American Journal of
Food Sciences and Nutrition
(AJFSN)

Physicochemical Properties of Starches from Four Local Varieties of Millet in Nigeria.

Eke-Ejiofor, J.
Nwosu, Amarachi. M.
Akusu, M.O

American Journal of Food Sciences and Nutrition

Vol.3, Issue 1, pp 21-33, 2021 www.ajpojournals.org

Physicochemical Properties of Starches from Four Local Varieties of Millet in Nigeria.

Eke-Ejiofor, J., Nwosu, Amarachi. M. and Akusu, M.O

Department of Food Science and Technology, Rivers State University,
Nkpolu, P.M.B. 5080, Port Harcourt,
Nigeria.
Correspondent author: E-mail: dualbasic@yahoo.com

Abstract.

Purpose: The study was carried out to evaluate the physico-chemical properties of starches from four local varieties of millet in salad cream production.

Methodology: Starches were extracted from four varieties of millet, two varieties of pearl millet were used namely Gero and Maiwa (Pennisetum glaucum), Tamba-Finger millet (Eluesine coracona) and Acha-Fonio millet (Digitaria exillis) using dry and wet milling processes for characterization and salad cream production. Standard analytical methods were used in determining the physicochemical properties of the starches.

Findings: The various starches physical properties, including colour, Amylose, Amylopectin, Starch Damage and Total Starch of millet cultivars were determined, and significant ($p < 0.05$) differences were observed among them. Values obtained for Amylose and amylopectin ranged from 24.47 to 26.91% and 73.09 to 74.51% respectively. The amount of starch damage varied from 0.08 to 0.10 % while total starch contained in the various samples ranged from 89.74 to 98.42 %. Proximate composition showed no significant difference among the starches in terms of moisture except in the wet milled Acha with 10 %. Ash content of the starches ranged between 0.79 and 9.22 %. Fat was higher in the control sample 10.22 % and lowest in the wet milled Tamba 1.69 %. Significant differences $P<0.005$ were found in the protein content amongst the various starches extracted, with Wmg having the highest value of 9.26 %. Crude fibre was in the range of 2.37 and 4.50 %. The Resistant starch was highest in Wmt (79.44%) and lowest in Dma (16.90%). Carbohydrate content was less in the control sample Wmc (62.40%) and highest in Wma (75.29%). Functional properties of various starches such as Bulk density ranged from 0.59% to 0.77%. Water absorption capacity of the starches were between 0.35% and 4.80% with Dmm starch having the lowest and Wmg the highest. Oil absorption capacity of starches varied between 2.10g/ml and 2.80g/ml. while swelling power were 0.43 to 0.91% with Dmc starch recording the lowest and Dmg starch the highest. Solubility values ranged from 9.50 to 24.00% with Dmm and Dmg having lowest and highest respectively. Least gelation capacity varied from 6% to 10%. The pasting characteristics of the four different starches were significantly ($p < .05$) different. Peak viscosity ranged from 2145.5 to 4379.0 RVU while Trough viscosity ranged from 1311.0 to 3190.0 RVU. Breakdown viscosity ranged from 625.5 RVU to 2401.5 RVU. The Final viscosity varied between 2704.5 and 5495.0 RVU. Increase may be attributed to high carbohydrate content in the different starches. Setback viscosity in this study ranged from 1393.5 to 2633.0 RVU. Peak time measured the peak viscosities in minutes of the cooking time of the starches and it ranged from 4.93 min to 6.30 min. Pasting temperature varied between 75.85°C and 88.40°C. Starches produced from the four local Millet varieties can be utilized for making diverse food products to meet the growing demand for starches in the food industries.

Keywords: Physicochemical, properties, millet, varieties, starches.

INTRODUCTION

Millet grain is a crop cultivated in areas with limited rainfall and can adapt to various Agro-climatic conditions (Songr´ *et al.*, (2008). cultivation period ranges between February and August while harvest period is within June or January (Jideani *et al.*, 2017). in Nigeria, the grain is cultivated using different names, Maiwa, Gero, Tamba and Acha. India is reported to be the largest producer of millet (Sireesha *et al.*, 2011), about 60% of the worldwide production (Siwela *et al.*, 2010). Millet contains an average of 10 - 12% protein, while its protein is superior to that of wheat or corn in terms of content of essential amino acids. However, Millet lacks gluten; for this reason, millet flour is not appropriate for leavened breads, the flour is used in making flat cakes and breads. The whole grain is used in soups, stews or as a cooked cereal. Several potential health benefits have been reported for millet (Gupta *et al*., 2012) These includes prevention of cancer and cardiovascular diseases, lowering blood pressure, risk of heart disease, delaying gastric emptying, and supplying gastrointestinal bulk.

Starch is the key ingredient of millet and determines the quality of millet-based food products. The application of starch for various purposes depends upon its physicochemical, structural, and functional properties. Starch is the major dietary source of carbohydrates and is the most abundant storage polysaccharide in plants (Ali *et al.,* 2016). Amylose and amylopectin are two macromolecular components of starch granules. Isolated starch is used in the food industry to impart functional properties, modify food texture, consistency and so on.

