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**Effect Of Decortication On Quality Of Yellow And White Maize For *Tuwo* Production**

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**Abstract:** The study examined effect of decortications on quality of yellow maize and white maize for “*tuwo”* production was investigated. *Tuwo* flour from decorticated and undecorticated white and yellow maize were made and coded as sample DWF (decorticated white maize flour), UWF (undecorticated white maize flour), DYF (decorticated yellow maize flour) and sample UYF (undecorticated yellow maize flour). The flour samples were analyzed for carbohydrate, functional properties and beta carotene while sensory evaluation was determined on the *tuwo* meal produced. Data analysis was carried out using standard established procedures. Results shows that functional properties revealed that bulk density ranged from 0.51-0.70 g/g, water absorption capacity (6.96-7.94 g/g), oil absorption capacity (7.70-8.93 g/g), emulsion capacity (42.38-54.95 %), emulsion stability (43.19-48.53 %), foam capacity (8.82-14.21 %), swelling capacity (1.94-2.25 g/g), swelling index (1.31-1.45 g/g), dispersibility (58.00-73.00 %) and gelatinization temp (62.00-72.00 oC). Carbohydrate values ranged from 73.66-79.10 %, total starch (55.49-67.43 %), amylase (13.48-21.44 %) and β-carotene (7.12-8.40 ug/g). Sensory evaluation shows that all the samples were acceptable by the semi-trained panelists. The study results revealed significant changes and differences in the functional, carbohydrate characteristics and β-carotene of tuwo from the maize varieties.

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**Keywords:** β-carotene; decortication; functional property; sensory evaluation; “*tuwo*”; undecortication

**Introduction**

 “Tuwo”, a non-fermented maize dumpling is a popular diet native to Northern Nigeria where it is consumed by different tribes including the Hausas, Fulanis, Kanuri and Nupes. Popularity of tuwo has increased as Yoruba speaking people of the South West Nigeria and some other West African countries including Ghana, Togo, Benin, Mali and Burkina-Faso are now eating Tuwo [1]. Tuwo is usually consumed with different types of soup depending on the taste of the community where it is consumed. Soups such as okro, ogbono, melon and some local vegetable soups such as kubewa, kuka and tafshe which are side dishes also go with tuwo. It is a dietary staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice for a teeming, world population of 400 million who are majorly Africa and Central America [2].

 Maize (*Zea mays*) is an important food crop providing about 30 % of the calories for approximately 4.5 billion peoples in 94 developing countries [3]. It is one of the most widely utilized cereals in Nigeria and other West African countries due to its high yielding potentials, storability and versatility in processing. Maize is a good source of carbohydrates but very low in fats, proteins and some of the important vitamins as well as minerals. In addition, one of the main nutritional circumscriptions of maize grains, however, is its deficiency in two important essential amino acids - lysine and tryptophan [4]. Efforts at improving the protein quality of maize led to the development of quality protein maize (QPM) varieties. QPM kernels contain double the quantity of lysine and tryptophan, balanced ratio of isoleucine to leucine and increased desirable proteins ingestion [3].

 Tuwo is traditionally prepared by making a slurry of the maize flour and adding the slurry to adequate boiling water on fire, stirring, adding more maize flour and stirring to thicken and form a consistent gel-like dough. Water may be added if the dough is too thick, the dough is then left on fire to cook for about 10 minutes, and stirred thoroughly to get a uniform consistency of the tuwo meal [5]). Tuwo is faced with limitations in its acceptability due to its poor textural quality [6]. Tuwo from local indigenous maize is also low in nutrients; hence there is dire need to improve the nutrients content of tuwo through the use of bio fortified maize. Thus, this research work deal with production of tuwo from decorticated and undecorticated white and yellow maize.

**Materials and Methods**

**Source of Materials**

 The maize used for this project was purchased from Owode Market in Offa, Kwara State and transported to Food Processing Laboratory, Department of Food Technology, Federal Polytechnic Offa, Kwara State, Nigeria.

**Sample preparation**

**Preparation of decorticated and undecorticated maize flour**

 This was achieved according to the method of Bolade and Adeyemi [7] with little modification. This was done by initially cleaning the maize grains manually by the removal of stones, damaged kernels and other extraneous materials. The grains were dehulled and finally milled to obtain the flour followed by sieving using a sieve with 300-μm aperture and then kept in airtight polythene bags until needed while its undecortication one were milled wholly after sorting, cleaning and destining.

