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Determination of Proximate Compositions, Functional Properties and Pasting Properties of Selected Cereals Grains from Mali

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Abstract In this work, we determine proximate composition, functional properties and pasting properties of six samples of cereals grain (millet, wheat, rice, corn, sorghum and cowpea). The raw materials were sampling at three sites in MALI (Region of Ségou, Sikasso and center market of Bamako) and were cultivated in the same year. The proximate composition were chemically analyzed using the standard method [1]. As for the functional properties of flours, we focused on pH, Bulk Density of Tapped (g/mL), Water Absorption Capacity (WAC, %), Oil Absorption Capacity (OAC, g/g), Swelling Powder (SP, g/g) and Least Gelation Concentration (LGC, w/v). The Pasting properties of different flours were determined by using the methods advocated in [2] and [3]. The results of proximate composition of the flours revealed that the following parameters ranged from their smallest value to highest value given by: content of fiber (15.06 to 33.67%), protein (12.47 to 48.52%) and carbohydrate (20.06 to 56.56%). The means of moisture content values ranged from (5.71 to 11.33%) which are lower than the level stability (15%) for cereal grain. The ash content of the rice (RSk17 and RSg) and cowpea (CaB18 and CaSk17) were significantly higher than ($P< 0.05$) whereas the other samples satisfy this bond. This is certainly due to the fact that these samples were not decorticated. The values of crude fat of Sikasso are significantly difference from that of the others regions. The protein values found for each variety is almost the same for all the three regions. Majority of samples have high carbohydrate content, which shows that our samples are rich in sugar and have a good energy value. The highest pH value is observed in the rice sample (RB 18). The pH of the samples are less than or equal to 7 indicating that the cereals grains are slightly acidic. The functional properties of flours variated as follows: bulk density of tapped ranged from (0.56 to 0.77g/mL), Water Absorption Capacity ranged from (81.68 to 159.13%), Oil Absorption Capacity ranged from (1.86 to 2.29g/g), Swelling Powder ranged from (11.90 to 16.95g/g) and Least Gelation Concentration ranged from (9.41 to 25.03g/100 mL). These values will be used as data in different processing processes of cereals. Besides, the pasting properties exhibited that, all the flours have highest maximum viscosity ranging from (541.33 to 2976.33), long time of hot temperature during processing and lowest rate of breakdown viscosity ranged from (24.33 to 474). More importantly, we observed a re-association between the starch molecules during cooling in setback viscosity except only the starch molecules of the CnB17 (1229.67) sample which was not retrograded. Finally, the peak time ranged from (4.78 to 5.71 minutes), signaling that this value will be used as data during cooking.

Keywords: *proximate, functional properties, pasting properties, cereals, grain*

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1. Introduction

Knowing proximate composition, functional properties and pasting properties of cereals is of extremely important in food science. These physical, chemical and technological parameters have been determined by several techniques in the recent years [1,2,3,4]. For instance, in order to figure out the relative amounts of protein, lipid, water, ash and carbohydrate in any sample, one simply has to do proximate analysis which means the content (%) in the sample of the components of moisture, crude protein, crude fat, crude fibre, crude ash and nitrogen-free extracts. It is true that protein, lipid and carbohydrate individually contributed to the total energy content of an organism, while water and ash only add value to the total mass. Consequently, finding the values of these quantities is of capital interest in the food industry and are not only crucial for product development [5,6] but also useful for quality control (QC) in food industries [7]. All in all, the determination of proximate composition, functional properties and pasting properties of cereals can considerably boost forward the food industry and hence the economy of a country. This may indirectly or directly reduces the employment of workforce in the field of agriculture.

Economy of Mali is based on agriculture, forest, catch and breeding, Mali have got more than 12 millions (Ha) of cultived land. For instance, agriculture occuppied an important place in economy of Mali, and 80% of population are cultivators and work hard in this sector. Although the type of fertilize land varies from region to region, the seeds used in various region are identical, Mostly, the cereal grains cultivated are rice, corn, millet, fonio sorghum, cowpea and wheat.