Nutritionally, pearl millet makes an important contribution to human diet due to high levels of calcium, iron, zinc, lipids and high-quality proteins. Pearl millet has the higher arginine, threonine, valine, isoleucine and lysine values than maize (Shahidi and Naczk 2003). Starch content of pearl millet varies from 50 to 75% of the grain composition.

Fonio is also one of the most nutritious of all grains. Its seed is rich in methionine and cystine, amino acids vital to human health and deficient in today's major cereals: wheat, rice, maize, sorghum, barley, and rye. This combination of nutrition and taste could be of outstanding future importance. Most valuable of all, however, is Fonio's potential for reducing human misery during "hungry times." (Adebayo *et al*., 2010).

Finger millet (*Eleusinecoracana* (L.) Gaertn), is also considered a helpful famine crop as it is easily stored for lean years (FAO, 2012). The grain is readily digestible, highly nutritious and versatile, and can be cooked like rice, ground to make porridge or flour used to make cakes (Kaur *et al.,* 2014). Sprouted grains are recommended for infants and elderly people. Finger millet has a carbohydrate content of 81.5%; its protein is relatively better balanced; it contains more lysine, threonine and valine than other millets. Finger millet contains methionine, an essential amino acid lacking in the diets of hundreds of millions of the poor who rely mostly on starchy staples (Balasubramanian *et al*., 2011).

Materials

Millet was purchased from Bori-camp mami market in Port Harcourt, Obio Akpor Local Government Area of Rivers State, Nigeria.

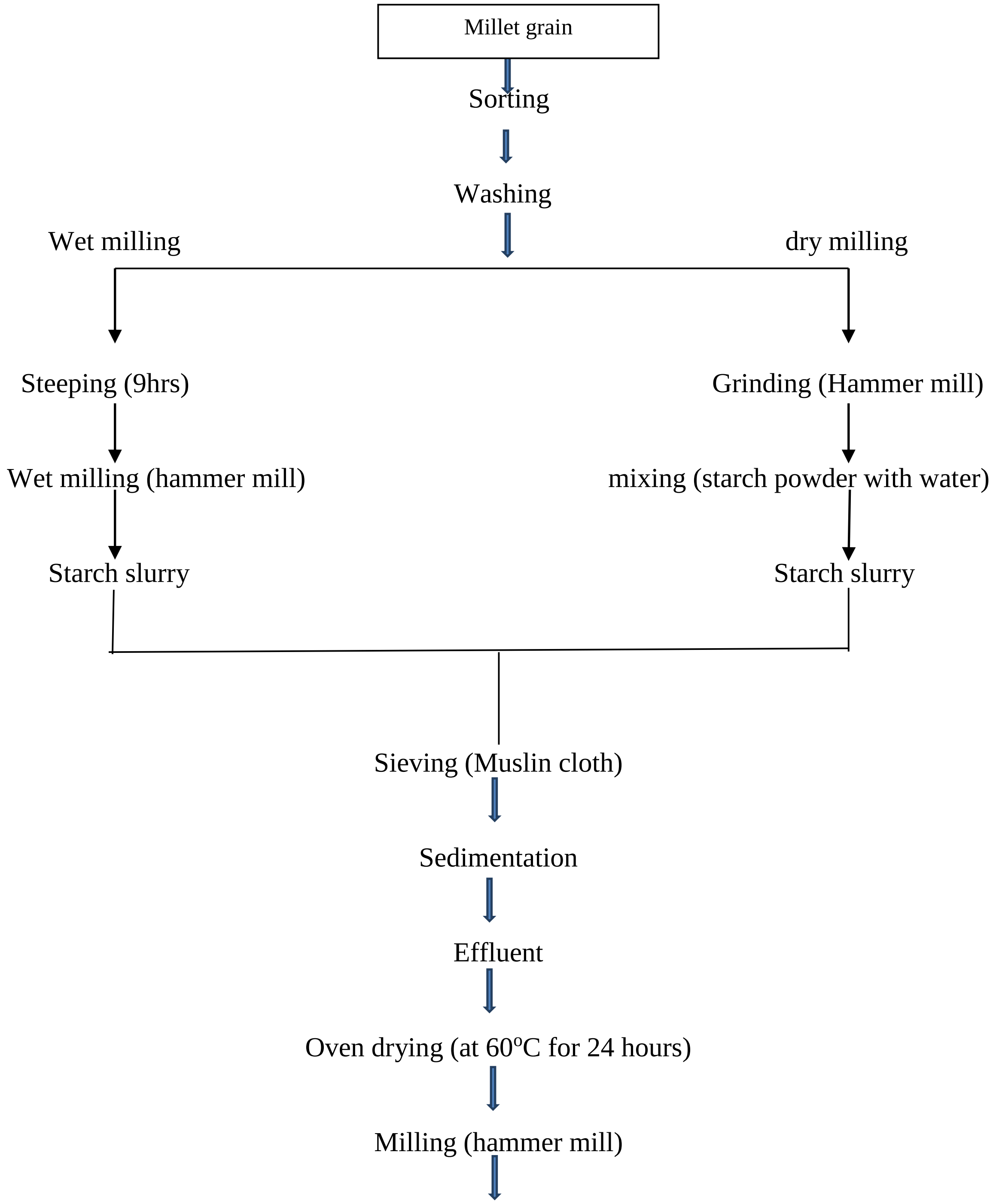
Chemicals

All chemicals used for this study were of analytical grade obtained from the Biochemistry Laboratory, Department of Food Science and Technology, Rivers State University Port Harcourt, Rivers State, Nigeria.

