Scientific Research Publishing

American Journal of Plant Sciences, 2022, 13, 929-942
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Physical and Cooking Characteristics of Six Cowpea Varieties Seeds Cultivated in Burkina Faso

Karidiatou Traore[1], Pingawindé Sawadogo[2], Téyouré Benoit Joseph Batiéno[1], Nerbéwendé Sawadogo[3*], Hamadou Zongo[1], Saadon Leandre Poda[1], Jean Baptiste De Salle Tignegré[1], Tinga Jeremy Ouédraogo[1], Mahamadou Sawadogo[3]

[1]Institut de l'Environnement et de Recherches Agricoles (INERA), CNRST, Ouagadougou, Burkina Faso
[2]Centre Universitaire de Tenkodogo, Université Thomas SANKARA, Tenkodogo, Burkina Faso
[3]Équipe Génétique et Amélioration des Plantes/Laboratoire Biosciences, Ecole Doctorale Sciences et Technologies, Université Joseph KI-ZERBO, Ouagadougou, Burkina Faso
Email: *kadi.gnank@yahoo.fr, *nerbewende.sawadogo@ujkz.bf

How to cite this paper: Traore, K., Sawadogo, P., Batiéno, T.B.J., Sawadogo, N., Zongo, H., Poda, S.L., Tignegré, D.S.J.B., Ouédraogo, T.J. and Sawadogo, M. (2022) Physical and Cooking Characteristics of Six Cowpea Varieties Seeds Cultivated in Burkina Faso. *American Journal of Plant Sciences*, **13**, 929-942.
https://doi.org/10.4236/ajps.2022.137061

Received: May 19, 2022
Accepted: July 9, 2022
Published: July 12, 2022

Abstract

Cowpea is essential in the diet in Burkina Faso. The information on their physical properties and cooking quality is important for consumer acceptance. This study has therefore been undertaken in order to fill the gap. Thus, six cowpea varieties were evaluated for their physical and cooking properties. The seeds had between 9% to 12% moisture. For physical proprieties, the result revealed that the variety Makoyin had the highest seed length (9.65 mm), the variety Gourgou recorded the highest seed width (7.08 mm), seed thickness (5.13 mm), and seed area (153.29 mm^2), and 100-seeds weight (21.1 g). The lowest seed sizes were presented by the variety Teeksongo with values of 7.88 mm, 6.34 mm, 4.88 mm, 122.68 mm^2, and 16.87 g for respectively the length, the width, the thickness, the area, and the 100-seeds weight. The variety Makoyin produces seed elliptical form and varieties Neerwaya, Gourgou, Yipoussi and Issa-sosso, and Teek-songo the seeds spherical form. For cooking proprieties, the highest value of the bulk density of the seeds was presented in the variety Teek-song (1.51 g/ml). The highest hydration and swelling capacity were observed in varieties Gourgou (0.22 g/seed and 0.24 ml/seed respectively) and Yipoussi (0.22 g/seed and 0.21 ml/seed respectively). The seed with large size, greater hydration, and swelling capacity is preferred by consumers and processors for food products. Varieties Makoyin, Neerwaya, Gourgou, Yipoussi, and Issa-sosso presented cooking time of unsoaked seeds equal to one hour (from 60 to 68 min) excepted Teek-songo which had 46 min. These cooking times are acceptable for consumers. Seed length, surface area, thickness, the weight of seeds, hydration capacity, and cooking time have been the most discriminating among the cowpea varieties studied.

Keywords

Cowpea Varieties, Physical Properties, Cooking Properties, Burkina Faso

1. Introduction

Cowpea is an important legume crop in Burkina Faso occupying over 1,200,000 hectares with a mean production of 480.6 kg/ha during the five-last year before 2020 [1]. Cowpea seeds a is an important source of protein with the average protein content reaching 25.4% [2] and soluble sugar contents with an average of 54.5 mg/g [3]. In spite of the high nutritional value, the grain legume is under-utilized as food due to their long cooking time. Cowpea cooking time can reach 135 mins [4]. It is one of the foremost limitations that make legumes uneconomical and unacceptable to consumers [5]. The long cooking time leads to loss of nutrients, loss of useful time, require more firewood or energy, and increased greenhouse gas emissions. The long cooking time is costlier for processors and consumers. In order to encourage cowpea utilization, the short cooking time must be coupled with the physical preference of consumers and seeds' yield. A quick-cooking variety may achieve premiums in the marketplace. Nutritional value is also improved by losses reduction of nutrients as well as the destruction of vitamins [6], the reduced effect on the contents of protein, potassium, calcium, iron, and zinc in cowpea grains [7]. It encourages less use of firewood and gas. So, it increases the consumption of cowpea, triggers an increase in demand for cowpea, and thus drives cowpea production by smallholder farmers in Sub-Saharan Africa.

In addition to cooking time, the assessment of seeds' physical proprieties is also critical to the determination of cooking quality. Earlier studies showed considerable genetic variation for cooking time and others seeds proprieties. [8] reported ten quantitative trait loci (QTL) for the cooking time in dry bean (*Phaseolus vulgaris* L.) and the QTL TZ-37 always contributed to the faster cooking time and increased protein concentration. [9] revealed QTL (CT8.2 and CT10.2) for water uptake and cooking time in bean varieties. [10] reported that the short cooking time was dominant over long cooking time and the genes that controlled cooking time were all nuclear and no cytoplasmic genes. Short cooking time is also observed to be dominant over long cooking time in cowpea, governed by two dominant alleles interacting at 12 different loci [10]. All the results indicate that population improvement is possible through recurrent selection in cowpea. Few studies have been conducted on seed physical and cooking properties of improved cowpea in Burkina Faso. So, there is a need to evaluate varieties for their physical and cooking properties and the relationship among these properties.

