigeration and freezing temperature.

**Evaluation of Sensory Attributes**

Consumer assessment of overall acceptability of the cookies was done according to Jimoh *et al.*, (2020). Twenty (20) students of Bells University of Technology, Ota, Nigeria was chosen. These are regular consumer of cookies and randomly selected for the evaluation. There were sixty (60) samples and each sample was placed in separate identical, transparent and sealed package. The samples were coded as sample 1, 2, ..... and 60 respectively and placed on a clean table. A questionnaire was designed and distributed among twenty respondents to score attributes namely color, texture, aroma, taste, and overall acceptability on a Hedonic scale of 9 points: 9 like extremely, 8 like very much, 7 like moderately, 6 like slightly, 5 neither like nor dislike,4 dislike slightly, 3 dislike moderately, 2 dislike very much and 1 dislike extremely. Each of the samples was presented at different times to each of the respondents to avoid any bias in judgement. The responses were collated to compare the consumer preferences of the cookies.

**Statistical Analysis**

The data obtained for each sample was analyzed and interpreted by analysis of variance (ANOVA), Duncan's Multiple Range Test (DMRT) at a level of 5% significance, using SAS statistical software (SPSS version 2.3). Mean values in row with different superscripts were significantly difference ($p<0.5$).



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

## RESULTS AND DISCUSSION

### Pasting Properties of Flour Samples

The pasting properties of starch depends on the amylose content of the flour with the amount of non-starchy components (protein and fat) and processing techniques (Onitilo *et al.*, 2007). Table 2 shows the effect of tiger nut flour and date palm fruit enrichment on the pasting properties of wheat blends. The peak viscosity gives an indication of the strength of paste induced by swelling of the starch granules and it is also the maximum viscosity that is developed during heating (Ohizua *et al.*, 2016; Adejuyitan *et al.*, 2011). It was revealed in the result that WC had the highest peak viscosity, trough viscosity and breakdown viscosity with values 3130 RVU, 2212 RVU and 915 RVU respectively. These values were found to be significantly different ($P<0.5$). It is important to note that high peak viscosity can be associated with good textural property of paste and this also shows that such flour is applicable to food product that requires high gel strength. This parameter can be used to correlate final product quality of foods made from flours (Osungbaro *et al.*, 2010). Breakdown viscosity is an important parameter which indicates the stability of paste. It explains ability of flour to withstand controlled heating and application of shear during food processing (Ohizua *et al.*, 2016). The higher the breakdown viscosity, the lesser the ability of the flour to withstand shear and heat during processing. It explains the weakness of the swollen granules against the high temperature that was being applied during the test period while low breakdown viscosity indicates that the starch in the product might possess cross linking abilities (Oladele and Aina, 2009; Chinma *et al.*, 2012). The breakdown viscosity value of the flours ranges between 434 RVU to 915 RVU. The result shows that CDT 1 would be more stable to withstand heat during processing.

Pasting time was found to be highest in CDT 1 with 9.31minutes while CDT 5 had lowest value with 8.77 minutes. This might be attributed to limited starch content of tiger nut and date palm fruit, therefore, physical reduction of starch available in continuous phase of the sample might have reduced the resulting viscosity. There was no difference in the level of significance ($P> 0.5$) in all the samples. The setback viscosity can be defined as the difference between the final viscosity and trough viscosity or strength viscosity (Ezeocha and Onwuka, 2010). It shows an indication for the potential of retro-gradation and gel stability. The higher the setback viscosity value, the higher the tendency for retro-gradation during period of cooling (Wani *et al.*, 2016). This by extension has an effect on staling rate of products made from such flour. Setback viscosity of flour samples ranges from 1210 RVU to 1536 RVU. The result shows that CDT 5 had the highest value 1536 RVU and it would show a greater retro-gradation and by extension faster spoilage when used in food application while CDT 1 and WC would be more relatively stable. It is important to note that fat could also responsible for retro-gradation in flours because in the presence of a lipid, which is high in tiger nut flour, there might be retardation of starch gelatinization due to possible interaction of lipids and starch leading to formation which could entrap amylose (Radhika *et al.*, 2008).