These Cereal grains are daily used as the essential dietary components providing substantial amount of nutrients including vitamins, dietary fiber, minerals, energy, protein and complex carbohydrates for human and animal consumption. These foods are rich in sugars and have a good energy value and also food fiber, vitamin B, minerals (iron and magnesium). In Africa, rice, corn, cowpea and wheat are the most cultivated and the most consumed cereal grains. Foods containing cereal flours have been very important to human nutritional needs since ancient time. In developing countries, most cereal flours are enriched with Vitamin B1, Vitamin B2, niacin and iron, Vitamin D and calcium are also added to flours for use in areas where flour is a primary nutritional [8]. In addition, the heathy benefits of these grains' nutritional compositions are very paramount for human consumption [9]. Due to the welfare of these, cereals, they are mainly used not only in the developing and but also in the underdeveloped countries. That is probably one of the reasons why in Mali, the majority of food are served with cereals, such as rice, corn, millet, sorghum, peanut, cowpea, sesame, fonio and wheat which are also the most commonly grown cereals nationwide, In order to conduct this work, we adopt severa methods and the different results and discussion are the topic of the results and discusions part below.

The remaining parts of this manusript are divided as follows: In the next section, we begin with materials and the methodology we are going to apply, Section 3 is devoted to results and discussions. The last section is about the conclusions one can draw from this work.

2. Materials and Methods

2.1. Materials

The experiments were conducted in the Mycotoxin and Food Analysis Laboratories and the Central Lab to the College of Science, Kwame Nkrumah University of Science and Technology (KNUST). Samplings were carried out on three sites of the national territory (the Ségou region, Sikasso and the biggest market of Bamako). Samples of plant material composed of grains of millet, sorghum, cowpea, maize, wheat and rice were taken. Samples of Segou were supplied by different farmers in different locaty in this region. Samples from Sikasso were taken from the Dalabani experimental station. These samples were the first generations of the seeds grown at this station. Finally, samples from Bamako were purchased at the biggest market of Bamako.

2.2. Methods

2.2.1. Preparation of Flour Samples

The grains of cereals were first cleaned manually, bladed and the flour were sifted with a sieve which has 200 micros. The samples of flour have been tripled for each experiments.

2.2.2. Proximate Composition

Proximate composition of samples flour were analyzed using the standard method [1] adopted by Lab method MOA/FST/FSL/1.19/KNUST. The carbohydrate was calculated by difference of moisture content, crude fat, ash content, crude fiber and crude protein:

$$\%\ \textbf{Carbohydrate} = \textbf{100} - \begin{pmatrix} \%\ \textbf{Moisture content} + \%\ \textbf{crude Fat} \\ +\ \%\ \textbf{Ash content} \\ +\ \%\ \textbf{Crude fiber} + \%\ \textbf{Crude protein} \end{pmatrix}.$$

2.2.3. Functional Properties

The functional properties of flours which were analyzed are, pH, bulk density of tapped (g/mL), Water absorption capacity (WAC, %), oil absorption capacity (OAC, g/g), swelling powder (SP, g/g) and least gelation concentration (LGC, w/v).

pH: It was determined by using a portable digital pH meter (OAKTO pH6 +), 2.5g of flour in 25mL of distilled water (10%) were mixed.

Bulk Density of Tapped: In order to determine this parameter, we rely on the technique advocated in [10], 10g of samples was filled into graduated cylinder and their weigh were noted. The cylinder was tapped continuossly until there was no further change in volume, Bulk density was determined as grams per milliliter (g/mL) of samples.

Water Absorption Capacity: As far as this parameter is concerned we closely follow [11]. One gramme of sample was weighed and mixed with 10mL distilled water and allow to stand at ambient temperature (30±2°C) for 30 minutes, the suspension was centrifuged for 30 minutes at 3500 rpm. Water absorption was examined as percent water bound per gram flour.

Oil Absorption Capacity: The method adopted for its determination is presented in [11] which is very well describe by the authors of [12]. One gram of sample were mixed with 5mL vegetable oil and allow to stand at ambient temperature (30±2°C). It shacked and vortex for 1 min, the suspension was centrifuged for 30 min at 3000 rpm, Oil absorption was examined as percent oil bound per gram flour.

Swelling Powder: The value of this parameter is obtained by borrowing ideas from [13]. One gram of sample were mixed with 40mL of distilled water. The suspension were put in a water bath at 85°C for 30 minutes. The samples were centrifuged at 2200 rpm for 15 minutes. Swelling powder was examined as percent water bound per gram flour.