The present study was conducted to evaluate the physical, and cooking properties of improved cowpea varieties with the view to select characteristics that help to promote improved cowpea varieties for commercial production and industrial use.

2. Materials and Methods

2.1. Plant Materials

Certified cleaned seeds of six white seeded cowpea varieties from "Kamboinsé" research center/INERA/Burkina Faso were used in the study (**Table 1**, **Figure 1**). All of the six genotypes were brown eyes. Cultivars were grown and harvested at one location during the rainy season of 2019. The moisture contents of the dry cowpea samples were equilibrated to each other by storing them. The seeds of each variety's moisture contents were measured using a GMK-303RS moisture meter calibrated. The grains were crushed inside the grain moisture meter and readings were recorded. The process was repeated three times for each variety, and the averages of percentage moisture content were recorded.

Before cooking, seeds' physical characteristics were measured. Each of the cowpea varieties was handled separately. The distiller water was used in this study.

Table 1. Cowpea varieties used and their seeds characteristics.

Cowpea varieties	Coat color	Eyes color	Coat texture	moisture content	T˚C
Gourgou	White	Brown	Rough	11.7	27.9
Issa-Sosso	White	Brown	Rough	9.4	28.4
Teek-Songo	White	Brown	Rough	9.4	28.6
Yipoussi	White	Brown	Rough	9.4	27.5
Neerwaya	White	Brown	Rough	9.7	28.8
Makoyin	White	Brown	Rough	8.9	27.7

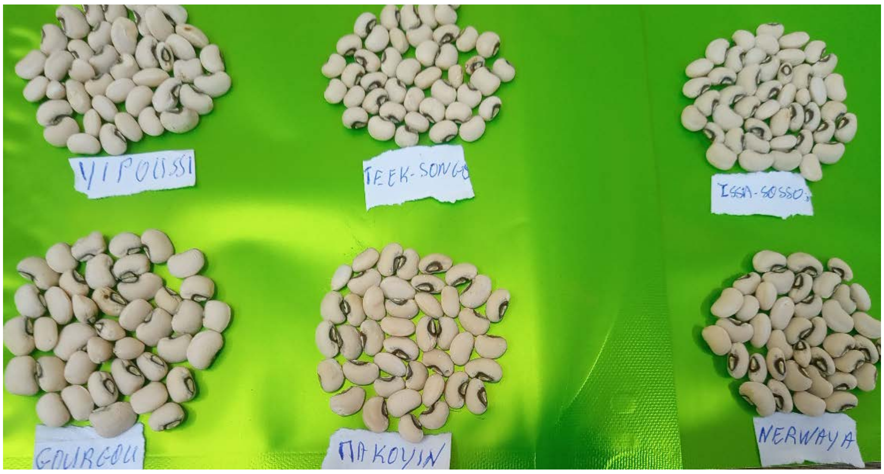

Figure 1. Seeds of cowpea varieties studied.

2.2. Physical Proprieties of Seeds

100-*Seeds Weight* (*PCG*)

100-seeds weight was determined by counting one hundred seeds manually and weighing. Seed mass values were determined using an electronic balance reading to 0.001 g. The average of three determinations is reported.

Seed Dimensions

Randomly selected seeds were used to measure the size of the crop varieties in terms of length (mm), width (mm), and thickness (mm), using a Vernier caliper reading of 0.01 mm). An average of ten determinations is reported for each of three repetitions. These size means were used to calculate the surface area (mm^2), and the sphericity (Φ) of the individual seeds [11].

$$\text{Surface area}\left(S\right)=\pi Dg^2$$

Dg is the geometric mean diameter, $Dg=\sqrt[3]{LWT}$

$$\text{Sphericity}\left(\Phi\right)=\frac{\sqrt[3]{LWT}}{L}$$

❖ Length/Width Ratio

The measure means of length (L), width (W), and thickness (T) were used to calculate the rate of the length/width calling shape index (Ew) [12].

$$\text{Length/width}\left(\text{Ew}\right)=\frac{L}{W}$$

The shape of the seed was determined according to the description of [13]:

– Round (L/W between 1.20 to 1.50).
– Elliptic (L/W between 1.51 to 1.70).
– Egg-shaped (L/W between 1.71 to 1.85).
– Long (L/W between 1.86 to 2.31).

2.3. Cooking Proprieties of Seeds

Bulk Density

The Bulk density is the weight per unit volume of an individual seed. The bulk density of seeds was determined using the liquid displacement method [14]. Seeds (50 g) of the sample were transferred to a measuring cylinder, where 80 ml of distilled water is added. Seed volume (ml) was obtained after subtracting 80 ml from the total volume (ml).

$$\text{Bulk density}\left(\text{g/ml}\right)=\frac{\text{mass of bulk seeds}}{\text{Volum of bulk seeds}}$$

Hydration Capacity and Hydration Index

The hydration capacity was expressed as hydration absorption per seed. Cowpea seeds (10 g) were placed in a measuring cylinder containing 80 ml of distilled water and covered with an aluminum foil and, allowed to stand over for 24 h at room temperature. After drained cowpea seeds, surface water was removed with filter paper. Swollen seeds reweighed [15].

