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Production, physico-chemical characteristics and acceptability of Tuwo (Stiff Porridge) produced from four local wheat varieties (Atilla Gan Atilla, Norman, Kauz, Reyna 15)

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Abstract
Tuwo (stiff porridge) is a traditional Nigerian dish made from cooked grains, such as wheat, corn meal, millet, or rice. That is served with various soups and stews, such as egusi soup, miyan kuka, and okra soup. Proximate composition, functional properties, viscosity, pH, mineral content and acceptability test were conducted. Protein content was found higher in Tuwo (stiff porridge) produced from atilla gan atilla with 11.12 %, Norman 10.26 %, reyna 9.22 % and kauz 9.42 %. Norman and control are significant. Fats contents of atilla gan atilla 2.15 %, norman 2.55 %, Reyna 1.96 %, kauz 2.11. Ash content Tuwo (stiff porridge) implies that the wheat varieties are good sources of minerals. Tuwo (stiff porridge) from Atilla gan atilla had the highest bulk density of 0.84 g/cm^3. Reyna 15 had the highest water absorption of 6.34 %. Swelling capacity decreased while solubility also increased with the wheat variety from 3.94 to 3.74 %. Viscosity and the pH values were significant. Variations were observed in all the mineral contents of the Tuwo (stiff porridge). Tuwo (stiff porridge) produced from Nigerian local grown wheat serve as a great food source of nutritional quality. The overall acceptability showed that Tuwo (stiff porridge) produced from atilla gan atilla and reyna 15 were highly accepted, followed by kauz and Norman when compared with the control.

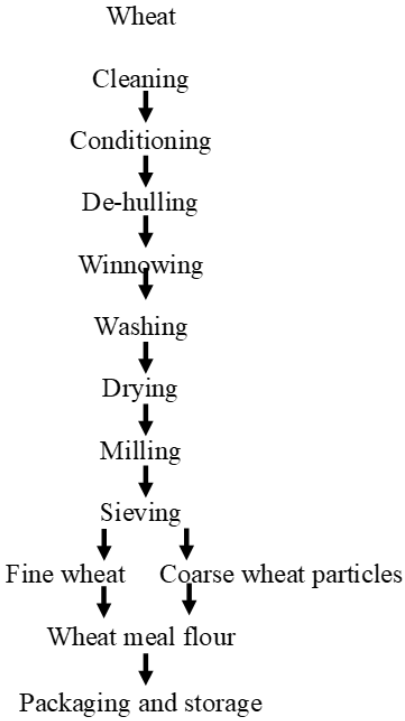
Keywords: Tuwo (stiff porridge), wheat, proximate, mineral acceptability

Introduction
Tuwo (stiff porridge) is one of the most popularly processed and consumed foods, usually made by the people of the Northern part of Nigeria especially the Hausa tribes, preparation and consumption of Tuwo (stiff porridge) spread to other non-Hausa-speaking communities as a result of inter-ethno tribal movement of people in the sub region (Bolade *et al*., 2006) [9]. Due to its properties (thickness), Tuwo (stiff porridge) is being heated and stirred, moulded or shaped into a ball which was later serves with soups. It is generally produced from the cereal grains (millet, maize, wheat, sorghum) flour and grits and as well as whole rice grain. In the north central such as Bauchi, Kaduna and Plateau states of Nigeria whole meal from fonio is used in the preparation of Tuwo (stiff porridge) known as "Tuwon acha" (Jediani, 2012). It also spread across Africa, more especially West African countries such as Ghana, Mali, Niger and Benin. The thickness of Tuwo (stiff porridge) depends on the choice of individuals and families. Some people prefer their Tuwo (stiff porridge) very thick while others prefer it light. And the colour goes with the grain colour and the method adopted for preparing the flour. In some practices, spent steep water is used to improve the white colour appearance by soaking the grains overnight. The taste is unlike the colour, depends on the grain from which it is prepared and the method of flour preparation. Knowledge of traits preferred by consumers is valuable for crop improvement programs and provides valuable signals for food processors Ndjeunga and Nelson, (2003). However, Ndjeunga and Nelson, (2005) [17] reported that understanding preference for consumption characteristics of millet varieties in western Niger Republic reported that consumers' ratings of all traits of millet Tuwo (stiff porridge) did not differ by gender, level of education, age, household size or daily consumption frequency of Tuwo (stiff porridge), but all the traits except colour significantly differed by ethnic groups between the Zarma and the Hausa ethnic groups of Niger republic, Bolade and Adeyemi (2013) [10] reported that most commercial processors of Tuwo (stiff porridge) do not include maize Tuwo (stiff porridge) in their menu, because, according to them, maize Tuwo (stiff porridge) is attracting the lowest consumer patronage; the quality of the food product not being liked by the consumers; and consumers' preferences for other gel-like food products like 'fufu, semovita, pounded yam, and rice Tuwo (stiff porridge) and 'amala' being higher than that of maize Tuwo (stiff porridge). With this Tuwo (stiff porridge) was produced from four local wheat varieties (Atilla gan atilla, Norman, Reyna 15 and Kauz) and valuated for proximate, functional, viscosity, minrals, pH and acceptability test.