Least Gelation Concentration: To compute this concentration, we closely follow [14]. It is summarized as follows: 5mL of distilled water is added into test tubes containing samples of 2. 4. 6. 8 and up to 20% (w/v). These tubes are then put into boiling water for 1 hour. The last step is to let them for 2 hours into a cooling system of 4°C. Afterwards, the tubes are reversed and the one with which the contain did not fall down or slip is used for the determination of the concentration we are interested in.

2.2.4. Pasting Properties

As far as pasting properties are concerned, the usual procedures we espouse for its determination are the standard one [3] and the methods in [4] which is done by using a Rapid Visco Analyzer RVA 4500 Perten Instrument, Australia. This RVA was used to measure the viscosity, the performance of starches, the characteristic ingredients, the intermediates and final products. These parameters allow one to optimize the quality and the performance of samples in food industry. The determination in this analysis depends on percentages of moisture content of the samples. In the RVA instrument, weight of (3±0.01g) for the samples and the quantity (25±0.01 g) of distilled water were well mixed in the test tube of RVA (a sample canister). The RVA 4500 instrument has a programmed heating and cooling cycle which is satisfied in this investigation. Importantly, in all the RVA tests procedure, the moisture level of 14% was maintained, and the samples were done in triplicate. For each of the test, the RVA curve were represented by the profile of the viscogram, the temperature (°C) and the speed (rpm) which are function of time.

The pasting properties we were seeking are the properties of the viscosity: peak viscosity, trough viscosity, breakdown viscosity, final viscosity, set back viscosity, peak time and pasting temperature.

3. Results and Discussion

In this section, we resume the results of our investigation, and discuss theirs importance. First of all, Table 1 dealts with. Proximate Composition for the flour of the seeds of cereals. One can visualy draw the following conclusions:

3.1. Proximate Composition

The results of proximate reveal that **Moisture contents** varied from (5.71 to 11.33%) with 9.19% as the average. The lowest moisture value was observed with the sample cowpea (CaSg17), and the highest moisture values were observed for the samples wheat (WRB17 and W2B17) and corn (CnSg17) (Table 1).

More importantly, the overall mean value of moisture contents is lowest than 15% which is the level of the stability in food industry according to the codex alimentarius [15]. Therefore, we undoubtedly arrive to the conclusion that the grains of the cereals can be practically stabilized and physiologically stored without a risk of contaminations. This is very important in food industry since it has been, see for instance [16,17], explained that reducing the moisture content is beneficial. This has the effect of reducing the proliferation of spoilage organisms, especially molds, and it also leads to improving the stability during the shelf life of the product.

To hightly our results, we must recall that when the moisture content of flours is more than 14%, mold begin to appear, flavor change, enzyme activity also changes, and insect infestation are likely to occur [18]. Thus the moisture contents of cereals grain will be affected by conditions storeding and the period where cereals grain were sampled. This bad side is that the temperature containing in the grains will be subject to fluctuations.

Ash content varied from (0.44 to 6.28%) and 1.9% is the average. The lowest value was observed in the rice sample (RB18) and the highest ash value is detected in the rice sample (RSg17). The result of ash content values explain that our samples are poor as far as inorganic matter are concerced but they are riche inorganic matter. There was no significant difference between the ash contents except for the samples of rice (RSk17 and RSg) and of cowpea (CaB18 and CaSk17). For these samples, the ash contents were significantly different to the other samples. This difference is mainly due to the fact that these samples were not decorticated. We stress that our ash content are comparable to the results found by [19]. One possible conclusion is that the contamination of grains by bacteria may occur due to the fact that the Ash content value are little high.

As for **Crude Fat,** we witnessed that they varied from (1. 01 to 7.01%) along with 4.04% as average. The lowest value is below to its reported value by [8] and the high values is observed in the corn (CnSk 17) sample which is also higher than to its value 5.40% found by [20]. It is however, comparative to the result in [19]. One noticeable observation is that the values of crude fat significantly increase from variety to variety. However, the crude fat contents of the same variety are in the same order of magnitude. It is surely possible that the difference of crude fat of assorted samples could be due to the genetical or environmental factors of samples according to the aothors in [21] but also the fat participed to the germination of grain according [22].

The percentage of **protein** varied from (12.47 to 48.52%) along with 30.49% as average. Besides, the Rice sample (RSg17) has the lowest percentage of protein compare to that of the corn, millet, wheat, sorghum, and cowpea. The cowpea sample (CaSg) has the highest percentage of protein. The values of protein we obtained are relatively close from variety to variety. This result confirms that cereals do not have the same protein composition within the same diversified family. It is known that once the protein content of a seed is higher, on can use it to content supplement grain based foods of lower protein contein [23].