$$\text{Hydratation capacity}\left(\text{g/seed}\right)=\frac{\text{Weight after soaking}-\text{Weight before soaking}}{\text{Number of seed}}$$

$$\text{Hydration index}=\frac{\text{Hydration capacity of seed}}{\text{weight of one seed}}\times 100$$

Swelling Capacity and the Swelling Index

The swelling capacity gives an indication of increase in the volume upon absorption of water. Cowpea seeds (10 g) were weighted and subsequently soaked in distilled water for 24 h. The volume of cowpea seeds was estimated before and after soaking by determination of displaced water. Swelling capacity and the swelling index were determined according the formula using by [15].

$$\text{Swelling capacity}\left(\text{ml/seed}\right)=\frac{\text{Volume after soaking}-\text{Volume before soaking}}{\text{Number of seed}}$$

$$\text{Swelling index}=\frac{\text{Swelling capacity of seed}}{\text{Volume of one seed}}\times 100$$

Cooking Time

The method used the aluminum pot containing 600 ml of water for 20 g of seed unsoaked because consumers in Burkina Faso often cook cowpea seeds without soaking. Cooking time commenced when the seeds of a sample were placed in the container of boiling water. Boiling is continued, and two (2) seeds were drawn using a spatula at every 5 mins intervals up to 35 mins and thereafter after every 2 mins. The seeds were then compressed between the thumb and forefinger and rated: 1 = seed is difficult or not able to smash and cotyledon feels hard, 2 = seed is less difficult to smash and cotyledon feels slightly hard, 3 = seed is firm but smashes easily and cotyledon feels soft, 4 = there is little resistance to smash seed and cotyledon feels mushy, 5 = seed is easily pressed into a mush [16]. In every cooking trial, the order of samples was randomized. The samples were randomized and cooking trials were repeated on three days, with each trial conducted by day.

2.4. Statistical Analysis

The data obtained from the physical parameters, hydration parameters, and, cooking time of the seed were subjected to a one-way analysis of variance (ANOVA) with a significance level of 5% and the Student Newman-Keuls test was applied to determine the differences between means. Pearson's correlation coefficients of various properties of seeds were carried out to establish relationships between variables. Analysis (PCA) was carried out in order to test the variables of 6 cultivars in groups. An analysis was done in three replications using the JMP software version 14.

3. Results

3.1. Variability for Seed Physical Proprieties

The mean values of length (mm), width (mm), thickness (mm), surface area (mm^2), length-width ratio (shape index), sphericity, and PCG (g) of cowpea seed are presented in Table 2. Significant differences were observed among the cowpea varieties in terms of seed length (0.0001), seed width (0.0001), and seed thickness (0.0349). The highest value of seed length was registered by variety Makoyin (9.65 mm) and the lowest value by variety Teek-songo (7.88 mm). Concerning the seed width, the highest value was observed in the variety Gourgou (7.08 mm) whereas the lowest value was obtained in varieties Teek-songo (6.34 mm), and Issa-sosso (6.34 mm). The highest thickness value was observed in the variety Gourgou (5.13 mm), while the lowest value was observed in varieties Neerwaya (4.97 mm), Makoyin (4.88 mm), Issa-sosso (4.93 mm), and Teek-songo (4.88 mm). Concerning the seed area, a significant difference was observed among cowpea varieties (0.0002). The highest value was presented by Gourgou (153.29 mm^2) and the lowest value was obtained in Teek-songo (122.68 mm^2). The length-width ratio showed significant variation (0.0001). Out of six genotypes, five genotypes recorded the least value ranging from 1.24 to 1.49 while the highest value was recorded in the case of Makoyin (1.51). The six cowpea varieties showed significant difference in 100 seeds weight with the highest value in Gourgou (21.1 g). Issa-sosso, Makoyin, Neerwaya, and Teek-songo required the lowest value ranging from 16.87 to 17.83 g.

3.2. Variability for Seed Cooking Proprieties

The values for bulk density (g/ml), Hydration capacity (g/seed), Hydration index, swelling capacity (ml/seed), swelling index, and cooking time (min) are presented in Table 3. A significant difference was observed in bulk density (0.0092) among the six cowpea varieties. The bulk density of seed varieties (Makoyin, Neerwaya, Gourgou, Yipoussi, Issa-sosso) ranged from 1.17 to 1.20 g/ml was significantly lower than the bulk density value of Teek-songo (1.51 g/ml) which was the highest. The result shows that a significant difference was observed in seed hydration capacity and in swelling capacity (0.0420) and (0.0050) respectively.

Table 2. The result of the seed size, seed shape and 100 seed weight of cowpea genotypes.