Final viscosity is an important parameter that is used to determine gel forming ability of flour after a period of progressive cooking and cooling (Balewu *et al.*, 2010). The final viscosity ranged from 3016 RVU to 3422 RVU where CDT 5 had least while WC had highest value. At ($p<0.5$) level of significance, there was no significant difference in final viscosity of the samples. Pasting



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

temperature in this study shows that there was a difference in level of significance (P<0.5) across all samples. Pasting temperature is the temperature at onset of the rise in viscosity of a starch-based food product. When the temperature is above gelatinization temperature, starch granules began to swell and viscosity on shearing (Adebowale *et al.,* 2005; Ikegwu, 2010). Pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required to cook a given sample, energy cost involved and other stability factors (Ikegwu *et al.,* 2009). The pasting temperature ranged from 65.40$^{o}$C to 71.55$^{o}$C with sample WC having least value and CDT 5 having highest value. Trough viscosity ranged from 1480 RVU to 2212 RVU with sample CDT 5 having least value and sample WC having highest value. There was a difference in the level of significance (P<0.5).

**Table 2: Pasting properties of flour samples**

| Samples | Peak viscosity (RVU) | Trough viscosity (RVU) | Pasting temp. ($^{o}$C) | Breakdown viscosity (RVU) | Pasting time (min.) | Final viscosity (RVU) | Setback viscosity (RVU) |
|---|---|---|---|---|---|---|---|
| CDT 1 | 2359$^{a}$ | 1923$^{a}$ | 68.20$^{a}$ | 434$^{a}$ | 9.31$^{a}$ | 3133$^{a}$ | 1210$^{a}$ |
| CDT 2 | 2792$^{b}$ | 2031$^{b}$ | 68.60$^{ab}$ | 759$^{b}$ | 9.01$^{a}$ | 3258$^{ab}$ | 1227$^{a}$ |
| CDT 3 | 2215$^{c}$ | 1785$^{c}$ | 69.55$^{bc}$ | 437$^{a}$ | 9.14$^{a}$ | 3035$^{ac}$ | 1250$^{a}$ |
| CDT 4 | 2254$^{d}$ | 1802$^{d}$ | 69.55$^{bc}$ | 455$^{c}$ | 8.96$^{a}$ | 3094$^{ac}$ | 1292$^{a}$ |
| CDT 5 | 2093$^{e}$ | 1480$^{e}$ | 71.55$^{d}$ | 610$^{d}$ | 8.77$^{a}$ | 3016$^{abc}$ | 1536$^{a}$ |
| WC | 3130$^{f}$ | 2212$^{f}$ | 65.40$^{e}$ | 915$^{e}$ | 8.84$^{a}$ | 3422$^{abcd}$ | 1210$^{a}$ |

Samples with different letters within column are significantly different (P < 0.5) from each other.

**LEGEND**

CDT 1: 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit

CDT 2: 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit

CDT 3: 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit

CDT 4: 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit

CDT 5: 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit

WC: 100% Wheat flour

**Proximate Composition of Samples**

The result of the proximate composition of the cookies is presented in Table 3. Crude protein content ranges from 11.33% to 13.99% as compared to value obtained from 100% wheat (control) which had a protein content of 1.32%. Protein content increases with increased in tiger nut



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

inclusion. The high protein content in the samples is in accordance with high level of protein (9.4% - 15.1%) reported by Ade-Omowaye *et al.*, 2008. At ($p<0.5$) level of significance, the samples were significantly different in protein content except CDT 1 and CDT 2. Crude fat content of the cookies ranges from 1.25% to 2.36% as compared to 100% wheat sample with 0.66% fat content. Fat content increases as tiger nut increased. Crude fat content of the samples was significantly different except CDT 4 and CDT 5. Crude fibre content of the cookies ranges from 1.88% to 2.40% compared to 100% wheat with 0.75% crude fibre content. There was an increase in fibre content as tiger nut flour inclusion increased and this could be as a result of high fiber content in tiger nut and date palm fruit. The value is higher than the value, 1.66% – 1.72% reported by Okorie and Ikegwu, (2018). At ($p<0.5$) level of significance, there was no significant difference in fibre content of the samples. Total ash content is an indication of minerals present in cookies samples and it ranges from 1.68% to 1.89% compared to 100% wheat cookies with 0.66% ash content. The ash content increases as tiger nut flour and date palm fruit flour inclusion increased. Increase in ash content justifies high level of ash content (0.89% - 1.57%) in tiger nut as reported by Dada *et al.*, (2012). There was no significant difference in ash content of the cookies except WC. The Moisture content of cookies samples ranges from 10.83% to 12.63% compared to 100% wheat cookies with 11.46%. Moisture content of the samples decreases as ratio of wheat flour decreased and this is an indication of shelf-life stability of cookies. However, the lower the moisture content, the higher the amount of dry solids in the cookies (Adeleke and Odedeji, 2010). The moisture content is relatively lower than the value reported by Ade-Omowaye *et al.*, (2008), 13.8% - 14.7%; and Okorie and Ikegwu, (2018), 12.22% - 14.86%. There was no significant difference in moisture content of the cookies produced. The carbohydrate content of the flour ranges from 68.48% to 70.89% compared to 100% wheat flour with 85.80%. High carbohydrate content of the 100% wheat flour cookies was as a result of low protein, fat, fibre and ash content of the sample. At ($p<0.5$) level of significance, there was no significant difference in carbohydrate content of the flour samples except WC.