Materials and Methods
1. Sample collection
Four local wheat samples were used Atilla gan atilla, Norman, Kauz, Reyna15, and Golden penny which were used as the control. The wheat samples were purchased from Lake Chad Research Institute Maiduguri, Borno State Nigeria. While the control was purchased from Kano main market. The samples were placed in air tight sterile polythene bags and then transported to the Aliko Dangote University of Science and Technology, Wudil for analysis.

2. Sample preparation
Wheat grains varieties were initially cleaned and sorted manually by removing the grain impurities, contaminants,

discolored grains and other extraneous materials. The grains were washed thoroughly with water and allowed to dry under the sun on a clean platform. The cleaned dried grains were then milled into fine flour using an attrition mill. The flour was sieved to remove any coarse particles while the fine flour was labeled, placed in a polythene bags and stored in a dry place at room temperature. The flour produced was according to method described by Barde *et al*., (2022) [7]. The flow chart for the production of whole wheat meal flour for Tuwo (stiff porridge) was shown in fig.2 below.



Source: Barde *et al*., (2022) [7]

Fig 1: Flowchart of whole wheat flour production

3. Whole wheat Tuwo (stiff porridge) production

The local production of wheat Tuwo (stiff porridge) was carried out by the methods described by Nkama, *et al*., 1990 [18]. This involves using freshly milled whole flour and coarse flour for the product. Then the flour proportion and water were reconstituted and mixed thoroughly making slurry. Slurry of 200g of the wheat meal flour was added to 250mls of already boiling water while stirring with wooden spoon to prevent lumps formation and aid in homogenous mixing of the slurry with the boiling water. This was allowed to cook for 40 minutes. With continuous stirring while adding the remaining proportion of the flour until thick paste was formed. A small quantity 50ml of warm water was added covered and allowed to cook further under low temprature. This is then mixed by turning with the wooden spoon to have a homogenous smooth Tuwo (stiff porridge). The Tuwo (stiff porridge) was then served with soup of choice. The local production of wheat Tuwo (stiff porridge) was shown in fig. 2 below:

Table 1: Tuwo (stiff porridge) produced from Nigerian grown wheat varieties.

S/N	Samples	Whole wheat meal (g)
1	Atilla gan atilla	500
2	Norman	500
3	Reyna 15	500
4	Kauz	500
Control	Golden penny whole wheat meal	500

4. Proximate compositions of the four local wheat samples

Proximate compositions of the four local wheat samples were determined (dry basis). Each sample of Tuwo (stiff porridge) was determined for moisture, protein, fat, ash and crude fiber using standard methods of AOAC (2000) [5]. Total carbohydrate content was by difference.

5. Determination of functional properties of four local wheat samples

The functional properties (Bulk density, Water absorption capacity, Swelling, Solubility, despersibility) of samples were determined based on standard methods of the Association of Official Analytical Chemist AOAC (2000) [5].