In Table 1, it is also visible that the percent of **crude fiber** varied from 15.06 to 33.67 percent where the average is 24.36. We should stress that the lowest value is observed with the millet sample (MSg17) and the opposite value of it is observed with the rice sample (RSk17). The results of Crude fiber reveal a significant difference from it to the other samples. The highest value in rice samples (RSk17, RSg) is due to the presence of bran in cereal grain. Generally, it is true that consumption of crude fiber in food may increase stool volume.

Table 1. Proximate Composition of flour Cereal

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrate (%)
MB17	9.87±0.29	1.57±0.02	5.87±0.58	18.88±0.19	15.41±0.13	48.40±2.52
MSg17	8.4±0.10	1.7±0.03	1.50±0.17	23.23±0.12	15.06±0.03	50.11±3.88
MSk17	9.64±0.20	1.45±0.03	5.62±0.98	19.62±0.17	16.22±0.02	47.45±1.89
W1B17	8.94±0.17	1.75±0.09	3.25±0.58	24.06±0.21	19.21±0.02	42.79±0.11
WRB17	11.33±0.21	1.31±0.02	3.74±0.55	21.47±0.50	21.62±0.05	40.53±0.03
W2B17	10.33±0.17	1.61±0.02	2.89±0.32	23.05±0.29	18.66±0.02	43.46±0.23
RB17	9.68±0.40	0.45±0.02	1.80±0.45	14.96±0.10	16.55±0.02	56.56±11.64
RB18	10.18±0.06	0.44±0.02	2.72±0.35	13.00±0.06	23.82±0.10	49.84±3.65
RSg17	8.76±0.28	6.28±0.11	4.41±0.13	12.47±0.07	27.32±0.04	40.76±0.01
RSk17	9.28±0.27	2.31±0.11	4.83±0.30	17.07±0.24	33.67±0.05	31.98±4.34
CnB17	7.84±0.28	1.26±0.01	5.69±0.59	16.96±0.07	21.09±0.02	47.16±1.72
CnSg17	10.35±0.36	1.37±0.07	6.29±0.73	18.71±0.11	18.24±0.02	45.05±0.70
CnSk17	9.44±0.52	1.2±0.05	7.01±0.71	19.39±0.28	22.28±0.02	40.68±0.02
SB17	8.35±0.30	1.47±0.06	6.56±0.50	22.23±0.07	17.78±0.01	43.61±0.27
SSg17	8.51±0.49	1.32±0.06	1.01±0.95	22.94±0.43	21.66±0.18	44.56±0.53
SSk17	9.77±0.29	1.51±0.03	5.96±0.39	21.23±0.40	18.13±0.02	43.40±0.22
CaB18	9.06±0.36	3.43±0.31	3.11±0.55	42.35±0.14	18.10±0.02	23.95±15.05
CaSg17	5.71±0.23	3.82±0.05	2.81±0.74	48.52±0.13	19.09±0.02	20.06±22.57
CaSk17	8.09±0.52	3.69±0.21	1.77±0.19	44.53±0.34	17.56±0.01	24.36±14.35

Values are means ± standard deviations of triplicate determinations. Samples code: M: millet; W: wheat; R: rice; Cn: corn; S: sorghum; Ca: cowpea; B: Bamako: Sg: Ségou and Sk: Sikasso.

The calculation of **carbohydrate**, show that its value varied from (20.06 to 56.56%) and 38.31% is its global average. Its lowest value is observed with the cowpea sample (CaSg17) and its highest value is observed with the rice sample (RB17). Most of the samples have high carbohydrate content, which indicates that our samples are rich in sugar and they then have a good energy value.

3.2. Functional Properties

In our investigation, we have also computed the **pH** value of the samples. We witnessed that its value is between 6.36 and 6.95. What is more, its average is 6.7. Additionally, from Table 2, one notices that the lowest value of pH is observed with Corn samples (CnSk 17 and CnSg 17). The highess value is observed with rice samples (RB18). It follow rom this analysis that the means value is higher than 95% confidence level, and the pH are less than or equal to 7. So we can conclude that the samples of the grains are slightly acidic.