**Table 3: Proximate composition of cookies**

| Samples | Crude protein (%) | Crude fat (%) | Crude fibre (%) | Total ash (%) | Moisture content (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| CDT 1 | 11.86$^{a}$ | 1.25$^{a}$ | 1.88$^{a}$ | 1.68$^{a}$ | 12.53$^{a}$ | 70.48$^{a}$ |
| CDT 2 | 11.33$^{a}$ | 1.32$^{ab}$ | 2.29$^{ab}$ | 1.77$^{ab}$ | 12.63$^{ab}$ | 70.89$^{a}$ |
| CDT 3 | 13.07$^{c}$ | 2.35$^{bc}$ | 2.35$^{abc}$ | 1.75$^{ab}$ | 12.02$^{ac}$ | 68.48$^{b}$ |
| CDT 4 | 13.63$^{cd}$ | 2.33$^{b}$ | 2.40$^{abcd}$ | 1.79$^{abc}$ | 10.96$^{acd}$ | 68.89$^{bc}$ |
| CDT 5 | 13.99$^{d}$ | 2.36$^{b}$ | 2.40$^{abcd}$ | 1.89$^{bc}$ | 10.83$^{cd}$ | 68.53$^{bc}$ |
| WC | 1.32$^{e}$ | 0.66$^{abc}$ | 0.75$^{a}$ | 0.66$^{e}$ | 11.46$^{abcd}$ | 85.80$^{e}$ |

Samples with different letters within column are significantly different ($P < 0.5$) from each other.



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

**LEGEND**

CDT 1: 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit

CDT 2: 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit

CDT 3: 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit

CDT 4: 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit

CDT 5: 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit

WC: 100% Wheat flour

**Microbial Count of Cookies made from Flour blends**

The total viable count is the number of bacteria able to grow in an aerobic environment at moderate temperature. It is an indicator of quality, not safety and cannot directly contribute towards a safety assessment of ready-to-eat (EFSA, 2005). Table 4 shows result of microbial analysis during storage at week 0, 1, 2 and 3.

Result at week 0 shows that there was no growth both in the nutrient agar plates for bacteria count and in the potato dextrose agar plate for fungi count. Result of microbial analysis during storage stability in week 1 depicts that total viable count of cookies stored at ambient temperature increased from $2.0\times10^2$ cfu/g - $6.5\times10^2$ cfu/g for bacteria and $1.0\times10^2$ cfu/g - $2.0\times10^2$ cfu/g for fungi. Total viable count of cookies stored at refrigeration condition increased from $1.5\times10^2$ cfu/g - $3.0\times10^2$ cfu/g for bacteria and $1.0\times10^2$ cfu/g - $1.5\times10^2$ cfu/g for fungi. Bacteria growth increased from $1.0\times10^2$ cfu/g - $3.0\times10^2$ cfu/g and fungi growth increased from $0.5\times10^2$ cfu/g - $1.0\times10^2$ cfu/g for cookies stored at freezing condition. Result of microbial analysis during storage stability in week 2 revealed that total viable count of cookies stored at ambient temperature increased from $2.0\times10^2$ cfu/g - $5.0\times10^2$ cfu/g for bacteria and $1.0\times10^2$ cfu/g - $2.0\times10^2$ cfu/g for fungi. Total viable count of cookies stored at refrigeration condition increased from $1.0\times10^2$ cfu/g - $2.5\times10^2$ cfu/g for bacteria and $0.5\times10^2$ cfu/g - $1.5\times10^2$ cfu/g for fungi. Bacteria growth increased from $0.5\times10^2$ cfu/g - $1.5\times10^2$ cfu/g and fungi growth increased from $0.5\times10^2$ cfu/g - $1.0\times10^2$ cfu/g for cookies stored at freezing condition.