**Preparation of Tuwo**

 Tuwo was prepared from each flour sample using a method as described by [7] however, with slight modification. The overall ratio of flour to water used in the tuwo production was 1:3.5 (w/v). Cold slurry of the flour was first prepared by mixing 20 % of the desired quantity of flour (1.0 Kg) with 25 % of the desired quantity of water (3.5 L). This was followed by bringing 60 % of the water into boiling and the cold slurry initially prepared was added to this boiling water coupled with vigorous stirring, using a wooden flat spoon, to form a pap-like consistency. The remaining quantity of the flour (80 % of the desired total) was then added gradually to the boiling pap-like paste with continuous stirring so as to facilitate non-formation of lumps and ensure a homogenous gel formation. The remaining quantity of water (15 % of the desired total) was finally added to the formed gel, covered properly without stirring and allowed to cook for about 2 min after which it was stirred vigorously to ensure smoothness of the gel. The final product obtained is called Tuwo.

**Methods of analysis**

**Determination of chemical composition of the maize varieties flour samples**

 The standard method described by Association of Official Analytical Chemists, AOAC [8] was used for chemical analysis such as total starch, amylose content and beta-carotene of the samples while carbohydrate content was determined by difference.

**Determination of functional properties of the maize varieties flour samples**

 The functional properties (bulk density, water and oil absorption capacity, emulsion activity and stability) of the maize varieties flours samples were determined as described by Yasumatsu et al. [9]*.* Foaming capacity was evaluated using the method of Narayana and Narasinga [10] while swelling power and solubility capacity were analyzed by the methods of Ukpabi and Ndimele [11]. Dispersibility was determined by the methods described by kulkarni et al. [12] while gelatinization temperaturewas determined by the method described by Shinde [13].

**Determination of sensory evaluation of the maize varieties cooked dough samples**

 Sensory attributes of the maize varieties flour samples were determined using preference test as described by Akinsola *et al*. [14]. Twenty semi-trained panelists that was familiar with *moin-moin* and *ekuru* puddy, a similar steaming product to the study samples were drawn from the Polytechnic community. The panelists were asked to indicate their preference for the samples in term of colour, appearance, mouldability, flavour, taste and overall acceptability on 9-point Hedonic scale where 9 =like extremely and 1=disliked extremely. Each panelist sat in an enclosed cubicle designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples.

**Statistical Analysis**

 A one-way analysis of variance and Duncan’s test were used to establish the significance of differences among the mean values at the 0.05 significance level. Results were expressed as mean of triplicate analyses. The statistical analyses were performed using SPSS software (Systat statistical program version 21, SPSS Inc.,

USA).

**Results and Discussion**

**Results**

**Carbohydrate and beta carotene properties of the maize varieties flour samples**

 Table 1 shows results of the carbohydrate and β-carotene property of the maize varieties flour samples. The starch contents of the flours ranged between 55. 49 to 67.43 %. The result showed that sample produced from undecorticated yellow maize (sample UYF) had the highest value (67.43 %) while sample produced from decorticated white maize (sample DWF) had the least value (55.49 %). The result showed insignificant variation between the samples (p<0.05). It was observed that samples produced from yellow maize had the highest starch value than samples produced from white maize flour this could be as result of genetic variation. Also, the differences in the value obtained may be due to difference in preparation operations which may have resulted in different scored obtained. The result obtained (67.34 to 69.22 %) in this study was lower than (79.38 to 80.07 %) from yam and jackbean flour blends as reported by [15]; on water yam and cowpea flour (59.57 to 78.31 %) by [16] and on water yam and lima bean (70.54 to 71.77 %) by [17]. Starch has been shown to determine the physicochemical, rheological and textural characteristics of food products.

 Amylose content ranged from 13.48 to 21.97 % for sample UYF and sample UWF. The result showed significant variation between the samples (p<0.05). The ranged value obtained in this research work was within the ranged value (18.30 to 21.63 %) of tuwo made from maize-cassava starch in the findings of [18].The result obtained for amylose (25.36 to 29.88 %) in this study was not in agreement with the values of [17] on water yam and lima bean (28.53 to 29.82 %), the findings of [15] on greater yam and jackbean flour (17.23 to 20.38%) was within the ranged value obtained in this research work while the values obtained in this study was higher than sweet potato and soybean flour blend (12.62 to 12.94 %) as reported by [19]. Amylose is a major component of starch which influences pasting and retrogradation behaviour [20] and impart definite characteristics to starch [21]. However, Rohmah *et al*. [17] reported that food with high amylose content will be hard and firm after cooking. This is often used to predict rate of starch digestion, blood glucose and body response (insulin).Thus, substitution of cassava flour with maize flour would give a hard and firm tuwo meal which can be used as semolina, a product of wheat and cassava starch flours.