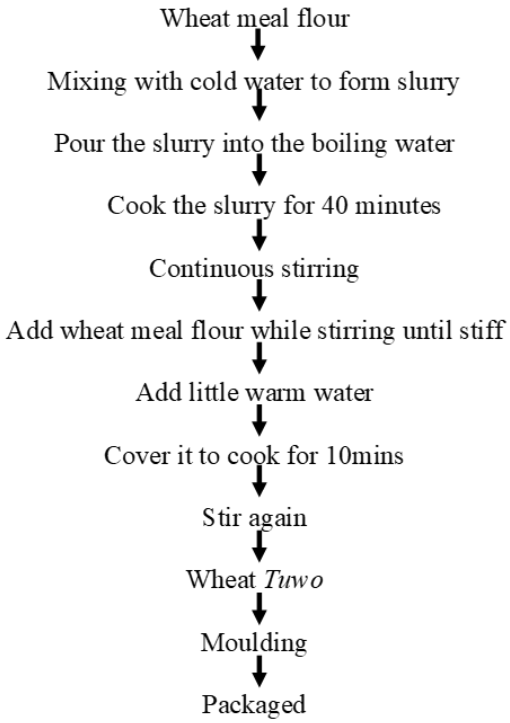
6. Determination of Viscosity

Viscosity was measured using Brookfield viscometer at room temperature with a spindle number 3 at a speed of 30 rpm. Tuwo (stiff porridge) was prepared by mixing 50g of modified flour with distilled water to make a volume up to 500mL. Raina *et al*., (2006) [21]

7. Determination of pH

Ten grams of the Tuwo (stiff porridge) samples was weighed and dissolved in a beaker containing 25ml distilled water to form slurry. It was allowed to stand for 10 minutes with constant stirring. The pH was then directly determined with the aid of pH meter (Model PHS-25CW Microprocessor pH/mv meter) Makanjuola and Coker, (2019)

8. Determination of mineral contents of the samples.
The minerals content of each sample was carried out to determine the concentration by the used of atomic absorption spectrophotometer (Perkin Elmer Analyst 400SP.). The phosphorus content was determined with the use of flame photometry according to AOAC, (2004).



Source: (local production process)

Fig 2: Flow chart of wheat Tuwo production

9. Sensory evaluation of Tuwo (stiff porridge) samples
The sensory evaluation was conducted by a panel of fifteen (untrained) judges drawn from staff and students of Aliko Dangote University of Science and Technology, Wudil. The samples of Tuwo (stiff porridge) were rated for aroma, appearance, taste, texture and overall acceptability which were based on nine point hedonic scale where 9 representing like extremely and 1 representing dislike extremely as described by Ihekoronye and Ngoddy (1985) [12]. The panelists were served in white and transparent glass cups and were asked to rinse their mouth with water before next serving. The sample were coded and kept far apart to avoid overcrowding and for independent judgment.

Proximate composition of Tuwo (stiff porridge) produced from four local wheat varieties.
Table 2 shows the proximate composition of Tuwo (stiff porridge) produced from different varieties of wheat. Moisture content ranged from 13.05 to 11.10 %, protein ranged from 11.12 to 9.22 %, fats from 2.55 to 1.73 %, ash 1.54 to 0.72 %, crude fibre 1.96 to 1.32 %, carbohydrate 74.77 to 71.32 % and 355.75 to 344.09 %. The control sample had the highest moisture content of 13.05 %. This also showed that there was a variation in the ranged of moisture when compared with the control sample. The lower moisture content value of the Tuwo (stiff porridge) from wheat indicates that it would have good keeping quality under consideration. Scientific investigation has reported that low moisture content in food samples increased the storage periods of the food products Alozie *et al*., (2009) [8] while high moisture content in foods encouraged microbial growth; hence, food spoilage. Protein content was found higher in Tuwo (stiff porridge) produced from atilla gan atilla with 11.12 %, followed by norman with 10.26 %, reyna 9.22 % and kauz 9.42 % when compared with the control 10.20 %. Significant difference ($p \geq 0.05$) exits in the range of protein content. Norman and control are significant ($p \geq 0.05$). McKevith (2004) reported that wheat protein is relatively low amounts and therefore, essential amino acids must be supplied from another source of the diet. Fats contents of the four wheat varieties atilla gan atilla 2.15%, Norman 2.55 %, Reyna 1.96 %, kauz 2.11 and the control 1.73 %. This shows variations in the range of fats contents, which was significant ($p \geq 0.05$). There was a significant difference ($p \geq 0.05$) in ash content. Tuwo (stiff porridge) from these four samples of wheat atilla gan atilla, Norman, reyna 15, kauz implies that the wheat varieties are good sources of minerals when compared with the control sample. This is lined with the report by Akinyemi *et al.,* (2020) [3] who reported 1.7% ash content. The low ash values indicate the level to which non-endosperm components and contaminants are present, Evers, (2021). The range of crude fibre was attributed higher in atilla gan atilla 1.96 % when compared with the control 1.78 % which was significant ($p \geq 0.05$). According to Schneeman (2002) [22], crude fibre contributes to the health of the gastrointestinal system and metabolic system in man. kauz recorded the highest carbohydrate content 74.77 % and energy value of 355.75kcal of which there was a significant difference ($p \geq 0.05$) in the range of carbohydrate and energy value. The results were in line to the findings of Pandey *et al*., (2017) [20] who reported carbohydrate contents of 73.7 %.