Result of microbial analysis during storage stability in week 3 showed that total viable count of cookies stored at ambient temperature increased from $2.0\times10^2$ cfu/g - $7.0\times10^2$ cfu/g for bacteria and $3.0\times10^2$ cfu/g - $4.5\times10^2$ cfu/g for fungi. Total viable count of cookies stored at refrigeration condition increased from $0.5\times10^2$ cfu/g - $1.5\times10^2$ cfu/g for bacteria and $0.5\times10^2$ cfu/g - $1.0\times10^2$ cfu/g for fungi. Bacteria growth increased from $0.5\times10^2$ cfu/g - $1.5\times10^2$ cfu/g and fungi growth increased from $0.5\times10^2$ cfu/g - $1.0\times10^2$ cfu/g for cookies stored at freezing condition. From week 1 to week 3, total viable count in cookies stored at ambient condition was found to be higher than those stored in the refrigeration and freezing condition. This could be as a result of relatively high temperature that is favorable for the growth of bacteria and fungi. The high number of total



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

bacterial found in each storage condition in week 1, 2 and 3 could be attributed to poor sanitation, raw material contamination, packaging sanitary and processing method.

**Table 4: Microbial Count of Cookies during Storage at Week 0, 1, 2 and 3**

| Week | Storage condition | Count | CDT 1 (cfu/g) | CDT 2 (cfu/g) | CDT 3 (cfu/g) | CDT 4 (cfu/g) | CDT 5 (cfu/g) | WC (cfu/g) |
|---|---|---|---|---|---|---|---|---|
| Week 0 | Ambient | Bacteria | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Fungi | 0 | 0 | 0 | 0 | 0 | 0 |
| | Refrigeration | Bacteria | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Fungi | 0 | 0 | 0 | 0 | 0 | 0 |
| | Freezing | Bacteria | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Fungi | 0 | 0 | 0 | 0 | 0 | 0 |
| Week 1 | Ambient | Bacteria | $5.5x10^2$ | $6.5x10^2$ | $2.0x10^2$ | $4.0x10^2$ | $2.0x10^2$ | $4.0x10^2$ |
| | | Fungi | $2.0x10^2$ | $2.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.5x10^2$ | $1.0x10^2$ |
| | Refrigeration | Bacteria | $3.0x10^2$ | $1.5x10^2$ | $3.0x10^2$ | $1.5x10^2$ | $2.0x10^2$ | $3.0x10^2$ |
| | | Fungi | $1.5x10^2$ | $1.0x10^2$ | $1.5x10^2$ | $1.5x10^2$ | $1.0x10^2$ | $1.5x10^2$ |
| | Freezing | Bacteria | $3.0x10^2$ | $2.0x10^2$ | $2.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ |
| | | Fungi | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $1.0x10^2$ | $1.0x10^2$ |
| Week 2 | Ambient | Bacteria | $4.0x10^2$ | $5.0x10^2$ | $2.0x10^2$ | $4.0x10^2$ | $2.0x10^2$ | $4.0x10^2$ |
| | | Fungi | $2.0x10^2$ | $2.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ |
| | Refrigeration | Bacteria | $2.5x10^2$ | $2.0x10^2$ | $2.5x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.5x10^2$ |
| | | Fungi | $1.5x10^2$ | $1.5x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $0.5x10^2$ |
| | Freezing | Bacteria | $1.0x10^2$ | $1.0x10^2$ | $1.5x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $0.5x10^2$ |
| | | Fungi | $0.5x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $0.5x10^2$ | $1.0x10^2$ | $1.0x10^2$ |
| Week 3 | Ambient | Bacteria | $5.5x10^2$ | $7.0x10^2$ | $5.0x10^2$ | $4.5x10^2$ | $2.0x10^2$ | $5.5x10^2$ |
| | | Fungi | $3.5x10^2$ | $3.5x10^2$ | $3.0x10^2$ | $3.5x10^2$ | $4.0x10^2$ | $4.5x10^2$ |
| | Refrigeration | Bacteria | $1.5x10^2$ | $0.5x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $1.0x10^2$ | $1.5x10^2$ |
| | | Fungi | $0.5x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $0.5x10^2$ |
| | Freezing | Bacteria | $1.5x10^2$ | $0.5x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ | $1.0x10^2$ |
| | | Fungi | $1.0x10^2$ | $0.5x10^2$ | $1.0x10^2$ | $0.5x10^2$ | $0.5x10^2$ | $1.0x10^2$ |