 Carbohydrate content shows that sample UYF had high value of (79.10 %) and sample UWF had the least value (73.66 %). Carbohydrate content obtained in this present work was low compared to (89.91 to 91.80 %) range value of the previous work of by [22] for gari produced from yellow cassava varieties. The difference in carbohydrate content might be as a result of starch degradation during the long fermentation period.

 The total carotenoid ranged between 7.12 to 8.40 μg/g. Tuwo produced from undecorticated white maize (sample UWF) had the lowest value (7.13 μg/g) while tuwo produced decorticated yellow maize (sample DYF) had the highest value (8.40 μg/g). The result showed significant difference between the samples (p<0.05). The result obtained in this study was higher than the value (5.24 and 6.65 μg/g) reported for yellow yam and jackbean flour blends by [23]. Carotenoids are antioxidant components which offer various health benefits such as reducing the risk of cardiovascular diseases, cancer and other degenerating diseases if ingested adequately [24]. In this study, the total carotenoids content of samples produced from high quality cassava starch and cassava starch substitute were low this could be as a result of heat, temperature and drying methods employed during flour processing which could be responsible for the total carotenoids degradation [25]. However, Hiane *et al*. [26] and [27] also reported that total carotenoids degradation also occurs in temperature close or superior to 40 °C. Other factor such as grinding /milling could influence the total carotenoids degradation of these flours thereby exposing their cellular content to the environment (oxygen) in the passage through the milling machine thus facilitating the oxidative process which could also contribute to the low total carotenoids content obtained in this work [25].

**Table 1: Carbohydrate and beta carotene properties of the maize varieties flour samples**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | DWF | UWF | DYF | UYF |
| Total starch  | 55.49±0.01a | 58.92±0.01b | 63.40±0.01c | 67.43±0.01d |
| Amylose  | 21.44±0.01c | 21.97±0.01d | 16.04±0.01b | 13.48±0.01a |
| Carbohydrate  | 74.45±0.01b | 73.66±0.01c | 78.12±0.01c | 79.10±0.01d |
| Beta carotene (ug/g) | 7.62±0.01b | 7.12±0.01a | 8.40±0.01c | 8.22±0.01c |

Results are mean values of duplicate determination ± standard deviation. Mean value within the same column having the same letter are not significantly different at p<0.05. Sample DWF- Decorticated white maize flour, sample UWF – Undecorticated white maize flour, sample DYF –Decorticated yellow maize flour, sample UYF- undecorticated yellow maize flour.

**Functional properties of the maize varieties flour samples**

 The result of functional composition of tuwo flour was shown in Table 2. Bulk density of the flour significantly ranged from 0.51 to 0.70 g/ml with sample DYF (decorticated yellow maize flour) having the highest bulk density value while sample UWF (undecorticated white maize flour) had the lowest bulk density. The result shows significant difference between the samples (p<0.05) Variation in values could be attributed to the processing methods adopted. The range value obtained in this research work was within the range value (0.62 to 0.89 g/ml) obtained by [28] for kadal flour from whole and decorticated maize and millet. Bulk density is a measure of the heaviness of a flour sample. Jones *et al*. [29] reported that bulk density is generally affected by the particle size and density of the flour and it is one of the essential parameter in determining the type of packaging material, handling and application in the food industry.

 A range of 6.96 to 7.94 g/g was recorded for water absorption capacity. The result shows that sample UWF had the highest value (7.94 g/g) while sample UYF had the least value (6.96 g/g). the result shows significant variation between the samples (p<0.05).The range value obtained in this research work was high compared to the range value (1.54 to 1.86 ml/g) for different pearl millet varieties in research work of [30]. The range value obtained in this research work was very low to the range value (51.09 to 126.32 %) obtained by [28] for kadal flour from whole and decorticated maize and millet, and 121.31 to 245 % of maize-cassava starch tuwo made by [18] but high to the result (2.31-2.34 ml/g) of [31] for maize tuwo produced from grit non soaking method and grit soaking method respectively. According to Seena and Sridha [32], high water absorption causes high retention of water without dissolution of protein, thus increasing the body and viscosity of gel while [7] reported that water absorption capacity of *ogi* (a fermented maize product) reduced with increased in soaking time of maize grains. Water absorption capacity is essentially a measure of the ability of the flour to associate with water, particularly in a food product where hydration is required in its preparation, so as to enhance its handling characteristics such as in dough and pastes.