Parameters	Genotypes						P (0.05)
	Gourgou	Issa-Sosso	Makoyin	Neerwaya	Teek-Songo	Yipoussi	
Length (mm)	9.37 ± 0.11 ab	9.26 ± 0.11 b	9.65 ± 0.11 a	9.52 ± 0.11 ab	7.88 ± 0.11 c	9.34 ± 0.11 ab	0.0001
Width (mm)	7.08 ± 0.07 a	6.33 ± 0.07 c	6.41 ± 0.07 bc	6.41 ± 0.07 bc	6.34 ± 0.07 c	6.59 ± 0.07 b	0.0001
Tickness (mm)	5.13 ± 0.05 a	4.93 ± 0.05 b	4.88 ± 0.05 b	4.97 ± 0.05 b	4.88 ± 0.05 b	5.01 ± 0.05 ab	0.0349
Area (mm^2)	153.29 ± 2.52 a	137.18 ± 2.52 b	141.17 ± 2.52 b	141.82 ± 2.52 b	122.68 ± 2.52 c	143.41 ± 2.52 b	0.0002
Ew (*L*/*W*)	1.32 ± 0.01 d	1.46 ± 0.01 b	1.51 ± 0.01 a	1.49 ± 0.01 ab	1.24 ± .01 e	1.42 ± 0.01 c	0.0001
Sphericity	74.54 ± 0.45 b	71.38 ± 0.45 cd	69.52 ± 0.45e	70.55 ± 0.45 de	79.28 ± 0.45 a	72.33 ± 0.45 c	0.0001
Shape	Round	Round	elliptical	Round	Round	Round	
100-seeds weigh (g)	21.1 ± 0.70 a	17.1 ± 0.70 b	17.83 ± 0.70 b	17.9 ± 0.70 b	16.87 ± 0.70 b	17.83 ± 0.70 b	0.018

Legend: Ew: Length/width ratio. The values followed by the same letters are not significant different at the threshold of > 5%.

Table 3. Seed cooking proprieties of cowpea genotypes.

Parameters	Genotypes						P (0.05)
	Gourgou	Issa-Sosso	Makoyin	Neerwaya	Teek-Songo	Yipoussi	
Bulk density (g/ml)	1.16 ± 0.05 b	1.17 ± 0.05 b	1.20 ± 0.05 b	1.20 ± 0.05 b	1.51 ± 0.05 a	1.20 ± 0.05 b	0.0092
HC (g/seed)	0.22 ± 0.01 a	0.17 ± 0.01b	0.18 ± 0.01ab	0.19 ± 0.01 ab	0.16 ± 0.01 b	0.22 ± 0.01 a	0.042
HI (%)	100.76	96.32	105.46	108.38	93.14	118.16	0.3024
SC (ml/seed)	0.24 ± 0.00 a	0.20 ± 0.00 b	0.19 ± 0.00 b	0.19 ± 0.00 b	0.17 ± 0.00 c	0.21 ± 0.00 ab	0.005
SI (%)	137.68	148.942	128.241	137.5	148.661	132.87	0.6112
TC (min)	63.33 ± 2.77 a	60 ± 2.77 a	66.67 ± 2.77a	68.33 ± 2.77 a	46.67 ± 2.77 b	66.67 ± 2.77 a	0.0023

Legend: WA: Water absorption, HC: Hydration capacity, HI: Hydration index, SC: swelling capacity, SI: swelling index, CT: cooking time. The values followed by the same letters are not significant different at the threshold of > 5%.

Out of the six varieties, Gourgou and Yipoussi exhibited the highest value of hydration capacity (0.22 g/seed) whereas the lower value was recorded by Issa-sosso (0.17 g/seed) and by Teek-songo (0.16 g/seed). The highest value of swelling capacity was presented by Gourgou (0.24 ml/seed) and the lower value of swelling capacity by Teek-songo (0.17 ml/seed). Concerning the cooking time, a significant difference was noticed among the six cowpea varieties (0.0023). The study revealed that a minimum cooking time of 46.67 mins was required for Teek-songo variety compared to Makoyin, Neerwaya, Gourgou, Yipoussi and, Issa-sosso varieties which exhibited relatively similar cooking time ranging from 60 to 68.33 mins.

3.3. Pearson's Correlation Coefficient between the Physical and Cooking Proprieties

Pearson's correlation coefficients between various proprieties of cowpea seeds are presented in Table 4. Seed length was positively correlated with surface area ($r = 0.81$, $p \leq 0.05$), length-width ratio (0.77, $p \leq 0.05$) and cooking time (0.83, $p \leq 0.05$) but negatively correlated with bulk density (−0.77, $p \leq 0.05$). Seed width was positively correlated with hydration capacity (0.51, $p \leq 0.05$), as well as with swelling capacity (0.55, $p \leq 0.05$). Seed thickness is positively correlated with hydration capacity (0.55, $p \leq 0.05$). The area was positively correlated with hydration capacity (0.60, $p \leq 0.05$), swelling capacity (0.55, $p \leq 0.05$), and cooking time (0.61, $p \leq 0.05$), and negatively correlated with bulk density (−0.64, $p \leq 0.05$). 100 seed weight was positively correlated with surface area (0.69, $p \leq 0.05$) and hydration capacity (0.50, $p \leq 0.05$). Hydration capacity was positively correlated with swelling capacity (0.74, $p \leq 0.05$), Seed sphericity was positively correlated with bulk density (0.67, $p \leq 0.05$) and negatively correlated with seed length-width ratio (−0.98, $p \leq 0.05$) and cooking time (−0.78, $p \leq 0.05$).

3.4. Description of Varieties

In order to explain the relationship between variables and detect the most important factors of variability, principal component analysis was applied to mean

Table 4. Variability parameters for water absorption and cooking traits in cowpea.