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

**LEGEND**

CDT 1: 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit

CDT 2: 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit

CDT 3: 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit

CDT 4: 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit

CDT 5: 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit

WC: 100% Wheat flour

**Storage Stability of Cookies**

Table 5 shows result of sensory attributes (colour, appearance, aroma, taste and overall acceptability) of cookies. At ($p<0.5$) level of significance; there was no significant difference in all the attributes in week 0, 1, 2 and 3 for sample CDT 1 except colour attribute in week 1 under refrigeration and freezing condition, aroma attribute in week 1 under freezing condition, and taste in week 1 under refrigeration condition. There was no significant difference in sample CDT 2 except colour attribute in week 0. There was no significant difference in sample CDT 3 except colour attribute in week 0, appearance attribute in week 1 under refrigeration and freezing condition, taste attribute in week 2 under refrigeration and freezing condition, and overall acceptability in week 2 under refrigeration condition. There was no significant difference in sample CDT 4 except colour and appearance attributes in week 0, and aroma and overall acceptability attributes in week 1 under freezing condition. There was no significant difference in sample CDT 5 except colour, appearance and overall acceptability attributes in week 0, and colour attribute in week 1 under refrigeration and freezing condition. There was no significant difference in 100% wheat flour (WC) except colour, appearance and overall acceptability attributes in week 0. Photo shot of the cooking produced at different formulations is shown in Figure 2.



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

**Table 5: Sensory Attributes of Cookies**

| Samples | Sensory Attributes | Week 0 | Week 1 | | | Week 2 | | | Week 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Amb. | Refr. | Free. | Amb. | Refr. | Free. | Amb. | Refr. | Free. |
| CDT 1 | Colour | 6.3$^{a}$ | 6.5$^{a}$ | 7.5$^{ab}$ | 5.0$^{ac}$ | 5.5$^{a}$ | 6.5$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ | 6.5$^{a}$ |
| | Appearance | 5.5$^{a}$ | 6.5$^{a}$ | 7.5$^{a}$ | 5.0$^{a}$ | 8.0$^{a}$ | 6.5$^{a}$ | 5.0$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ |
| | Aroma | 6.5$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 5.0$^{ab}$ | 6.5$^{a}$ | 6.5$^{a}$ | 5.5$^{a}$ | 8.0$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ |
| | Taste | 5.8$^{a}$ | 4.5$^{a}$ | 8.0$^{ab}$ | 5.5$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ | 6.0$^{a}$ |
| | Overall acceptability | 6.2$^{a}$ | 5.5$^{a}$ | 7.5$^{a}$ | 5.0$^{a}$ | 6.0$^{a}$ | 6.5$^{a}$ | 5.5$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ | 6.0$^{a}$ |
| CDT 2 | Colour | 6.8$^{ab}$ | 6.5$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 5.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ |
| | Appearance | 6.2$^{a}$ | 6.5$^{a}$ | 6.5$^{a}$ | 6.5$^{a}$ | 6.0$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 5.5$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ |
| | Aroma | 6.7$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ | 6.0$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 5.0$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ |
| | Taste | 6.3$^{a}$ | 6.5$^{a}$ | 6.5$^{a}$ | 7.5$^{a}$ | 6.5$^{a}$ | 6.0$^{a}$ | 7.5$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ |
| | Overall acceptability | 6.6$^{a}$ | 6.5$^{a}$ | 6.5$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 5.5$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ |
| CDT 3 | Colour | 6.8$^{ab}$ | 7.0$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ | 6.0$^{a}$ | 5.0$^{ab}$ | 8.0$^{bc}$ | 6.5$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ |
| | Appearance | 5.8$^{a}$ | 6.5$^{a}$ | 6.0$^{ab}$ | 8.0$^{ac}$ | 7.0$^{a}$ | 6.0$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 6.0$^{a}$ | 7.5$^{a}$ |
| | Aroma | 6.2$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ | 6.5$^{a}$ | 8.0$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ | 7.5$^{a}$ |
| | Taste | 6.5$^{a}$ | 6.0$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 4.5$^{ab}$ | 8.0$^{ac}$ | 7.0$^{a}$ | 6.0$^{a}$ | 7.5$^{a}$ |
| | Overall acceptability | 6.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 5.5$^{ab}$ | 7.0$^{a}$ | 7.0$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ |
| CDT 4 | Colour | 7.0$^{ab}$ | 6.5$^{a}$ | 8.0$^{a}$ | 6.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ |
| | Appearance | 6.3$^{ab}$ | 7.0$^{a}$ | 8.0$^{a}$ | 6.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 6.0$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ |
| | Aroma | 7.2$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ | 5.0$^{ab}$ | 7.5$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 6.5$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ |
| | Taste | 6.5$^{a}$ | 6.5$^{a}$ | 8.0$^{a}$ | 5.5$^{a}$ | 7.5$^{a}$ | 6.5$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ |
| | Overall acceptability | 6.8$^{a}$ | 7.5$^{a}$ | 8.5$^{a}$ | 6.5$^{ab}$ | 7.0$^{a}$ | 6.0$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ |
| CDT 5 | Colour | 7.3$^{ab}$ | 6.0$^{a}$ | 7.5$^{ac}$ | 8.5$^{bc}$ | 8.0$^{a}$ | 7.5$^{a}$ | 8.5$^{a}$ | 8.5$^{a}$ | 8.0$^{a}$ | 8.5$^{a}$ |
| | Appearance | 7.0$^{ab}$ | 6.5$^{a}$ | 7.0$^{a}$ | 8.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 8.5$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ |
| | Aroma | 7.3$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.5$^{a}$ | 7.0$^{a}$ | 8.5$^{a}$ |