 Oil absorption capacity ranged from 7.70 to 8.93 for sample UYF and DWF respectively. The result shows insignificant variation between the samples (p<0.05). The result obtained in this research work was high (2.31 and 2.34 ml/g) compare to maize tuwo made from non soaking and soaking maize grit, respectively by [31]. The oil absorption capacity is the flavour retaining capacity of flour which is an important element in food formulations. Oil absorption capacity is highly related to lipophilic properties of the starch molecule in cassava flour [33] while [34] stated that the variation in water or oil absorption capacity is depended on the degree of probability of hydroxyl group to form hydrogen and the covalent bond between the starch granule network. Furthermore, water and oil absorption capacity also depend on the intrinsic factors such as the composition of amino acid, protein conformation and surface polarity of protein hydrophobicity [35].

 Emulsion capacity simply determines the maximum amount of oil that can be emulsified by protein. The emulsion capacity of the flour samples ranged of 42.38 to 54.95 % with sample UYF having the highest value (54.95 %) and sample DWF had the least value (42.38 %). High emulsion capacities as observed in this research are positive indication that the flour samples could have excellent emulsifying properties in various foods. Highest Emulsion stability was observed in sample tuwo produced from undecorticated white maize (48.53 %) while tuwo produced from decorticated yellow maize was low in emulsion stability (43.19 %). This observation might be due to the genetic activity, time of harvest, environmental influence on both samples. Result of wheat flour (38.38 %) and rice flour (37.31 %) by [36] were all found to be low compared to the value obtained in this research work. Emulsion stability of foods is to the ability of a food emulsion to resist any change in its properties over time [37]. Increasing emulsion activity (EA), emulsion stability (ES) and fat binding during processing are functional properties of protein in such foods as comminuted meat products, salad dressing, frozen desserts and mayonnaise.

 The foam capacity of the flour samples ranged from 8.82 to 14.21 % with decorticated yellow maize flour, sample (DYF) having the lowest value (8.82 %) and decorticated white maize flour, sample (DWF) had the highest value (14.21 %). Kaushal *et al*. [38] reported that foaming capacity is related to protein content in cassava flour in which high protein content will increase foaming capacity and vice versa. Foam is a colloidal of many gas bubbles trapped in a liquid or solid. Small air bubbles are surrounded by thin liquid films. Foams are used to improve the texture, consistency and appearance of foods [39]. Flours with high foaming ability could form large air bubbles surrounded by thinner flexible protein film but easier to collapse and consequently lowered the foam stability [40].

 Foam stability ranged from 41.82 to 58.05 % for sample DYF (decorticated yellow maize flour) and sample UWF (undecorticated white maize flour) respectively. It was observed that samples produced from white maize were high in foam stability than samples produced from yellow maize. The result obtained in this research work was very high compared to the findings of [36] that recorded foam stability of wheat flour (1.94 %) and rice flour (0.98 %).The foam stability (FS) refers to the food ability to stabilize against mechanical and gravitational stresses. There is always an inverse relationship between the foaming capacity and the foam stability. Flours with high foaming capacity may form large air bubbles encircled by thinner flexible protein film.

 The swelling capacity of maize varieties flour under this study ranged from 1.94 to 2.25 g/g for sample UYF and UWF respectively. The result shows statistical variation between the samples (p<0.05). The variations in the swelling capacity of different forms of tuwo flour under study may be due to the difference in seed volume. Swelling capacity value obtained in this research work was low compared to (4.00 to 6.00 ul/seed) obtained for varieties of millet as reported by [30]. The result of yam and jackbean flour blends (67.34 to 69.22 %) as reported by [15]; on water yam and cowpea flour (59.57 to 78.31 %) as reported by [16] and [17] on water yam and lima bean (70.53 to 71.77 %), respectively are all higher than the values obtained in this present work. The result may be due to the variety of the samples and processing method adopted. Swelling capacity is regarded as a quality criterion in some food formulations. It is an evidence of non-covalent bonding between molecules within starch granules and a ratio of α-amylose and amylopectin factor.