Methods

Extraction of starch

The millet Starches used in this study was extracted in the department of Food Science and Technology, Rivers State University Port Harcourt using the method described by Kim *et al.*, (2012) with slight modification. The millet grains were selected, washed, and soaked for 9 hours for the first treatment, after which they were grinded, and then sieved the water used for the soaking was changed daily. For the second treatment, the millet grains were selected grinded dry.



Sieving with muslin cloth

↓

Millet Starch

Figure 1: Production of Starch from wet and dry Millet Mesh.
Kim *et al* (2012)

Pasting properties of millet starches

Pasting Properties was determined using Rapid ViscoAnalyser 3C (RVA,Model 3C, Newport Scientific PTYLtd, Sydney) according to Wani, Sogi and Gill (2012).

Chemical properties of millet starches

The methods described for determination of moisture content, ash, fat, Crude Fibre and protein by AOAC (2012) was employed. While Total available carbohydrate (TCA) was determined by difference and involved subtracting the amount of ash, protein, and fat from the total dry matter.

Amylose content was determined by the method of Yang, *et al.*, (2019**)**, Amylopectin was determined by difference and Starch Damage was determined by the method described by AACC (2008)

Statistical Analysis

Analysis of variance (ANOVA) and comparison of means by Tukey (significance level of 95%) were performed. Data was reported as means and standard deviations. Analyses were performed using the Minitab 16 statistics software.

RESULTS

The mean values of the physical properties and chemical composition of the four different millet cultivars are presented in tables 1. Colour characteristics of samples ranged from 81.06 to 83.12% with Wmm and Dmt starch having the lowest and Dmg and Wmt starches the highest. Amylose content ranged from 24.47 to 26.91% with Wma and Wmt starches as the lowest and Dmc, Dma and Wmg starches having the highest values. Amylopectin ranged from 73.09 to 75.75% with Dmc, Dma and Wmg starch the lowest and Wma the highest.

Starch Damage ranged from 0.08 to 0.10 % with Dmg, Dmc and Wmg recording the highest values. Dma Sample had the lowest starch damage with a value of 0.08 %. Total starch content recorded in this study ranged from 89.74 to 98.42%.

Moisture content varied between 6.99 and 10.70% with Wmg and Wmc starches having the lowest and Wma starch the highest. Ash content ranged from 1.00 to 9.22% with Dmc having the highest value and Wmt the lowest.

Fat content of millet starches presented in Table 2, showed a ranged of 2.29 and 10.22 %, with sample Dmc recording the highest while sample wma the lowest.

The highest Protein Content 9.26 % obtained from the millet starch was found in Wmg while the lowest 6.33 % was in Wmm. Protein content of Dma**,** Dmc, Wma, Wmc and Dmm was found to range from 6.33 to 6.64 %. Crude fibre content of the extracted millet starches ranged from 2.36 to 4.50 %, with Wmm having the highest and Wmg the lowest. However, the crude fibre content was 3.38

% for sample Dma, 3.59 % for wma sample and 3.39 % for Dmg. The resistant starch was highest in Wmt (79.44%) and lowest in Dma (16.90%). Carbohydrate content was less in the control sample (62.40%) and highest in Wma (75.29%).

The functional properties of various starches are presented in Table 2. Bulk density ranged from 0.59% to 0.77%. Water absorption capacities of the starches were between 0.35% and 4.80% with Dmm starch having the lowest and Wmg the highest. Oil absorption capacity of starches varied between 2.10g/ml and 2.80g/ml.

Swelling power were 0.43 to 0.91% with Dmc starch recording the lowest and Dmg starch the highest. Solubility values ranged from 9.50 to 24.00% with Dmm and Dmg having lowest and highest respectively. Least gelation capacity varied from 6% to 10%. Highest value was found in Wmg.

Table 3 shows the pasting properties of the various starches, such as peak, trough, breakdown, and final viscosity, set back viscosity, pasting time and pasting temperature.

The pasting characteristics of the four different starches are as shown in Table3. Peak viscosity ranged from 2145.5 to 4379.0 RVU. Trough viscosity ranged from 1311.0 to 3190.0 RVU. Breakdown viscosity ranged from 625.5 RVU to 2401.5 RVU while Final viscosity varied between 2704.5 and 5495.0 RVU. Setback viscosity ranged from 1393.5 to 2633.0 RVU. With Wma starch recording the highest value and Dmt the lowest. Peak time ranged from 4.93 min to 6.30 min. The pasting temperature for the various starches ranged from 75.85°C to 88.40°C.