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Taste | 7.2$^{a}$ | 5.5$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 7.5$^{a}$ | 8.5$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 8.5$^{a}$ |
| | Overall acceptability | 7.2$^{ab}$ | 7.5$^{a}$ | 8.5$^{a}$ | 9.0$^{a}$ | 8.5$^{a}$ | 8.5$^{a}$ | 8.0$^{a}$ | 8.5$^{a}$ | 8.5$^{a}$ | 8.5$^{a}$ |
| WC | Colour | 8.2$^{b}$ | 8.0$^{a}$ | 8.5$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 7.0$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ |
| | Appearance | 8.0$^{b}$ | 9.0$^{a}$ | 7.5$^{a}$ | 8.5$^{a}$ | 7.0$^{a}$ | 7.0$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ |
| | Aroma | 7.3$^{a}$ | 8.5$^{a}$ | 7.5$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ | 8.5$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ | 9.0$^{a}$ |
| | Taste | 7.7$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 7.5$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.5$^{a}$ |
| | Overall acceptability | 7.8$^{ab}$ | 9.0$^{a}$ | 8.5$^{a}$ | 8.0$^{a}$ | 9.0$^{a}$ | 8.5$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 8.5$^{a}$ | 8.5$^{a}$ |

Samples with different letters within column are significantly different (P < 0.5) from each other.

**LEGEND**

CDT 1: 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit

CDT 2: 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit

CDT 3: 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit

CDT 4: 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit

CDT 5: 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit

WC: 100% Wheat flour




@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013


**Figure 2: Production of cookies at different formulations**

**LEGEND**

1: 75% Wheat flour + 15% Tiger nut flour + 10% Date palm fruit

2: 70% Wheat flour + 20% Tiger nut flour + 10% Date palm fruit

3: 65% Wheat flour + 20% Tiger nut flour + 15% Date palm fruit

4: 60% Wheat flour + 15% Tiger nut flour + 25% Date palm fruit

5: 50% Wheat flour + 30% Tiger nut flour + 20% Date palm fruit

6: 100% Wheat flour

## CONCLUSION

In the production of cookies from wheat flour blended with tiger nut and with date palm fruit as natural sweetener. The following conclusions were drawn from the study:

1. The pasting properties of the flour samples clearly indicated that the tiger nut flour and date palm fruit flour have good characteristic pasting profile when compared with the control (wheat flour). A proper pasting value was achieved at below 20% tiger nut flour


https://doi.org/10.37745/ejfst.2013

and below 20% date palm fruit formulations. Beyond this, retro-gradation could set in and by extension faster spoilage.