 The results of swelling index of maize varieties flour ranged from 1.31 to 1.45 g/g with sample UYF (undecorticated yellow maize flour) having the least value (1.31 g/g) and sample DWF (decorticated). The range value obtained (0.26 to 0.50) for varieties of millet by [30] were low to the range value obtained in this research work. It is an indication of the non-covalent bonding between the molecules of starch granules and also one of the factors of the α-amylose and amylopectin ratios [41]. The swelling index of flours is influenced by the particle size, species variety and method of processing or unit operations [36].

 Gelatinization temperature of all the flour samples investigated fell within the range (62 to 72 oC). The result shows that sample UYF (undecorticated yellow maize flour) had the lowest value (62 oC) while sample UWF (undecorticated white maize flour) had the highest value (72 oC). There was a significant variation between the samples (p<0.05). Result of [42] was within the range value (62 to 65.3 oC) of the current study from sorghum-cowpea and millet-cowpea composition flour. Gelatinization temperature is the temperature at which starch molecules in a food substance lose their structure and leach out from the granules as swollen amylose and it affects the time required for the cooking of food such substances [5]. Dispersibility value ranged from (58.00 to 73.00 %) . It was observed that sample DWF had the least value (58 %) while sample UYF had the highest value (73 %). The result shows significant variation between the samples (p<0.05). The result obtained for undecorticated yellow maize flour in this research work was within the range value (70.50 to 77 %) for kadal flour from whole and decorticated maize and millet in research work of [28].

**Table 2: Functional properties of the maize varieties flour samples**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | DWF | UWF | DYF | UYF |
| Bulk density, mg/ml  | 0.58±0.01b | 0.51±0.01a | 0.70±0.01c | 0.67±0.01c |
| Water absorption capacity, g/g | 7.85±0.01c | 7.94±0.01d | 7.18±0.01b | 6.96±0.01a |
| Oil absorption capacity, g/g | 8.93±0.01d | 8.64±0.01c | 7.95±0.01b | 7.70±0.01a |
| Emulsion capacity, % | 42.38±0.01a | 47.64±0.01b | 49.22±0.01c | 54.95±0.01d |
| Emulsion stability, % | 45.43±0.01b | 48.53±0.01d | 43.19±0.01a | 47.69±0.01c |
| Foam capacity, % | 14.21±0.01d | 10.80±0.01b | 11.66±0.01c | 8.82±0.01a |
| Foam stability, % | 56.40±0.01c | 58.05±0.01d` | 41.82±0.01a | 46.13±0.01b |
| Swelling capacity, g/g | 2.25±0.01d | 2.16±0.01c | 2.05±0.01b | 1.94±0.01a |
| Swelling index, g/g | 1.45±0.01c | 1.37±0.01b | 1.36±0.01b | 1.31±0.01a |
| Dispersibility, % | 58.00±0.01a | 64.00±0.01b | 69.00±0.01c | 73.00±0.01d |
| Gelatinization temp, oC | 67.00±0.01c | 72.00±0.01d | 60.00±0.01a | 62.00±0.01b |

Results are mean values of duplicate determination ± standard deviation. Mean value within the same column having the same letter are not significantly different at p<0.05. Sample DWF- Decorticated white maize flour, sample UWF – Undecorticated white maize flour, sample DYF –Decorticated yellow maize flour, sample UYF- undecorticated yellow maize flour.

**Sensory evaluation of tuwo samples produced**

 The sensory quality rating of tuwo prepared from both white and yellow maize flour is presented in Table 3. Tuwo prepared from decorticated white maize was rated highest in terms of colour and appearance while tuwo prepared from undecorticated yellow maize rated lowest. In terms of mouldability flavour, taste and overall acceptability tuwo prepared from undecorticated yellow maize was rated highest while tuwo prepared from decorticated white maize was scored lowest. The overall acceptability of tuwo from undecorticated yellow maize (UWF) could be as a result of increase in softness index due to the structural modification in the food product caused by dilution of starch granules.