Functional properties of Tuwo (stiff porridge) produced from four local wheat varieties

Table 3 shows the functional properties of Tuwo (stiff porridge). Bulk density ranged from 0.85 to 0.74 g/cm^3, water absorption capacity from 6.34 to 517 %, swelling capacity from 6.27 to 4.99 %, solubility ranged from 3.94 to 3.74 % and dispersibility from 52.86 to 47.13 %. There was a significant difference (p≥0.05) in bulk density. Atilla gan atilla had the highest bulk density of 0.84 g/cm^3 when compared with the control sample 0.85 %. Variations in bulk density may be due to the nature of the wheat or the wheat variety. Bulk density is very important in determining the packaging requirement, material handling and application in wet processing in the food industry Yellavila *et al.*, (2015) [25]. Water absorption capacity showed that reyna 15 had the highest water absorption of 6.34 % which was significant (p≥0.05). These values are close to the range reported by Adegunwa, (2014). High water absorption capacity is attributed to loose structure of starch polymers while low values indicate the compactness of the structure (Adebowale *et al*., 2015) [1]. Swelling capacity decreased with the wheat variety from 6.27 to 4.99 % when compared with the control sample, while solubility also increased with the wheat variety from 3.94 to 3.74 %. This was also attributed the nature of the soil of which the wheat variety was planted and the variety of the wheat. Swelling capacity and solubility are significant (p≥0.05) in the ranged of values. The dispersibility indicates its reconstitution when mix in water. The higher the dispersibility the better and more preferred. Variations in dispersibility rate of the four different types of wheat (Atilla gan atilla, Norman, Reyna 15, kauz) when compared with the control. That was significant (p≥0.05).

Viscosity and Ph of Tuwo (stiff porridge) produced from four local wheat varieties

Table 4 shows the range of viscosity and potential hydrogen (Ph) value. Viscosity ranged from 576.20 to 514.30 m^2/s and Ph ranged from 5.80 to 5.30. Higher viscosity was recorded with the control sample 576.20. The ranged recorded for both the viscosity and the Ph values were significant (p≥0.05). The viscous foods have desirable characteristics in foods known to facilitate chewing and swallowing (Waterlow and Payne, 2000). In addition, foods must have an easy to swallow, since liquid consistency 1000 to 3000 Centipoise. PH value is an indication of the history of flour storage (Belitz *et al.,* 2009) [8] Low acidity value often reflects poorly aged flour while higher acidity with a value above 7.0, suggests microbial spoilage. Low Ph observed in the Tuwo (stiff porridge) may indicate that these samples may have a longer shelf life.

Mineral content of Tuwo (stiff porridge) produced from four local wheat varieties