Variables	Length	Width	Tickness	SW	Sph	Area	Ew	B-D	HC	HI	SC	SI	TC
Length	1												
Width	0.36	**1.00**											
Tickness	0.37	**0.82****	**1.00**										
SW	0.36	**0.79****	**0.60****	**1.00**									
Sph	**−0.86****	0.14	0.11	0.01	**1.00**								
Area	**0.81****	**0.82****	**0.80****	**0.69****	−0.40	**1.00**							
Ew	**0.77****	−0.32	−0.18	−0.16	**−0.98****	0.26	**1.00**						
BD	**−0.77****	−0.31	−0.29	−0.28	**0.67****	**−0.64****	**−0.58***	**1.00**					
HC	0.43	**0.51***	**0.55***	**0.50***	−0.19	**0.60****	0.10	−0.44	**1.00**				
HI	0.31	0.07	0.23	0.13	−0.27	0.26	0.27	−0.25	**0.77****	**1.00**			
SC	0.38	**0.55***	0.42	**0.47**	−0.15	**0.55***	0.03	−0.39	**0.74****	0.36	**1.00**		
SI	−0.30	−0.16	−0.09	−0.20	0.24	−0.26	−0.18	0.41	0.01	0.03	0.38	**1.00**	
TC	**0.83****	0.21	0.20	0.23	**−0.78****	**0.61****	**0.71****	**−0.76****	0.42	0.32	0.36	−0.37	**1**

WA: Water absorption, HC: Hydration capacity (g/seed), HI: Hydration index, SC: swelling capacity, swelling index, Ew: Length/width ratio, Sph: Sphericity, BD: bulk-density, SW: 100 seeds weight.

values. The principal components (PCs) showing the proportion and cumulative variance of the variables are presented in **Table 5**. The first four components PC1, PC2, and PC3, PC4 showed 52%, 23%, 9% and 5% of the variation, respectively, for a total of 96.73% (**Figure 2**). The most important variables integrated by the first component (PC1) were length, area, hydration capacity and cooking time. The second component (PC2) was positively correlated with thickness, 100-seeds weight and negatively correlated with the length-width ratio. Bulk density was positively correlated with PC3. PCA was used to explain the variability among the cultivars. PCA produced two components that accounted for a cumulative 77% of the variation. The cultivars were plotted on two dimensions based on their PCA results. Gourgou was specifically associated with thickness, 100 seeds weight, Hydration and swelling capacity. Further, genotypes such as Yipoussi, Makoyin and Neerwaya were associated with high Length/width report (Ew), seed length and time cooking. Teek-songo and Issa-sosso separated themselves from the other by their high sphericity and their lower seed width.

4. Discussion

The seed quality is a criteria choice by consumers. It is appreciated through the seed size defined by the length, the width, and the thickness. In this study, the Makoyin variety produces the length seeds and Gourgou presents wide large seeds comparably to Issa-sosso, Neerwaya, and Teek-songo. The seed size varied with cowpea varieties [17] [18]. That propriety is important in cowpea variability. The length, the width, and the thickness are commonly used to determine

Table 5. Eigen values of the principal component (PC) analysis.

Variables	PC 1	PC 2	PC 3	PC 4
Length	0.35514	−0.15252	−0.23126	0.05585
Width	−0.04131	0.29673	0.0003	0.87965
Tickness	0.25834	0.36371	0.08314	−0.28023
100-seeds weight	0.24681	0.35863	0.05096	−0.13103
Sphericity	−0.27159	0.3174	0.30562	−0.10061
Area	0.37297	0.14148	−0.06929	−0.03901
Ew	0.21637	−0.38884	−0.30454	0.07221
Bulk-density	−0.04555	−0.30506	0.63208	−0.0338
Hydration capacity	0.32418	0.19448	0.29337	−0.02853
Hydration index	0.27559	−0.19933	0.38322	0.05485
Swelling capacity	0.29326	0.34208	−0.08342	0.04447
swelling index	−0.28913	0.18014	−0.32281	−0.3174
Cooking Time	0.36348	−0.18906	−0.04943	−0.05332
Proportion	0.50	0.28	0.12	0.07
Cumulative	0.50	0.78	0.90	0.97

PC: principal components, Ew: Length/width ratio.