**Table 3: Sensory evaluation of tuwo samples produced**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Samples (%) | DWF | UWF | DYF | UWF |
| Colour  | 8.2 | 8.1 | 8.0 | 7.8 |
| Appearance | 8.0 | 8.2 | 7.8 | 7.6 |
| Mouldability | 6.8 | 7.6 | 8.4 | 8.2 |
| Flavour | 7.4 | 7.6 | 8.0 | 8.0 |
| Taste | 7.2 | 7.4 | 8.0 | 8.0 |
| Over acceptability | 7.0 | 7.2 | 7.6 | 8.2 |

Sample DWF- Decorticated white maize flour, Sample UWF – Undecorticated white maize flour, Sample DYF –Decorticated yellow maize flour, Sample UYF- undecorticated yellow maize flour.

**Conclusion**

 The study showed the functional properties, total starch, amylose content, carbohydrate and beta carotene variation that exists in samples of “tuwo” preparation. Result of functional properties, total starch, total amylose and beta carotene content showed that yellow maize result had advantage over white maize flour sample for tuwo production. However, white maize flour has improved texture, consistency and appearance. Hence, acceptability of white maize flour in preparation of tuwo should be encouraged especially in the food industry particularly in the areas of ingredient formulation and food product development.

**Funding and conflict of interest**

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**References**

[1]. Bolade, M.K., Adeyemi, I.A. & Ogunsua, A.O, (2012). Functionality Enhancement of Composite Cassava Flour in the Production of Maize Tuwo (A Non-fermented Maize-Based Food Dumpling). *Food Bioprocess Technology, 5,* 1340-1348.

[2]. Shindano, J. (2007). Functional properties of white maize meal stored under tropical conditions. Thesis submitted in fulfillment of the requirements for the degree of doctor (PhD) in Applied Biological Sciences: *Chemistry. Falculty of Bioscience Enguneering. Ghent University,* Belgium, pp.23-25.

[3]. Kaul, J., Jain, K. & Olakh, D. (2019). An Overview on Role of Yellow Maize in Food, Feed and Nutrition Security. *International Journal of Current Microbiology and Applied Science. 8(2)*. 3037-3048.

[4]. Hossain, F., Sarika, K., Muthusamy, V., Zunjare, R.U. & Gupta, H. S. (2019). Quality protein maize for nutritional security. In A. M. I. Qureshi *et al*. (eds.), Quality breeding in field crops. Springer. 217-238.

[5]. Adedeji, O. & Tadawus, N. (2019). Functional properties of maize flour (Zea mays) and stability of its paste (tuwo) as influenced by processing methods and baobab (Adansonia digitata) pulp inclusion. *Ukrainian Journal of Food Science. 7(1)*. 49-60.

[6]. Bolade, M.K., Adeyemi, I.A. & Ogunsua, A.O. (2009). Influence of particle size fractions on the physicochemical properties of maize flour and textural characteristics of a maize-based nonfermented food gel. *International Journal of Food Science and Technology, 44*, 646–655.

[7]. Bolade, M.K. & Adeyemi, I.A. (2012). Functionality enhancement of composite cassava flour in the production of maize tuwo (a nonfermented maize-based food dumpling). *Food Bioprocess Technol, 5*, 1340–1348.

[8]. Association of Analytical Chemists (AOAC). (2010). Official Methods of Analysis of Association of Official Analytical Chemists (18th ed.) Washington DC.

[9]. Yasumatsu, k., Sawada, K, Moritaka, S., Misaki, M., Toda, J., Wada, T. & Ishii, K. (1972). Whipping and emulsifying properties of soybean products," *Agricultural and Biological Chemistry*, *36*, 719-727.

[10]. Narayana, K & Narasinga-Rao, M. (1982). Functional properties of raw and heat processed winged bean (Psophocarpus tetragonolobus) flour. *Journal of Food Science, 47*, 1534-1538.

[11]. Ukpabi, U. & Ndimele, C. (1990). Evaluation of the quality of gari produced in Imo state. *Nigerian food journal*, *8*, 105-110.

[12]. Kulkami, K.D., Kulkami, D. & Ingle, U. (1991). Sorghum malt-based weaning food formulation preparation, functional properties, and nutritive value. *Food and Nutrition Bulletin, 13*, 1-7.

[13]. Shinde, B. G. (2001). Isolation and characterization of starch horse grain.'' Rahuri (India)". Unpublished M.Sc Thesis, Mahatma Phule Krishi Vidyapeeth.