Another value we have considered in our manuscript is the **water absorption capacity (WAC).** The value varied from (81.68 ± 7.33 to 159.13 ± 9.77%) and its average is 120.41%. The lowest value however is observed in wheat sample (W2B17), whereas, its highest value is observed in sorghum (SSg 17) sample. The determination of WAC is important because it affects bread baking [24]. Water absorption capacity is a characteristic of a product indicating its limitation to absorb water [25]. This parameter is a very critical function of protein in various food products like soups, dough and baked products [26].

Table 2. Functional Properties of flour Cereal

SAMPLES	pH	WAC (%)	OAC (mL/g)	SP (g/g)	BDT (g/mL)	LGC (wt/v)
MB17	6,45±0.01	115.5±1.39	2.21±0.03	14.20±0.68	0.65±0.02	23.45±1.17
MSg17	6.63±0.02	83.18±8.45	2.24±0.07	12.61±0.39	0.62±0.02	25.03±1.25
MSk17	6.74±0.02	109.83±3.90	2.23±0.10	13.68±0.42	0.64±0.02	23.68±1.18
W1B17	6.69±0.03	85.01±0.64	2.18±0.15	15.25±0.78	0.64±0.02	18.05±0.91
WRB17	6.6±0.01	84.10±9.70	2.12±0.17	12.25±0.35	0.72±0.00	18.05±0.90
W2B17	6.65±0.04	81.68±7.33	2.21±0.06	13.17±0.66	0.67±0.00	17.05±0.85
RB17	6.73±0.03	119.52±3.70	2.14±0.12	16±0.78	0.79±0.04	15.02±0.75
RB18	6.95±0.05	112.82±6.14	2.08±0.23	16.95±0.62	0.77±0.00	10.28±0.51
RSg17	6.79±0.02	117.89±7.43	1.94±0.44	14.73±0.29	0.59±0.00	22.04±1.10
RSk17	6.72±0.02	122.10±5.68	2.2±0.13	15.47±0.32	0.64±0.02	19.60±0.98
CnB17	6.75±0.04	122.2±4.59	2.17±0.14	12.7±0.13	0.61±0.02	22.17±1.11
CnSg17	6.36±0.06	126.56±5.44	2.07±0.13	13.84±0.55	0.61±0.02	20.16±1.01
CnSk17	6.36±0.06	123.57±3.05	2.27±0.04	13.21±0.42	0.63 ±0.00	21.16±1.06
SB17	6.77±0.04	147.54±9.94	1.86±0.29	14.53±0.49	0.63±0.00	19.24±0.96
SSg17	6.81±0.01	159.13±9.77	2.22±0.02	13.27±0.43	0.58±0.02	21.04±1.05
SSk17	6.92±0.01	124.18±7.78	2.29±0.13	13.47±0.74	0.61±0.02	20.02±1.00
CaB18	6.94±0.13	127.99±2.69	2.19±0.13	13.12±0.57	0.77±0.00	9.73±0.49
CaSg17	6.77±0.09	149.80±9.83	2.2±0.15	11.9±0.62	0.71±0.00	11.34 ±0.57
CaSk17	6,64±0,02	151,78±9,82	2.24±0.18	13.12±0.31	0.77±0.06	9.41±0.47

Values are means ± standard deviations of triplicate determinations. WAC: Water Absorption Capacity. OAC: Oil Absorption Capacity. SP: Swelling powder. BDT: Bulk Density of Tapped. LGC: Least Gelation Concentration.

We have also worked out the **oil absorption** parameters of our samples. The value of this quantity varied from (1.86 to 2.29mL/g) with an average of 2.07mL/g. The lowest and highest values were observed in the sorghum samples (SB17 and SSk17) sample. Oil absorption capacity data can be used to predict the palatability of a flour based product since oil increases mouthfeel and retains flavor (Aremu et al, 2007) [25,27].

The last but not the least of functional properties is the **swelling powder** value. This value varied from (11.90 to 16.95g/g) with an average of 13.87g/g. The lowest value is observed in the cowpea sample (CaSg17). Often, solubility and swelling power are influenced by the water-holding capacity obtained from flour, which is a function of the proteins and carbohydrates present in the flour [28,29,30].