Table 5 shows that sodium ranged from 64.32 to 46.64 mg/100g, potassium ranged from 937.0 to 672.0 mg/100g, calcium from 90.21 to 40.33 mg/100g, magnesium from 11.23 to 8.47 mg/100g and zinc from 49.70 to 10.63 mg/100g. Sodium showed a significantly different at p≥0.05 when compared with the control sample. The ranged of potassium, calcium, magnesium and zinc were significant p≥0.05. variations were observed in all the mineral contents of the" Tuwo" analyzed. It could be seen that the control sample had the highest values for all the mineral content determined in this study. This could be attributed to the industrial fortification of the control sample with micro nutrients which consequently increased the mineral content of the control wheat meal flour sample. Minerals (dietary minerals) are among the constituents of a food product or a diet that are vitals, required in a specified amount for physiological and biochemical processes of the body by various reactions. Some of the major and significant of this elements includes; Sodium (Na), Calcium (Ca), Potassium (K), Magnesium (Mg) and Zinc (zn) etc. which are required for daily intake, they play roles in the transportation across biological membrane, as enzyme cofactors, in the bone formation and strength, relaxation and contraction of muscles, maintenance of acid base balance, blood formation, energy transduction etc. Minerals as an inorganic nutrient are required in some small quantities from less than 1 to 2500 mg per day, depending on the mineral (Soetan *et al.,* 2010) [23]. Tuwo from these four different types of wheat varieties possessed all this minerals in different proportions.

Acceptability of Tuwo (stiff porridge) produced from four local wheat varieties

Table 6 shows the acceptability of Tuwo (stiff porridge) from different four local wheat varieties. Aroma ranged from 8.01 to 7.18, appearance from 8.61 to 8.27, taste ranged from8.78 to 8.13, texture from 8.84 to 7.33 and the overall acceptability ranged from 8.79 and 7.87. Similarities in the range of aroma within the different wheat varieties (atilla gan atilla, norman, reyna 15, kauz) as compared with the control sample. "Tuwo " from different wheat varieties showed different appearances when compared with the control, Appearance is an important attribute in food choice and acceptance Muhimbula *et al*., (2011) [16]. Variations in taste and texture are significant p≥0.05. This shows that atilla gan atilla and kauz were observed to have the same taste and texture when compared with the control. Texture is the prevailing textural characteristics of the food product at the point of consumption that usually determine whether such food is swallowable or chewable (Omeire *et al*., 2011) [16]. The texture also indicates the cohesiveness of the Tuwo (stiff porridge) mold during cooking and eating which is related to maximum cooking and desired quality. The overall acceptability showed that atilla gan atilla and reyna 15 were highly accepted, followed by kauz and norman when compared with the control.

Conclusion

Roughly 90 to 95 percent of the wheat produced in the world is common wheat (*Triticum aestivum*), which is better known as hard wheat or soft wheat, depending on the variety. Wheat is utilized mainly as flour (whole grain or refined) for the production of a large variety of products around the world. Despite the intensification of the production of wheat locally in Nigeria, wheat still remains an imported commodity, consuming a greater part of Nigeria foreign exchange. It is therefore essential to patronize and consume Nigerian local grown wheat as it is readily available raw material. This may be concluded that the quality of Tuwo (stiff porridge) produced from Nigerian local grown wheat meets the valuable nutritional components required for consumption, that serve as a great food source. The overall acceptability showed that Tuwo (stiff porridge) produced from atilla gan atilla and reyna 15 were highly accepted, followed by kauz and norman when compared with the control.

Recommendation

The following recommendations are drawn from this study

1. Nigeria should intensify the production of wheat locally
2. The storage stability of the Tuwo (stiff porridge) should be conducted

Table 2: Proximate composition of Tuwo (stiff porridge) produced from four local wheat varieties in (%)

S/N	Samples	Moisture	Protein	Fat	Ash	Crude Fibre	Carbohydrate	Energy (kcal)
1	Atilla Gan Atilla	12.02±1.14^{d}	11.12±0.45^{a}	2.15±1.14^{b}	1.54±0.03^{a}	1.96±0.23^{a}	71.21±0.50^{e}	348.67^{d}
2	Norman	12.70±0.15^{b}	10.26±0.03^{b}	2.55±1.18^{a}	0.72±0.00^{e}	1.32±0.34^{e}	72.45±0.41^{c}	353.79^{b}
3	Reyna 15	12.24±0.13^{c}	9.22±0.62^{e}	1.96±1.03^{d}	0.98±0.07^{d}	1.60±0.17^{c}	74.00±0.38^{b}	350.52^{c}
4	Kauz	11.10±1.01^{e}	9.42±0.53^{d}	2.11±1.16^{c}	1.12±0.01^{c}	1.48±0.51^{d}	74.77±0.44^{a}	355.75^{a}
5	Control	13.05±1.10^{a}	10.20±0.47^{c}	1.73±1.13^{e}	1.31±0.05^{b}	1.78±0.01^{b}	71.93±0.46^{d}	344.09^{e}