[14]. Akinsola, A., Segilola, V., Oloso, S. & Durojaiye, O. (2018). Quality evaluation of plantain-African yam bean flour blends and sensory properties of its cooked (amala) paste. *Research Journal Food Science and Nutrition*, *3*, 31-40.

[15]. Affandi, D.R., Praseptiangga, D., Nirmala, F.S., Amanto, B.S. & Atmaka, W. (2016). Physical and chemical characterization of greater yam (Dioscorea alata) and jack bean (Canavalia ensiformis) - based composite flour. International Conference on Food Science and Engineering 2016, IOP Conf. Series: MaterialsScience and Engineering 193, edited by V. Suryani*et al*. (IOP Publishing Ltd, Bristol, UK, 2017), pp. 012041-1 - 012041-8.

[16]. Okorie, P.A., Ikegwu, O.J., Nwobasi, V.N., Odo, M.O. & Egbedike, C.N. (2016). Physicochemical properties and akara making potentials of water yam and cowpea composite flour. *Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7(6)*, 3031-3041.

[17]. Rohmah, F.U., Danar, P., Dian, R.A. & Windi, A. (2018). Formulation and physicochemical characterization of composite flour from yam (Dioscorea alata) and lima beans (Phaseolus lunatus). AIP Conference Proceedings 1927,030019https://doi.org/10.1063/1.5021 212.

[18]. Sunmonu, B.A.O., Akinsola, A.O., Ayanlola, B.T., Obisesan, D.O. & Taiwo-Oshin, M.A. (2021). Production and quality evaluation of “Tuwo” (a cooked paste of non fermented whole maize flour) made from maize and different cassava adjuncts. *Nature and Science,* *19*(11), 21-29.

[19]. Omoniyi, S.A., Awonorin, S.O., Idowu, M.A. & Adeola, A.A. (2016). Physico-chemical and functional properties of sweet potatosoybean flour blends. *Applied Tropical Agriculture, 21(2)*, 84-88.

 [20]. Zhenghong, C., Schols, H.A. & Voragen, A.G.J. (2003). Physicochemical properties of starches obtained from three different varieties of Chinese sweet potatoes. *Journal of Food Science, 68,* 431- 437.

[21]. Rosida, R., Harijono, E.T.& Sriwahyuni, E. (2017). Functional and pasting characteristics of modified water yam flour (Diocorea alata). *International Food Research Journal, 24(5)*, 1880-1888.

[22]. Islamiyat, F.B., Kehinde, Y. O. & Rasheed, G.A. (2017). Effect of processing on beta-carotene content and other quality attributes of cassava flakes (gari) produced from yellow cassava varieties. *Journal of Agricultural Science and Research, 4(1)*, 25-36 © TJPRC Pvt. Ltd.

[23]. Oke E.K, Idowu M.A, Sobukola O.P & Bakare H.A. (2020). Nutrient composition, functional, physical and pasting properties of yellow yam (Dioscorea cayenensis) and jack bean (Canavalia ensiformis) flour blends. Carpathian *Journal of Food Science and Technology.* Journalhomepage:http://chimie-biologie.ubm.ro/carpathian\_journal/index.html

[24]. Eleazu, C. & Eleazu, K. (2012). Determination of the proximate composition, total carotenoids, reducing sugars and residual cyanide levels of flours of six new yellow and white cassava (Manihot esculenta Crantz) varieties. *American Journal of Food Technology, 7*, 642-649.

[25]. Oliveira, R.G.A., Lucia de Carvalho, M.J., Nutt, R.M., Jose de Carvalho, L.V. & Fukuda, W.G. (2010). Assessment and degradation study of total carotenoid and βcarotene in bitter yellow cassava (Manihot esculenta Crantz) varieties. *African Journal of Food Science, 4(4)*, 148-55.

[26]. Hiane, P.A., Bogo, D., Ramos, M.I.L & Ramos F.M.M. (2003). Pro-vitamin carotenoids and fatty acid composition of bacuri fruit and flour (Scheeleaphalearata Mart.). *Food Science and Technology, 23*, 206-209.