One fundamental feature worth considering is the **bulk density.** In our investigation it varies from (0.58 to 0.79g/mL) with an average of 0.68g/mL. Its lowest value is observed in the sorghum sample (SSg 17), whereas its highest value is observeb in the rice sample (RB17). The standart deviation of significance for individual regression are close and are significantly different ($p< 0.05$) from all the samples. One should stress that the Bulk density is the function of mass and volume of flour which depends on not only the size of particles and initial moisture content of the flour [31], but also the structural arrangement of carbohydrates and other polymers present in flour [32]. It is worth remembering that high bulk density makes the flour more suitable for packaging, transportation and use in the preparations. However, low bulk density is considered favorable for formulation of complementary foods [31].

What is more, in our work, we have also considered the value of the **least gelation concentration** (LGC). One observes that its values vary from (9.41 to 25.03wt/v) along with 17.22 as average. The lowest value is obtained in the cowpea sample (CaSk17) while the highest value is observed in the millet (MSg17) sample. Bassically, the least gelation concentration is defined as the lowest protein concentration at which gel remained in the inverted tube which was used as index of gelation capacity [33]. For instance, Cowpea samples (CaSk) formed a gel at the lowest concentration of flour (9.41g/100mL), according to [33]. More importantly, it demonstrated that the lower is the LGC the better is gelating ability of the protein ingredient [34] and the swelling ability of the flour [35].

3.3. Pasting Properties

The **peak viscosity,** ranging from (541.33 to 2976.33) with an average of 1758.83, is a useful parameter that one must calculate. It indicates the beginning of gelatinization for the starch. The greatest peak viscosity is observed in the rice sample (RB17) while the lowest is observed in the wheat sample (W2B17). All the cereal seed flours showed a high maximum viscosity which shows that the water molecules is easily penetrated into the starch granules, then interacted with the amylose molecules, finally causing a huge granular swelling. Viscosity is largely influenced by the shape of the starch grains, their swelling power and the interactions between amylopectin and amylose molecules [36,37]. The observed differences in maximum viscosities of the composite flours indicate that there were differences in the rate of water absorption and swelling of the starch granules during heating. This fact is reported for instance by the following authors [38,39].

Trough Viscosity is the minimum viscosity and ability of starch to withstand a long period of hot temperature during processing or heating. In our investigation, it ranges from (541 to 2502.33) with an average of 1521.67. The W1B17 wheat seed flour exhibited a lower viscosity value compared to the rice flour (RB17). All flours withstood a long time of hot temperature during processing. Therefore, we notice the different flours, having high dip viscosity, will have high hot dough stability, and hence could preferably be used in food processing.

Table 3. Pasting properties of flour cereal

Samples	Peak Viscosity (cP)	Trough Viscosity (cP)	Breakdown Viscosity (cP)	Final Viscosity (cP)	Set back Viscosity (cP)	Peak time (min)	Pasting temp (°C)
MB17	1305±13.45	830.67±27.15	474.33±15.37	1426.33±6.31	595.67±1.53	4.78±0.04	79.47±0.42
MSg17	1240±22.72	952±19.08	284±4	1636.67±59.77	684.67±40.72	5.51±0.03	80.50±0.56
MSk17	1681±32.35	1324.33±20.50	356.33±11.85	2119.67±83.55	795.33±63.52	5.27±0.07	79.17±0.06
W1B17	812±7.55	541±6.66	270.67±2.52	954.67±12.50	413.33±7.23	5.87±0.00	78.85±7.92
WRB17	1428±21.17	1073.67±15.14	354.33±14.05	1718.67±21.03	645±9.85	6.40±0.00	90.65±0.58
W2B17	541.33±19.52	820.67±13.65	251.33±12.34	1324.67±32.72	504±27.87	6.04±0.10	71.50±0.48
RB17	2976.33±40.05	2502.33±74.84	474±114.58	3747±148.29	1244.67±75.04	6.71±0.17	85.35±0.44
RB18	2108.33±42.34	1795±27.18	313.33±16.65	2539.3±36.17	744.33±14.57	6.31±0.03	81.57±0.08
RSg17	1452.67±28.59	1304.33±31.37	148.33±14.98	2096.7±118.37	792.33 ± 149.43	6.67±0.35	82.03±0.51
RSk17	1970±19.47	1657.33±71.51	312.67±78.45	2684±116.77	1026.67 ± 45.37	6.09±0.19	82.42±0.03
CnB17	1163±59.23	1068.33±33.72	94.67±35.35	2298±53.67	1229.67±84.16	5.87±0.06	83.50±0.53
CnSg17	1856.67±226.21	1581.00± 186	275.67 ± 55.59	2933.3±169.21	1352.33±32.56	5.01±0.33	80.18±0.45
CnSk17	1079±234.41	994.67± 181.99	84.33 ± 52.69	1996.6±482.50	1001.33±303.12	5.31±0.42	82.40±0.83
SB17	1527±19	1306.00±17.35	221.00 ± 4.58	2147.33±24.7	841.33±11.85	5.51±0.08	83.75±0.48
SSg17	1617.33±2.08	1303.00±1	314.33±2	2091.00±4	788.00±3.61	5.02±0.04	82.35 ±0.09
SSk17	1547.67±20.53	1364.67± 18.58	183.00±12.49	2519.00±34.87	1154.33±17.24	5.60±0.12	82.35±0.05
CaB18	1016±275.96	943.33 ± 219.62	72.67±59.58	1419.67±294.29	476.33±76.63	6.36±0.67	84.07±0.03
CaSg17	1183.67±196.88	952.00±129.04	231.67±67.84	1271.33±292.62	319.33±163.70	5.13±0.35	85.87±1.01
CaSk17	1151±97.86	904.67±43.98	24.33±54.10	1185.67±87.21	281.00±43.49	5.07±0.07	85.35±0.52