Table 1: Physicochemical Properties of Starches from Four Local Varieties of Millet

Sample	moisture%	Ash	Fat	Protein	Fiber	Carbohydrate	Color	Amylose	Amylopectin	Starch Damage	Total Starch	Resistant starch
Dmc	$9.30^{ab}\pm0.6$	$9.22^{a}\pm0.2$	$10.22^{a}\pm02$	$6.63^{e}\pm0.01$	$2.37^{g}\pm0.0$	$62.40^{bc}\pm0.14$	$82.38^{c}\pm0.0$	$26.91^{a}\pm0.11$	73.09 ± 0.00	$0.10^{ab}\pm0.0$	$89.74^{e}\pm0.9$	$44.13^{f}\pm0.25$
Wmc	$8.95^{ab}\pm0.0$	$1.73^{f}\pm0.0$	$7.54^{e}\pm0.0$	$6.35^{fg}\pm0.00$	$3.48^{c}\pm0.0$	$71.95^{ab}\pm0.14$	$81.38^{d}\pm0.0$	$25.89^{bc}\pm0.5$	$74.11^{cd}\pm0.00$	$0.08^{d}\pm0.00$	$93.41^{cd}\pm09$	$38.19^{gh}\pm0.10$
Dma	$9.47^{ab}\pm1.3$	$7.71^{b}\pm0.2$	$3.46^{h}\pm0.2$	$6.63^{e}\pm0.01$	$3.38^{f}\pm0.0$	$69.35^{c}\pm0.07$	$82.83^{b}\pm0.7$	$26.34^{b}\pm0.00$	73.66 ± 0.00	$0.08^{e}\pm0.00$	$95.53^{b}\pm0.0$	$16.90^{i}\pm0.02$
Wma	$10.70^{a}\pm0.3$	$1.49^{g}\pm0.1$	$2.29^{i}\pm0.1$	$6.64^{e}\pm0.04$	$3.59^{b}\pm0.0$	$75.29^{bc}\pm0.14$	$81.38^{d}\pm0.7$	$24.25^{e}\pm0.2$	$75.75^{a}\pm0.00$	$0.09^{d}\pm0.00$	$97.88^{a}\pm0.1$	$55.15^{e}\pm0.25$
Dmg	$6.99^{ab}\pm0.0$	$5.81^{e}\pm0.1$	$4.65^{f}\pm0.1$	$8.42^{b}\pm0.08$	$3.39^{e}\pm0.0$	$70.74^{bc}\pm0.14$	$83.08^{ab}\pm00$	$25.49^{a}\pm0.7$	$74.51^{c}\pm0.00$	$0.10^{a}\pm0.00$	$93.84^{c}\pm0.9$	$69.94^{c}\pm0.27$
Wmg	$8.49^{ab}\pm0.3$	$1.09^{h}\pm0.1$	$7.85^{d}\pm0.2$	$9.26^{a}\pm0.01$	$2.36^{g}\pm0.1$	$70.95^{a}\pm0.000$	$81.61^{d}\pm0.0$	$26.87^{cd}\pm0.5$	$73.13^{e}\pm0.00$	$0.10^{bc}\pm0.0$	$92.23^{d}\pm0.7$	$51.79^{d}\pm0.32$
Dmm	$9.59^{a}\pm0.01$	$6.31^{d}\pm0.1$	$9.71^{C}\pm01$	6.46 ± 0.014	$3.31^{f}\pm0.0$	$67.62^{abc}\pm0.14$	$83.12^{a}\pm0.0$	$25.24^{cd}\pm0.7$	$74.76^{b}\pm0.00$	$0.09^{c}\pm0.00$	$90.34^{e}\pm0.4$	$40.32^{g}\pm0.29$
Wmm	$9.98^{a}\pm0.02$	$0.79^{j}\pm0.1$	$9.99^{b}\pm0.0$	6.33g±0.04	$4.50^{a}\pm0.0$	$68.41^{abc}\pm0.14$	$81.06^{e}\pm0.4$	$25.49^{cd}\pm0.7$	$74.51^{c}\pm0.00$	$0.09^{d}\pm0.00$	$98.42^{a}\pm0.4$	$77.04^{b}\pm0.35$
Dmt	$9.24^{ab}\pm0.1$	$7.41^{C}\pm0.2$	$3.55^{g}\pm0.1$	$8.20^{c}\pm0.00$	$3.39^{e}\pm0.0$	$68.21^{abc}\pm0.21$	$81.06^{e}\pm0.4$	$25.85^{bc}\pm0.1$	$74.15^{d}\pm0.00$	$0.09^{c}\pm0.00$	$95.76^{b}\pm0.8$	39.09 ± 0.06
Wmt	$9.21^{ab}\pm0.1$	$1.00^{i}\pm0.01$	$1.69^{j}\pm0.01$	$7.72^{d}\pm0.007$	$3.45^{d}\pm0.0$	$70.99^{bc}\pm0.21$	$83.12^{a}\pm00$	$24.47^{e}\pm0.2$	$75.53^{ab}\pm0.00$	$0.10^{bc}\pm0.0$	$97.95^{a}\pm0.4$	$79.44^{a}\pm0.40$

Means with different superscript in the same column are significantly ($p<0.05$) different