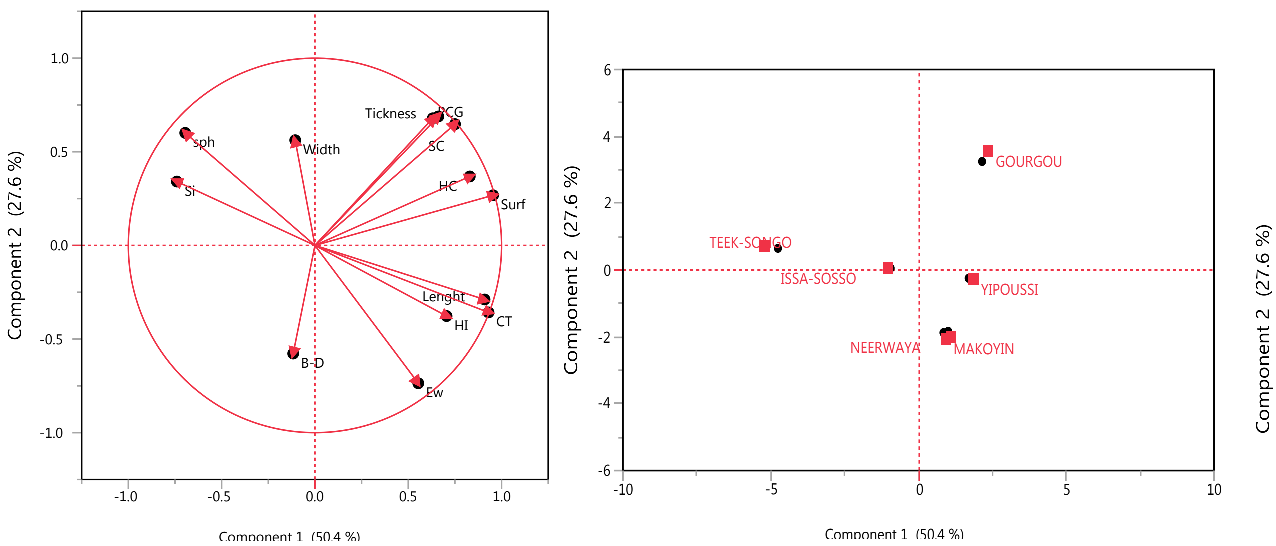

Figure 2. Genotype and trait biplot for seed physical and water hydration parameters. PCG: 100-seeds weight, HC: Hydration capacity (g/seed), HI: Hydration index, SC: swelling capacity, Ew: Length/width ratio, CT: cooking time, SI: swelling index.

the seed shape [19]. According to [13], the high value of the length-width ratio (1.51 to 1.70) indicates an elliptical shape seed whereas the least value (0.20 to 1.50) indicates a spherical shape seed. In fact, Makoyin produces the elliptic shape seeds whereas Gourgou, Issa-sosso, Yipoussi, Neerwaya, and Teek-songo produce the spherical shape seeds. These five genotypes showed the highest sphericity compared to the lowest value of sphericity in Makoyin. Out of the five, Teek-songo recorded the highest value of sphericity. These results indicate that Teek-songo seeds are the most spherical followed by Gourgou, Yipoussi, Issa-sosso, and Neerwaya. The variation was observed in 100-seeds weight of the six cowpea varieties. A similar variation was reported by [20] with 100-seeds weight ranging between 11 - 26 g. On the basis of 100-seeds weight, cowpea varieties are classified into size categories according to [20]. Varieties with seeds of 10 - 15 g are described as small, 15.1 - 20 g as medium-sized seeds while large seeds have 20.1 - 25 g. Seeds weighing over 25 g are described as very large seeds. Out of the six varieties, Makoyin, Yipoussi, Issa-sosso, Teek-songo, and Neerwaya produce medium-sized seeds and one (Gourgou) has the large size seed. The difference in 100-seed weight certifies the difference in cowpea varieties' seed size. According to [21], the differences in seed size may be due to genetic differences. [22] concluded that the gene action controlling seed size is predominantly additive. Knowledge of the physical parameters of cowpea seed would be important in order to design the sieves for seeds threshing, cleaning, and the genetic purity of cowpea germplasm [23]. This could help to make uniform seeds size of improved varieties. The size and shape of the seed is an essential character in the analysis of plant variability [24]. In addition, it indicates the productivity of the variety and determines grain quality for commercialization. Good quality seeds contribute 15% - 20% to increases in yield. The medium-sized seeds and the large size seed are the preference of consumers in Burkina Faso [25]. The difference in cowpea seeds size involved the difference in bulk density value meaning that an equal quantity of cultivars would occupy unequal space. The smallest seed sizes would occupy a greater mass per unit volume of space. This was observed by [26] in white and red cowpea varieties. According to [27], the bulk density of a material depends on the geometry, size, and surface properties of the individual particles. Bulk density indicates the degree of pod filling and therefore an indicator of seed and flour quality which would be suitable in various food preparations [28]. In this study, Teek-Songo registered a high bulk density. Regarding the hydration capacity and the swelling capacity, Gourgou got the highest values found to be in comparison with the values ranging from 0.13 to 0.22 g/seed for hydration capacity and from 0.12 to 0.26 ml/seed for swelling capacity in cowpea reported by [29]. Hydration capacity plays an important role in the food preparation process like doughs and baked products. Swelling capacity gives an indication of an increase in the volume upon absorption of water. The high swelling and water absorption capacity indicate that the Gourgou variety could be useful in food systems because this increase more after cooking. The cooking time in this study is lower than the cooking time ranging from 57 to 84 mins reported by [28]. Comparatively to some cowpea varieties grown in Ghana presenting 160 mins cooking time [30], the six improved cowpea varieties would be beneficial for producers and consumers of cowpea. The variation observed in cowpea cooking time seemed to suggest that there are intrinsic factors that control the cooking time. [31] reported that cooking time is a heritable characteristic for pulses. Hydration capacity correlated with swelling capacity and seed weight indicating that the seeds with greater seed weight lead to greater water absorption leads and to greater swelling. It is the similar result to [32] who reported that cowpea water absorbed before cooking is equivalent to their weights. Hydration parameters are not correlated with cooking time [33]. Whereas, the lines that have lower hydration and swelling capacities usually have longer storage life [34]. This study showed that seed length, surface area, hydration capacity, and cooking time have been the most discriminating among the cowpea varieties studied. Whereas [18], they identified 100-seed weight, seed breadth, hydration capacity, swelling capacity, and cooking time score as important traits.

5. Conclusion

From this study, it can be concluded that the cowpea varieties varied with respect to physical and cooking properties. The variety Teek-songo variety has the lowest seed size and the lowest hydration and swelling capacity. The varieties Gourgou and Yipoussi have the highest seed size, hydration, and swelling capacity. These cowpea varieties are useful in food products that require much water. This information can attract consumers and processors for food products. The four cowpea varieties Makoyin, Neerwaya, Gourgou, Yipoussi, and Issa-sosso have a cooking time of one hour and Teek-songo have a cooking time less of than one hour. These varieties use less energy during cooking. They are beneficial for consumers and for the environment. Seed physical characteristics, water absorption, hydration, and swelling capacity are very important traits that need to be considered in cowpea breeding to the fact that yield mainly depends on seed physical characteristics such as seed size and seed weight. The cooking time is not linked to hydration and swelling capacity. The physical and cooking properties would help breeders, other researchers, and processors to note which varieties are suitable best for producers and consumers.