Values are means ± standard deviations of triplicate determinations.

What is more, one clearly sees that flour samples showed a low rate of **breakdown viscosity** (24.33 to 474), meaning that the cereal flours resisted on both heating and shear stress.

The Final viscosity in our analysis is in the range (954.67 to 3747). Let us stress that this parameter is the most common parameter used to define the quality of a particular sample, as it indicates the ability of the material to form a viscous paste or gel after baking and cooling.

Another parameter which is important to address is the **setback viscosity.** This parametric quantity altered from 1352.33 (CnSg17) to 281 (Cask17). We observed a re-association between the starch molecules during cooling except only for the starch molecules of the CnB17 sample which was not retrograded. According to [40], low degradation flours are more stable under hot conditions and have high crosslinking in the granules.

In our probe, we also looked at the **pasting temperature** (71.50 to 90.65°C) which provides an indication of minimum temperature required to cooking the samples. It is true this quantity can have implications for the stability of other components in a formula, and also indicate energy costs. The sticking temperature is generally higher than the gelatinization temperature, the starch granules are gelatinized before the viscosity starts to increase or to be detected by RVA. Lower bonding temperature means faster swelling. Peak viscosity (PV) reflects the extent of swelling of the granules. Most of the time we have to cook in function of the pasting temperature in order to get a starch paste [41]. Depending on the nature and number of bonds, the hydration and solubilization temperature are different.

The last but not the least, we calculated the **peak time** which indicates the time required for cooking. Our results show that the peak time varying from 4.78 to 6.71 minutes. This signals that this value will be used as data during cooking.

4. Conclusion

All in all, the remarkable results of investigation point out few things. The seed flours were found to be higher in fiber, protein and carbohydrate. More importantly, one witnesses that cowpea showed a very high protein value in samples than millet wheat and sorghum. Equally important is the fact that Millet and Rice samples showed high carbohydrate values in relation to other cereals. What is more, one noticed that moisture content were less than 15% and the pH are less than or equal to 7. Consequently, we can undoubtedly say that the samples are slightly acidic. From our analysis, it should be remark that the majority of the samples have highest carbohydrate content, indicating that our samples are rich in sugar and had a good energy value.

The results for the Pasting properties of cereals seed flours reveal that there is highest maximum viscosity, long time of hot temperature during processing RVA and finally lowest rate of breakdown viscosity. We report, from our observation, a re-association between the starch molecules during cooling in setback viscosity except only for the starch molecules of the CnB17 (1229.67) sample which was not retrograded. Additionally, the peak time value should be used as data during cooking.

Finally, to summarize, by using the linear regression model (with R software of excel), one can conclude that although a strong correlation may exist between moisture and peak viscosity, but it is not linear in nature since it p-value is 0.5046 which is higher than 0.05. It is in principle possible to determine the type of nonlinear relationship between the two variables. Finally our results demonstrate that when the pH of the samples are lower, then the quantity of mineral and the viscosity are higher. Consequently, we observe an onset of germination.

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