Key:

Dmc = Dry milled corn Wmc = wet milled corn

Dma = Dry milled Acha Wma = wet milled Acha

Dmg = Dry milled Gero Wmg = wet milled Gero

Dmm = Dry milled Maiwa Wmm = wet milled Maiwa

Dmt = Dry milled tamba Wmt = wet milled tamba

Table 2: Functional Properties of Four Varieties of Millet Starches (%)

Sample	Bulk Density	Solubility	Swelling power	Dispersibility	Water absorption	Oil absorption	LGC	Colour
Dmc	$0.59^{j}\pm0.01$	$10.50^{cd}\pm0.70$	$0.43^{d}\pm0.00$	$88.50^{cd}\pm0.70$	$4.500^{a}\pm0.14$	$2.10^{bc}0.14$	8^{c}	$82.38^{c}\pm0.01$
Wmc	$0.73^{cd}\pm0.00$	$19.00^{ab}\pm0.00$	$0.71^{a}\pm0.00$	$80.00^{ab}\pm0.00$	$4.600^{a}\pm0.00$	$2.70^{ab}\pm0.14$	8^{c}	$81.38^{d}\pm0.01$
Dma	$0.70^{f}\pm0.01$	$15.00^{bc}\pm0.00$	$0.59^{c}\pm0.00$	$85.00^{bc}\pm0.00$	$3.50^{b}\pm0.14$	$1.95^{c}\pm0.07$	6^{d}	$82.83^{b}\pm0.07$
Wma	$0.62^{i}\pm0.01$	$11.00^{cd}\pm1.41$	$0.53^{c}\pm0.00$	$81.00^{cd}\pm1.41$	$1.20^{e}\pm0.00$	$2.70^{bc}\pm0.14$	6^{d}	$81.38^{d}\pm0.07$
Dmg	$0.77^{a}\pm0.01$	$24.00^{a}\pm1.41$	$0.91^{a}\pm0.00$	$94.00^{a}\pm1.41$	$2.90^{C}\pm0.14$	$2.10^{bc}\pm0.14$	9^{b}	$83.08^{ab}\pm0.00$
Wmg	$0.74^{b}\pm0.01$	$20.00^{d}\pm0.00$	$0.87^{b}\pm0.00$	$80.00^{d}\pm0.00$	$4.80^{ef}\pm0.00$	$2.80^{a}\pm0.00$	10^{a}	$81.61^{d}\pm0.01$
Dmm	$0.70^{g}\pm0.01$	$9.50^{d}\pm0.70$	0.21 ± 0.00	$89.50^{d}\pm0.70$	$0.35^{f}\pm0.07$	$2.30^{abc}\pm0.14$	9^{b}	$83.1^{a}\pm0.01$
Wmm	$0.72^{d}\pm0.01$	$11.00^{cd}\pm1.41$	$0.53^{c}\pm0.00$	$81.00^{cd}\pm1.41$	$3.90^{b}\pm0.14$	$2.30^{abc}\pm0.14$	9^{b}	$81.06^{e}\pm0.14$
Dmt	$0.72^{e}\pm0.01$	$19.00^{b}\pm1.41$	$0.71^{a}\pm0.00$	$87.00^{b}\pm1.41$	$2.10^{d}\pm0.14$	$2.45^{abc}\pm0.21$	8^{c}	$81.06^{e}\pm0.14$
Wmt	$0.64^{h}\pm0.01$	$11.00^{cd}\pm1.41$	$0.53^{c}\pm0.00$	$80.00^{cd}\pm1.41$	$0.85^{e}\pm0.07$	$2.15^{bc}\pm0.21$	8^{c}	$83.12^{a}\pm0.01$

Means with different superscript in the same column are significantly ($p<0.05$) different

Key:

Dmc = Dry milled corn Wmc = wet milled corn

Dma = Dry milled Acha Wma = wet milled Acha

Dmg = Dry milled Gero Wmg = wet milled Gero

Dmm = Dry milled Maiwa Wmm = wet milled Maiwa

Dmt = Dry milled tamba Wmt = wet milled tamba

Table 3: Pasting Properties (RVU) of Four Varieties of Millet Starches

Sample	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (Min)	Pasting Temp. (°C)
Dmc	2145.5^{e}±17.7	1311.0^{e}±5.7	834.5$^{e f}$±23.3	2704.5^{f} ±19.1	1393.5^{d} ±13.4	4.93^{e}±0.00	76.60^{de}±0.00
Wmc	3550.5^{c}±111.0	2149.5^{c}±53.0	1401.0^{c} ±58.0	4782.5^{b}±18.1	2633.0^{a} ±65.1	5.23^{c}±0.04	75.85^{e}±0.07
Dma	3551.0^{c} ±83.4	2045.5^{c} ±9.2	1505.5^{c} ±74.2	4632.5^{bc}±64.3	2587.0^{a}±55.2	5.63^{c}±0.04	79.12^{c}±0.03
Wma	4379.0^{ab}±72.1	1977.5^{c}±102.5	2401.5^{a}±174.7	3930.0^{d}±17.0	1952.5^{b} ±119.5	5.56^{c} ±0.04	79.12^{c}±0.10
Dmg	2721.5^{d}±186.0	1536.5^{de}±137.9	1185.0^{cd}±48.1	3152.5^{e} ±190.2	1616.0$^{b c d}$±52.3	5.53^{d} ±0.09	80.75^{b}±0.00
Wmg	3534.0^{c} ±52.3	1650.5^{d} ±3.5	1883.5^{b}±55.9	3304.0^{e}±12.7	1653.5^{bcd} ±16.3	5.16^{d} ±0.04	78.70^{b}±0.70
Dmm	2667.0^{d}±24.0	1632.0^{d}±21.2	1035.0$^{d e}$±2.8	3048.0$^{e f}$±33.9	1416.0^{d} ±55.2	5.67$^{b c}$±0.00	87.95^{a}±0.00
Wmm	2404.5^{de}±37.5	1424.0^{de} ±14.1	980.5 $^{d e}$±51.6	2920.0$^{e f}$±1.4	1496.0 $^{c d}$±12.7	5.73$^{b c}$±0.09	88.40^{a}±0.49
Dmt	3580.5^{c}±19.1	2955.0^{b}±96.2	625.5 ^{f}±115.3	4324.5^{c} ±150.6	1369.5^{d}±246.8	6.30 ^{a}±0.042	81.12^{b}±0.67
Wmt	4026.0 ^{a} ±0.02	3190.0 ^{a} ± 0.00	836.0^{cd} ± 0.00	5495.0^{b} ±0.03	1636.0$^{b cd}$±0.02	6.27 ^{a} ±0.00	78.25^{cd}±0.03

Means with different superscript in the same column are significantly ($p<0.05$) different

Key:

Dmc = Dry milled corn Wmc = wet milled corn

Dma = Dry milled Acha Wma = wet milled Acha

Dmg = Dry milled Gero Wmg = wet milled Gero

Dmm = Dry milled Maiwa Wmm = wet milled Maiwa

Dmt = Dry milled tamba Wmt = wet milled tamba

Discussion

The colour differences can be attributed to differences in pigments, composition, and genetics of the cultivars (Kaur *et al.*, 2013). Starch extracted under perfect condition is pure white in colour and is an important criterion for starch quality. Moorthy (1985) reported that the colour of starch will determine its clarity when cooked and that clarity depends on the associative bonds between the starch molecules in the granules.

Amylose content in the present study falls within the range reported by Eke-Ejiofor, (2015), which is 16.09 to 26.73 % in cassava starch. Amlyose is the linear components of starch, however, many researchers suggested that as the amylose content increases, the irregularity of starch granule shape increases too (Wang *et al*., 1993). Amylose decreased with increase in amylopectin, a high value of amylose amylopectin ratio indicates low glycemic index (Dipnaik and Kokare, 2017). The result of Amylopectin in the present study is within the findings of (Eke-Ejiofor and Owuno, 2012) 66.27 to 76.79%. Swelling behaviour of cereal starches has primarily been reported as a property of their amylopectin content (Sofi, *et al*., 2013). Amylopectin readily dissolves in hot water and on cooling; it forms a starch paste or gel. Dissolved amylopectin starch has a lower tendency of retrogradation (gelling) during storage and cooling.

In the Starch Damage, damaged granules absorb more water and are more susceptible to enzymatic hydrolysis than undamaged starch, they influence the water absorption, rheology, gassing power of dough, and the crumb texture and crust colour of the baked products. Damaged starch is also a substrate for amylases which provide fermentable carbohydrate that is utilized by yeast (Adebayo *et al*., 2010).

Total starch content recorded in this study is in disagreement with the report of Geervani and Eggum (1989) who reported values of 64-79% range. Starch is an important ingredient in various food systems as thickening, gelling and binding agents. It imparts texture to various foodstuffs.

Moisture content of the different starches is in agreement with the findings of (Eke-Ejiofor and Owuno, 2012) who reported moisture content of 7.36 to 11.42% in three leaf yam and cassava starch. The lower the moisture content of the starches the better the keeping quality. Ash content of the extracted millet starches compared to the values 0.05 and 0.40 % ash content for pearl millet starch earlier reported by Idris, (2001). Ash content gives clue of mineral content of a food.

Fat content of millet starches reported in this work is higher than the value of 1.72 to 3.37 % reported by Eke-Ejiofor and Owuno (2012) in cassava and potato starches and 1.1% report by Vodouche *et al*, 2003. It is also higher than the values of 0.2% and 0.3% fat reported by Idris, (2001) for traditionally extracted starch. The values reported in this study are in agreement with report of 4.86% for pearl millet flour (Taylor *et al*, 2010), 2.15% and 2.73% for finger millet starch (Babajide and Olowe (2013). High fat starch is also good as flavour enhancers and useful in improving palatability of foods. Lipid provides very good sources of energy and aids in transport of fat-soluble vitamins, insulates and protects internal tissues and contributes to important cell processes (Hassan *et al*, 2011).