Data Availability

The data supporting the findings of this study are available on request from the corresponding author.

Acknowledgements

The authors acknowledge all team members of INERA and of the "Laboratoire Biosciences" of the "Université Joseph KI-ZERBO" for their input in this manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

References

[1] FAOSTAT (2019). Production Data. https://www.fao.org/faostat/en/#data

[2] Ravelombola, W.S., Shi, A.N., Weng, Y.J., Motes, D., Chen, P.Y., Srivastava, V. and Wingfield, C. (2016) Evaluation of Total Seed Protein Content in Eleven Arkansas Cowpea (*Vigna unguiculata* (L.) Walp.) Lines. *American Journal of Plant Sciences*, **7**, 2288-2296. https://doi.org/10.4236/ajps.2016.715201

[3] Weng, Y.J., Ravelombola, W.S., Yang, W., Qin, J., Zhou, W., Wang, Y.-J., Mou, B.Q. and Shi, A.N. (2018) Screening of Seed Soluble Sugar Content in Cowpea (*Vigna unguiculata* (L.) Walp). *American Journal of Plant Sciences*, **9**, 1455-1466. https://doi.org/10.4236/ajps.2018.97106

[4] Longe, O.G. (1983) Varietal Differences in Chemical Characteristics Related to Cooking Quality of Cowpea. *Journal of Food Processing and Preservation*, **7**, 143-150. https://doi.org/10.1111/j.1745-4549.1983.tb00672.x

[5] Odogwu, B.A., Uzogara, M.O., Worlu, H. and Agbagwa, I.O. (2021) Factors Affecting Stakeholders' Preferences for Cowpea Grains in Selected Parts of Nigeria. *African Journal of Food Agriculture Nutrition and Development*, **21**, 17669-17681. https://doi.org/10.18697/ajfand.98.19890

[6] Akinyele, I. O., Onigbinde, A.O., Hussain, M.A. and Omololu, A. (1986) Physicochemical Characteristics of 18 Cultivars of Nigerian Cowpeas (*V. unguiculata*) and Their Cooking Properties. *Journal of Food Science*, **51**, 1483-1485. https://doi.org/10.1111/j.1365-2621.1986.tb13840.x

[7] Da Silva, D.O.M., Santos, C.A.F., Seido, S.L., Coelho, W.C.P. and De Aquino, D.A.L. (2017) Retention of Proteins and Minerals after Cooking in Cowpea Genotypes. *Pesquisa Agropecuária Tropical*, **47**, 353-359. https://doi.org/10.1590/1983-40632016v4747261

[8] Berry, M., Izquierdo, P., Jeffery, H., Shaw, S., Nchimbi-Msolla, S. and Cichy, K. (2020) QTL Analysis of Cooking Time and Quality Traits in Dry Bean (*Phaseolus vulgaris* L.). *Theoretical and Applied Genetics*, **133**, 2291-2305. https://doi.org/10.1007/s00122-020-03598-w

[9] Bassett, A., Katuramu, D.N., Song, O. and Cichy, K. (2021) QTL Mapping of Seed Quality Traits Including Cooking Time, Flavor and Texture in a Yellow Dry Bean (*Phaseolus vulgaris* L.) Population. *Frontiers Plant Science*, **12**, Article ID: 6702846. https://doi.org/10.3389/fpls.2021.670284

[10] Mashi, D.S. (2006) Genetic Studies on Seed Coat Texture and Cooking Time in Some Varieties of Cowpea (*Vigna unguiculata* (L.) Walp). Thesis in the Department of Botany, Faculty of Natural Sciences University of Jos, Jos, 1-131.

[11] Milani, E, Seyed, M., Razavi, A., Koocheki, A., Nikzadeh, V., Vahedi, N., Moein-Fard, M. and Gholamhossein Pour, A. (2007) Moisture Dependent Physical Properties of Cucurbit Seeds. *International Agrophysics*, **21**, 157-168.

[12] Fıratlıgil-Durmuş, E., Šárka, E., Bubník, Z., Schejbal, M. and Kadlec, P. (2010) Size Properties of Legume Seeds of Different Varieties Using Image Analysis. *Journal of Food Engineering*, **99**, 445-451. https://doi.org/10.1016/j.jfoodeng.2009.08.005

[13] Balkaya, A. and Adabas, M.S. (2002) Determination of the Seed Characteristics in Some Significant Snap Bean varieties grown in Samsun, Turkey. *Pakistan Journal of Biological Sciences*, **5**, 382-387. https://doi.org/10.3923/pjbs.2002.382.387

[14] Kabas, O., Yilmaz, E., Ozmerzi, A. and Akinci, I. (2007) Some Physical and Nutritional Properties of Cowpea Seed (*Vigna sinensis* L.). *Journal of Food Engineering*, **79**, 1405-1409. https://doi.org/10.1016/j.jfoodeng.2006.04.022

[15] Adebowale, Y.A., Adeyemi, I.A. and Oshodi, A.A. (2005) Functional and Physicochemical Properties of Flours of Six Mucuna Species. *African Journal of Biotechnology*, **4**, 1461-1468.