[27]. Thakkar, S.K., Maziya-Dixon, B., Dixon, A.G.O. & Failla, M.L (2007). β-carotene micellarization during in vitro digestion and uptake by caco-2 cells is directly proportional to β-carotene content in different genotypes of cassava. *Journal of Nutrition*, 2229-2233

[28]. Umar, B.H., Agbara, G.I., Alkali1, M.Y., Masaya, A.F. & Akubuiro, S.C. (2022). Proximate composition, functional, and sensory properties of kadal (fermented grain flour) produced from whole and decorticated maize and pearl millet grains. AZOJETE June 2022, *18*(2), 345-356. Published by the Faculty of Engineering, University of Maiduguri, Maiduguri, Nigeria. Print ISSN: 1596-2644, Electronic ISSN: 2545-5818 [www.azojete.com.ng](http://www.azojete.com.ng)

[29]. Jones,.D.M., Trim, D.S., Bambridge, Z.A. & French, L. (2004). Influence of selected process variables on the elimination of cyanide from cassava.*Journal of the Science of Food and Agriculture,* *66*, 535-542.

[30]. Pawase, P.A., Chavan, U.D. & Kotecha, P.M. (2021). Evaluation of functional properties of different pearl millet cultivars. *The Pharma Innovation Journal*, *10(6)*, 1234-1240. ISSN (E): 2277- 7695 ISSN (P): 2349-8242 NAAS Rating: 5.23 TPI 2021; 10(6): 1234-1240 © 2021 TPI www.thepharmajournal.com Received: 16-04-2021 Accepted: 26-05-2021.

[31]. Olajide E.A. & Nsakpuma, T. (2019). Functional properties of maize flour (Zea mays) and stability of its paste (tuwo) as influenced by processing methods and baobab (Adansonia digitata) pulp inclusion. *Food Technology, Federal University Wukari, Wukari,* Nigeria.

[32]. Seena, S. & Sridhar, K.R. (2005). Physiochemical, functional and cooking properties of under explored legumes, Canavalia of the Southwest coast of India. *Food Research International*. *38*, 803-814.

[33]. Danbaba, N., Ukwungwu, M.N., Maji, A.T., Ndindeng, S.A., Jiya, A.G., Danfulani, S.& Onyeneke, E.N. (2014). End-use quality of upland Nerica rice (Oryza sativa L) as affected by the addition of sweet cassava (Low cyanide, Manihotesculenta) flour. *International Journal of Agriculture and Forestry, 4(3)*, 237-245.

[34]. Mbougueng, P.D., Tenin, D., Scher, J. & Tchiengang, C. (2008). Physicochemical and functional properties of some cultivar of irish potato and cassava starches. *Journal of Food Technology, 6(3)*, 139-146.

[35]. Chandra, K.D. & Samsher, A.Y. (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research, 8(38)*, 4849-4852.

[36]. Suresh, C. & Samsher, S. (2013). Assessment of functional properties of different flours. Vol. 8(38), pp. 4849-4852, 3 October, 2013 DOI:10.5897/AJAR2013.6905 ISSN 1991-637X ©2013 Academic Journals http://www.academicjournals.org/AJAR. African Journal of Agricultural Research

[37]. McClements, D.J. (2004). Food Emulsions: the Principles, Practices, and Techniques, Second Edition. Taylor and Francis. pp. 269–. ISBN 978-0-8493-2023-1.

[38]. Kaushal, P., Kumar, V. & Sharma, H.K. (2012). Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (Colocasia esculenta), rice (Oryza sativa), pegion pea (Cajanus cajan) flour and their blends. *LWT Food Science and Technology, 48(1)*, 59-68. https:// doi.org/10.1016/j.lwt.2012.02.028

[39]. Akubor, P.I. (2007). Chemical, functional and cooking properties of biscuits from soybean meal and corn blends. *J. Food Sci Technol. 44(6)*. 619-622.

[40]. Jitngarmkusol, S., Hongsuwankul, J. & Tananuwong, K. (2008). Chemical composition, functional properties and microstructure of defatted macademice flours. *Food Chem*., *110*, 23–30.

[41]. Iwe ,M.O., Onyeukwu, U. & Agiriga A.N. (2016). Proximate, functional and pasting properties of Faro 44 rice, African yam bean and brown cowpea seeds composite flour. Food Sciecne and Technology/research rticle.

[42]. Bagirei, S.Y., Iro-Nkamaσ, M.H., Badau, P. & Idakwo, P.Y. (2022). Production of Tuwo from Sorghum-Cowpea and Millet-Cowpea Composite Flours: Assessment of Flour Quality Parameters and the Textural Properties and Acceptability of Tuwo. *London Journal of Engineering Research*, 22(7). Compilation 1.0449U London.

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