Protein content values are lower than 11.84 % reported by Thilagavathi *et al*, (2015). The protein content of 6.33 to 6.64% was close to 7.30% reported by Zhu, (2014), higher than 0.13% and 1.50 in cassava and three leaf yam starch and lower than 9% reported by Vodouche *et al*, 2003. Proteins are employed in functional roles in food formulations. According to

Pamela *et al.*, (2005), proteins from plant sources have lower quality but their combination with many other sources of protein such as animal protein may result in adequate nutritional value.

Crude fibre content of the extracted millet starches is in agreement with findings of 3.60% (Obadina, 2018).

The reduction in some nutrients (minerals, fibres, and antioxidants) and antinutrients (phytates, tannin) could be attributed to the fact that they are mainly located in the peripheral parts of the grains (pericarp and aleurone layer); therefore, removing of the pericarp during decortication leads to reduce in nutrient content (Khouloud *et al.*, (2013). Although crude fibre enhances digestibility, its presence in high level can cause intestinal irritation, lower digestibility and decreased nutrient usage (Oladiji *et al*, 2005). It is a known fact that although decortication of millet grains was found to reduce some nutrient contents such as fibre and minerals, but usually they are decorticated before consumption to improve their edible and sensory properties and to increase the appearance of their food products. The resistant starch was highest in Wmt (79.44%) and lowest in Dma (16.90%). Resistant starches are carbohydrates that do not break down into sugar and are not absorbed by the small intestine. Similar to insoluble fibre, they pass through most of the digestive system unchanged, usually fermenting in the colon. By decreasing the pH level in the colon and assisting the body in increasing its production of short-chain fatty acids, (Higgins *et al*. (2013) resistant starches help to create an environment in which beneficial bacteria thrive. Resistant starches include some high-fibre foods, such as legumes and whole grains, but they also include carbohydrate-rich foods and food additives that confer similar health benefits.

Functional properties of the starches such as Bulk density (BD) is used to evaluate the starch heaviness, handling requirement and the type of packaging materials suitable for storage and transportation of food materials (Oppong, Arthur, Kwadwo, Badu, & Sakyi, 2015). Carbohydrates have been reported to greatly influence the water absorption capacity (WAC) of foods (Anthony *et al*., 2014). Increase in water absorption capacity in food systems allows end users to control the functional properties of the dough in the bakery products.

Oil absorption capacity of starches falls within the range reported by Omodamro *et al*. (2007) which reported 1.0 to 2.5 g/ml. Oil absorption is important in food product development as it imparts flavour and mouth feel to foods.

Swelling power result is in disagreement with the findings of Eke-Ejiofor and Owuno (2012) who reported 7.06 to 10.90%. Swelling power is a factor of the ratio of amylose to amylopectin. Solubility values are in agreement with the findings of Eke-Ejiofor and Owuno (2012) who recorded a solubility of 12.64 to 13.73% for cassava and potato starches. Least gelation capacity (LGC) measures the minimum amount of starch.

CONCLUSION

The physical and chemical properties, including colour, Amylose, Amylopectin, Starch Damage and Total Starch moisture, Ash, Fat, Protein, Crude fibre and Carbohydrate of millet cultivars were determined, and significant ($p < 0.05$) differences were observed among them. Starches produced from the four local Millet varieties can be utilized for making diverse food products to meet the growing demand for starches in the food industries.

References

Adebayo GB, Otunola GA, Ajao TA. (2010). Physicochemical, microbiological and sensory characteristics of kunu prepared from millet, maize and guinea corn and stored at selected temperatures. *Advance Journal of Food Science and Technology*. 2(1):41-46

Ali, A., Wani, T. A., Wani, I. A. and Masoodi, F. A. (2016). "Comparative study of the physio -chemical properties of rice and corn starches grown in Indian temperate climate", *Journal of the Saudi Society of Agricultural Science*., 15: 75-82.

Babajide, J. M. and Olowe, S. (2013). Chemical, functional and sensory properties of water yam-cassava flour and its paste. *International Food Research Journal*, 20(2):903-909.

Balasubramanian S, Singh KK, Patil RT, Onkar KK. (2011). Quality evaluation of millet-soy blended extrudates formulated through linear programming. *Journal Food Science Technology* DOI: 10.1007/s13197-011-0297-0.Available from Springer [http://www.springerlink.com].

Dipnaik, K., and Kokare, P. (2017). Ratio of Amylose and Amylopectin as indicators of glycaemic index and in vitro enzymatic hydrolysis of starches of long, medium and short grain rice. *International Journal of Research in Medical Sciences*, *5*(10), 4502-4505

Eke-Ejiofor j, (2015). Physico-chemical and pasting properties of starches from cassava, sweet potato and three leaf yam and their application in salad cream production, *International Journal of Biotechnology and Food Science* Vol. 3(2), pp. 23-30, March 2015 ISSN: 2384-7344

Eke-Ejiofor J, Owuno F (2012). Functional and Pasting Properties of wheat/three-leaf yam Dioscorea Dumentorcem) Composite flour blend. Global Resources *Journal Agriculture Biology. Science.* 3(4):330-335

FAO (Food and Agriculture Organization) (2012). Economic and Social Department: The Statistical Division. Statistics Division 2012. Available from FAO

Gupta, N, Srivastava, A.K, Pandey, V.N., (2012). *Biodiversity and nutraceutical quality of some Indian millets*, Proceedings of the National Academy of Sciences, India Section B: Biological Sci.