2. The moisture content of all the samples is lower than that of other researchers. This guaranteed good quality and shelf-life of the cookies.
3. There was no growth both in nutrient agar plates for bacteria count and in potato dextrose agar for fungi count in week 0. The product is more stable when stored under freezing condition for three weeks.
4. From respondent assessment, sensory attributes such as colour, appearance, aroma, taste and overall acceptability of cookies were rated high between like slightly and like extremely. This is an indication that apart from additional nutritional benefit, the characteristic eating quality and suitability of the food satisfied consumer's perception.

## REFERENCES

Adebowale, A.A., Sanni, L.O. and Awonorin, S.O. (2005). Effect of texture modifier on the physicochemical and sensory properties of dried fufu. *Food Science and Technology International,* 11(5):373-382.

Adejuyitan, J.A., Otunola, E.T., Akande, E.A., Bolarinwa, I.F. and Oladokun, F.M. (2009). Some Physicochemical properties of flour obtained from fermentation of tiger nut (*Cyperus esculentus*) sourced from a market in Ogbomoso, Nigeria. *Afric. J. of Food Science*, 3: 51-55.

Adejuyitan, J.A. (2011). Tiger nut processing: its food uses and health benefits. *Am J Food Technol*ogy 6(3):197–201.

Adeleke, R.O. and Odedeji, J.O. (2010). Functional properties of wheat and sweet potato flour blends. *Pak. J of Nutrition.* 9(6):535-538.

Ajibola, F.C., Oyerinde, O.V. and Adeniyan, S.O. (2015). Physicochemical and antioxidant properties of whole wheat biscuits incorporated with Moringa oleifera leaves and cocoa powder. *Journal of scientific research and report*, 7(3):195 – 206.

Ade-Omowaye, B.I., Akinwande, B.A., Bolarinwa, I.F. and Adebiyi, A.O. (2008). Evaluation of tiger nut (*Cyperus esculentus*) - wheat composite flour and bread. *Afr.J. Food Sci.,* 2: 087-091.

Al-daihan, S. and Bhat, R.S. (2012). Antibacterial activities of extracts of leaf, seed and bark of *Phoenix dactylifera*. *Afr. J. Biotechol*., 11(42):10021-10025.

Al-Harrasi, A., Rehman, N.U., Hussain, J., Khan, A.L., Al-Rawahi, A. and Gilani, S.A. (2014). Nutritional assessment and antioxidant analysis of 22 date palm (*Phoenix dactylifera*) varieties growing in Sultanate of Oman. *Asian Pac. J. Trop. Med.,* 7, S591–S598. 10.1016/s1995-7645(14)60294-7.

AOAC. (1995). Official Methods of Analysis of the Association of Official Analytical Chemist, 16th ed. Washington, D.C.



@ECRTD-UK: https://www.eajournals.org/
https://doi.org/10.37745/ejfst.2013

AOAC, (2005). Official Methods of Analysis of the Association of Official Analytical Chemists. 18th ed. AOAC, Washington, D.C.

Belewu, M.A., Belewu, K.Y. and Bamidele, R.A. (2010). Cyper-coconut yoghurt: preparation, compositional and organoleptic qualities. *Afr. J. Food Sci.Technol.,* Vol. 1(1): 010-012.

Chinma, C. E., Abu, J. O., James, S. and Iheanacho, M. (2012). Chemical, functional and pasting properties of defatted starches from cowpea and soybean and application in stiff porridge preparation. *Nigerian Food Journal,* 30(2): 80-88.

Dada, M., Nwawe, C.N., Okere, R.A. and Uwubanmwen, I.O. (2012). Potentials of date palm tree to the Nigerian Economy. *World Journal of Agricultural Sciences,* 8(3): 309-315.

European Food Safety Authority, (EFSA). (2005). Opinion of the scientific panel on biological hazards on bacillus cereus and other *Bacillus spp* in foodstuffs. *EFSA Journal,* 175, 1-48.

Elom, S.A. and Ming, T.O. (2017). Tiger nut (*cyperus esculentus*): Source of natural anticancer drug? Brief review of existing literature. *Euromediterranean Biomedical Journal,* 12(19): 091-094.

Ezeocha, V.C. Onwuka, G.I. (2010). Effect of processing methods on the physico-chemical and nutritional quality of maize and soybean based complementary blends. *Nigerian Food Journal,* 28(2):210-216.

Farheena, I., Avanish, K. and Uzma, A. (2015). Development and quality evaluation of cookies fortified with date paste *(Phoenix dactylifera L*). *International Journal of Science and Technology,* 3(4). 2395-4752.