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p≥0.05. Key; Control = golden penny whole wheat meal

Table 3: Functional properties of Tuwo (stiff porridge) produced from four local wheat varieties

Samples	Bulk Density (g/cm^3)	Water Absorption Capacity (%)	Swelling Capacity (%)	Solubility (%)	Dispersibility (%)
Atilla Gan Atilla	0.84±0.02^{b}	5.17±0.14^{e}	6.27±0.70^{a}	3.74±0.07^{e}	48.00±0.21^{d}
Norman	0.81±0.06^{c}	6.28±0.19^{c}	5.90±0.90^{b}	3.80±0.01^{c}	51.60±0.10^{b}
Reyna15	0.78±0.07^{d}	6.34±0.23^{a}	5.87±0.12^{c}	3.88±0.06^{b}	47.13±0.18^{e}
Kauz	0.75±0.03^{e}	5.46±0.16^{d}	5.14±0.23^{d}	3.94±0.10^{a}	50.98±0.25^{c}
Control	0.85±0.04^{a}	6.32±0.36^{b}	4.99±0.29^{e}	3.75±0.03^{d}	52.86±0.16^{a}

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p≥0.05. Key; Control = golden penny whole wheat meal

Table 4: Viscosity and pH of Tuwo (stiff porridge) produced from four local wheat varieties

S/N	Samples	Viscosity (m^2/s)	Potential Hydrogen (pH)
1	Atilla Gan Atilla	555.50±0.50^{b}	5.80±0.10^{a}
2	Norman	514.30±0.00^{e}	5.60±0.07^{b}
3	Reyna 15	536.70±0.41^{c}	5.30±0.04^{d}
4	Kauz	528.90±0.33^{d}	5.40±0.11^{c}
Control	Control	576.20±0.27^{a}	5.60±0.09^{b}

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p≥0.05. Key; Control = golden penny whole wheat meal

Table 5: Mineral content of Tuwo (stiff porridge) produced from four local wheat varieties

S/N	Samples	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)	Zinc (mg/100g)
1	Atilla Gan Atilla	46.64±0.03^{e}	763.70±0.22^{c}	40.33±0.17^{e}	9.84±0.03^{c}	11.10±0.10^{d}
2	Norman	48.20±0.00^{b}	772.00±0.15^{b}	45.08±0.95^{b}	9.94±0.05^{b}	10.90±0.19^{e}
3	Reyna15	47.63±0.10^{d}	710.00±0.10^{d}	40.53±0.63^{d}	8.47±0.20^{e}	12.70±0.23^{b}
4	Kauz	48.11±0.15^{c}	672.00±0.23^{e}	42.36±0.48^{c}	9.60±0.12^{d}	10.63±0.62^{c}
5	Control	64.32±0.23^{a}	937.00±0.16^{a}	90.21±0.29^{a}	11.23±0.37^{a}	49.70±0.74^{a}

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p≥0.05. Key; Control = golden penny whole wheat meal

Table 6: Acceptability of Tuwo (stiff porridge) produced from four local wheat varieties

S/N	Samples	Aroma	Appearance	Taste	Texture	Overall acceptability
1	Atilla Gan Atilla	7.33±0.63^{c}	8.33±0.66^{d}	8.13±0.06^{d}	8.00±1.07^{c}	8.53±0.54^{b}
2	Norman	7.20±0.91^{d}	8.40±0.08^{b}	8.60±1.04^{b}	7.33±1.24^{e}	7.87±0.09^{e}
3	Reyna15	7.18±1.04^{e}	8.27±0.19^{e}	8.37±0.27^{c}	8.01±1.15^{b}	8.53±0.68^{b}
4	Kauz	7.63±0.18^{b}	8.37±1.04^{c}	8.13±1.53^{d}	8.00±1.21^{c}	7.96±0.10^{d}
5	Control	8.01±0.35^{a}	8.61±0.11^{a}	8.78±1.26^{a}	8.84±1.26^{a}	8.79±0.32^{a}

Values are mean of three replicates ± Standard Deviation, number in the same column followed by the same letter are not significantly different at p≥0.05. Key; Control = golden penny whole wheat meal

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