Hassan, E. G., Mustafa, A. M. I. and Elfaki, A. A (2015). "Characterization and evaluation of starches from different sources", *Journal Agriculture. Food Applied. Science.,* 3 (4): 101-109.

Higgins JA *et al*. (2013) Resistant starch: a promising dietary agent for the prevention/treatment of inflammatory bowel disease and bowel cancer. *Current Opinions in Gastroenterology*.;29(2):190-194

Idris, K.M.A., (2001). The effect decortication on wet-milling and starch quality of sorghum and millet grains. M.Sc. Thesis, University of Khartoum. Sudan

Jideani VA, Nkama I, Agbo EB, Jideani IA (2017). Fura production in some northern states of Nigeria—A survey. Plant Foods for Human Nutrition. 2012; 56:23. John R.N. Taylor. *Gluten-Free Ancient Grains*.

Kaur KD, Jha A, Sabikhi L, Singh AK (2014). Significance of coarse cereals in health and nutrition: A review. *Journal of Food Science and Technology*. 2014; 11:

Kaur, M., Kaushal, P., & Sandhu, K. S. (2013). Studies on physicochemical and pasting properties of taro (*Colocasia esculenta* L.) flour in comparison with a cereal, tuber, and legume flour. *Journal. Food Science. Technology.,50*(1), 94-100.https://doi.org/10.1007/s13197-010-0227-6

khouloud b., elhem m., abdennarceur k., mabrouka a., mansour h., leila y., nacer j., and elfje m (2013). fiber content and mineral composition of finger millet of the oasis of gabes tunisia. *Journal of agricultural science.* issn 1916-9752

Moorthy SN (1985). "Actylation of cassava starch using perchloric acid catalyst" starch/Starke. 37:301-308.

Obadina, A. O. (2018). Improving nutrition, health and livelihood through traditional grains 2018. http://www.afripro.org.uk/paperd/paper02Obilana.pdf

Ojediran, J. O., Adamu, M. A., & Jim-George, D. L. (2010). Some physical properties of pearl millet (Pennisetum glaucum) seeds as a function of moisture content. *African Journal general Agriculture*., 6(1), 39-46.

Oladiji A.T. and Mih, F.O. (2005). *African Journal. Biotechnology*., 4 (12): 1440- 1441.

Omodamiro RM, Iwe MO, Ukpabi UJ (2007**).** Pasting and functional Properties of Lafun and starch processed from some improved cassava genotypes in *Nigerian Food Journal*. 28(2):122-126

Shahidi F, Naczk M (2003) Cereals, legumes, and nuts. In: Phenolics in food and nutraceuticals. CRC Press Boca Raton, USA.

Sireesha Y, Kasetti RB, Swapna SAS, Apparao C (2011;). Antihyperglycemic and hypolipidemic activities of Staria italic seeds in STZ diabetic rats. Pathophysiology.;18(2):159–64

Siwela M, Taylor JRN, de-Milliano WAJ, Duodu KG (2010;). Influence of phenolics in finger millet on grain and malt fungal load, and malt quality. Food Chemistry. 121(2):443–9.

Sofi, B. A., *Wani*, I. A., Masoodi, F. A., Saba, I. and Muzaffar, S. (2013) "Effect of gamma irradiation on physicochemical properties of broad bean (Vicia faba L.) starch", *LWT Food Science Technology*, 54: 63-72.

Songr´e-Ouattara LT, Mouquet-Rivier C, Icard-Verni`ere C, Humblot C, Diawara B, Guyot JP (. 2008). Enzyme activities of lactic acid bacteria from a pearl millet fermented gruel (ben-saalga) of functional interest in nutrition. *International Journal of Food Microbiology;*128(2):395- 400.

Taylor, J. R. N., Barrion, S. C., Rooney, L. W., (2010): Pearl millet – New developments in an ancient food grain. Cereal Foods World 2010, 55, 16-19.

Thilagavathi .T. , S. Kanchana, P. Banumathi, G. Hemalatha, C. Vanniarajan, M. Sundar and M. Ilamaran(2015).Physico-chemical and Functional Characteristics of Selected Millets and Pulses. *Indian Journal of Science and Technology*, 8(S7), 147–155.

Vodouche, S. R., A. Zannou and E. A. Dako. (2003). (eds) Actes du premier atelier sur la diversitégénétique du fonio (Digitaria exilisstapf) en Afrique de l'Ouest, Conakry, Guinée, 4-6 aout 1998. Rome (Italie) IPGRI. Vi, p.73.

Wang, Y. J., White, P., Pollak, L. and Jane, J (1993). "Characterization of Starch Structure of 17 Maize Endosperm Mutant Genotypes with Oh43 Inbred Line Background", *Cereal Chemistry*. 70 (2): 171-179.

Zhu, E (2014): Structure. Physicochemical properties and uses of millet starch, *Food Res Int.* 64. 200