Harasym, J. and Oledzki, R. (2014). Effect of fruit and vegetable antioxidants on total antioxidant capacity of blood plasma. *Nutrition,* 30, 511–517.

Hazzouri, K.M., Flowers, J.M., Visser, H.J., Khierallah, H.S., Rosas, U. and Pham, G.M. (2015). Whole genome re-sequencing of date palms yields insights into diversification of a fruit tree crop. Nat. Commun. 6:8824. 10.1038/ncomms9824.

Ikegwu, O.J. Nwobasi, V.N., Odoh, M.O. and Oledinma, N.U. (2009). Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. *Afr. J. Biotechnol.,* 8 (10): 2310-2315.

Ikegwu, O.J. (2010). Effect of processing on the physicochemical and pasting properties of *Brachystegia eurycoma* flour. *Nigerian Food Journal* 28 (2):193-202.

Jerome-Morais, A., Diamond, A.M and Wright, M.E. (2011). Dietary supplements and human health: for better or for worse? *Molecular Nutrition & Food Research,* 55(1):122–135.

Jimoh, M.O., Ogunmoyela, O.A.B. and Ogabi, O.N. (2020). Development and performance evaluation of a multi-heat source plantain roaster. *Nigerian Journal of Technological Development,* 17(2): 120-126.

Liu, R.H. (2007). Whole grain phytochemicals and health. *J. cereal Sci.,* 46: 207-219.

Nakayama, A., Alladin, K.P. Igbokwe, O. and White, J.D. (2011). Systematic review: generating evidence-based guidelines on the concurrent use of dietary antioxidants and chemotherapy or radiotherapy.*Cancer Investigation,* 29: 655–667.

Ohizua, E. R., Adeola, A. A., Michael, A. I. (2016). Nutrient composition, functional and pasting properties of unripe cooking banana, pigeon pea and sweet potato flour blends. *Food Science and Nutrition,* 5: 750-762.

Okorie, P.A. and Ikegwu, O. J. (2018). Comparative evaluation of the physicochemical and pasting properties of flour from three varieties of *Brachystegia spp*. *African Journal of Biotechnology*, 17 (27): 856-861.

Oladele, A.K. and Aina, J.O. (2009). Chemical composition and properties of flour produced from two varieties of tiger nut (*Cyperus esculentus*). *African Journal of Biotechnology*, 6 (1): 2473-2476.

Olaoye , O.A., Onilude, A .A. and Idowu, O. A. (2007). Quality characteristics of bread produced from composite flour of wheat, Plantain and Soybean. *African. J.Biotechnol.*, 5: 1102-1106.

Onitilo, M. O., Sanni, L. O., Daniel, I., Maziyadixon, B and Dixon, A. (2007). Physiochemical and functional properties of native starches from cassava varieties in southwest Nigeria. *Journals of Food Science and Agricultural Environment,* 5: 108-114.

Adeleke, R.O. and Odedeji, J.O. (2010). Functional properties of wheat and sweet potato flour blends, *Pakistan Journal of Nutrition*, 9(6): 535–538.

Osungbaro, T. O., Jimoh, D. and Osundeyi, E. (2010). Functional and pasting properties of composite cassava-sorghum flour meals. *Agriculture and Biology Journal of North America,* 1(4): 715-720.

Radhika, G. S., Shanavas, S. and Moorthy, S. N. (2008). Influence of lipids isolated from soybean seed on different properties of cassava starch. *Starch/Starke,* 60: 485-492.

Sanchez-Zapata, E., Fernandez-Lopez, J., Angel Perez-Alvarez, J. (2012). Tiger nut (Cyperus esculentus) commercialization: Health Aspects, Composition, Properties, and food applications. Comprehensive Reviews in Food Science and Food Safety. 11(4): 366–377.

Tiwari, B. K., Tiwari, U., Mohan, R. J. and Alagusundaram, K. (2008). Effects of various pre-treatments on functional, physicochemical and cooking properties of pigeon pea *(Cajanus cajan L.). Food Sci. Technol.,* 14: 487–495.


https://doi.org/10.37745/ejfst.2013

Wani, I. A., Sogi, D. S., Sharma, P. and Gill, B. S. (2016). Physiochemical and pasting properties of unleavened wheat flat bread (*Chapatti*) as affected by addition of pulse flour. *Cogent Food & Agriculture*, 2(1): 1124486.