[16] Yeung, H.S. (2007) Evaluation of Legume Cooking Characteristics Using a Rapid Screening Method. Thesis, Department of Soil and Crop Sciences, University of Houston, Houston, 1-64.

[17] Davies, R.M. and Zibokere, D.S. (2011) Effect of Moisture Content on Some Physical and Mechanical Properties of Three Varieties of Cowpea (*Vigna unguiculata* (L) Walp). *Agricultural Engineering International: CIGR Journal*, **13**, 1-8.

[18] Gull, M., Sofi, P.A., Mir, R.R., Ara, A., Rashid, M., Tahir, M., Shafi, S. and Rather, I.A. (2017) Natural Variation for Seed Physical and Hydration Parameters in Cowpea (*Vigna unguiculata* L.) in Relation to Hard to Cook Trait. *International Journal of Pure & Applied Bioscience*, **5**, 321-330. https://doi.org/10.18782/2320-7051.3000

[19] Sehirali, S. (1988) Grain Legume Crops. Ankara University, Faculty of Agricultural Engineering, Ankara, Vol. 1089, 435 p.

[20] Henshaw, F.O. (2008) Varietal Differences in Physical Characteristics and Proximate Composition of Cowpea (*Vigna unguiculata*). *World Journal of Agricultural Sciences*, **4**, 302-306.

[21] Hu, Z., Zhang, H., Kan, G., Ma, D., Zhang, D., Shi, G., Hong, D., Zhang, G. and Yu, D. (2013) Determination of the Genetic Architecture of Seed Size and Shape via Linkage and Association Analysis in Soybean (*Glycine max* L. Merr.). *Genetica*, **141**, 247-254. https://doi.org/10.1007/s10709-013-9723-8

[22] Drabo, I., Redden, R., Smithson, J.B. and Aggarwal, V.D. (1984) Inheritance of Seed Size in Cowpea (*Vigna unguiculata* (L.) Walp.). *Euphytica*, **33**, 929-934. https://doi.org/10.1007/BF00021923

[23] Makanur, B., Deshpande, V.K., Deshpande, S.K. and Jagdish, J. (2012) Characterization of Cowpea Genotypes Based on the Morphological Characters of Seed and Seedling. *Bioinfolet*, **9**, 656-660.

[24] Cervantes, E., Martín, J.J. and Saadaoui, E. (2016) Updated Methods for Seed Shape Analysis. *Scientifica*, **2016**, Article ID: 5691825. https://doi.org/10.1155/2016/5691825

[25] Tignegre, J.B. (2010) Genetic Study of Cowpea (*Vigna unguiculata* (L.) Walp.) Resistance to *Striga gesnerioides* (willd.) Vatke in Burkina Faso", Ph.D. Dissertation, University of Kwazulu-Natal, Durban, 1-170.

[26] Dzikunoo, J., Adzinyo, O.A., Donyinah, D.A., Dah, H. and Fiave, C.A. (2017) Instant Cooking Cowpeas. *International Journal of Science and Research*, **7**, 135-141.

[27] Wani, I.A., Sogi, D.S., Wani, A.A. and Gill, B.S. (2011) Physical and Cooking Characteristics of Some Indian Kidney Bean (*Phaseolus vulgaris* L.) Cultivars. *Journal of the Saudi Society of Agricultural Sciences*, **16**, 7-15. https://doi.org/10.1016/j.jssas.2014.12.002

[28] Appiah, F., Asibuo, J.Y. and Kumah, P. (2011) Physicochemical and Functional Properties of Bean Flours of Three Cowpea (*Vigna unguiculata* L. Walp) varieties in Ghana. *African Journal of Food Science*, 5, 100-104.

[29] Verma, A., Kushwaha, A., Kumar, A. and Baghel, S.S. (2019) Physico-Chemical Properties and Nutritional Composition of Improved Varieties of Grain Cowpea Grown in Pantnagar. *Journal of Pharmacognosy and Phytochemistry*, **8**, 334-338.

[30] Ogunmoyela, O.A., Akingbala, J.O. and Oyewole, O.B. (1991) Physicochemical and Sensory Aspects of Five Cowpea Varieties in Relation to the Processing and Quality of Paste for Akara. *Association of African Universities Proceedings of Seminar on Development of High Protein-Energy Foods from Grain Legumes*, Legon, 5-7 February 1991, 5-7.

[31] Biama, P., Faraj, A., Mutungi, C., Osuga, I. and Kuruma, R. (2020) Nutritional and

Technological Characteristics of New Cowpea (*Vigna unguiculata*) Lines and Varieties Grown in Eastern Kenya. *Food and Nutrition Sciences*, **11**, 416-430. https://doi.org/10.4236/fns.2020.115030

[32] Williams, P.C., Nakoul, H. and Singh, K.B. (1987) Relationship between cooking time and physical characteristics in chickpea. *Journal of the Science of Food and Agriculture*, **34**, 492-497. https://doi.org/10.1002/jsfa.2740340510

[33] Harouna, D.V., Venkataramana, P.B., Matemu, A.O. and Ndakidemi, P.A. (2019) Assessment of Water Absorption Capacity and Cooking Time of Wild Under-Exploited *Vigna* Species towards Their Domestication. *Agronomy*, **9**, Article No 509. https://doi.org/10.3390/agronomy9090509

[34] Sofi, P.A., Wani, S.A., Zargar, M.Y., Sheikh, F.A. and Shafi, T. (2014) Comparative Evaluation of Common Bean (*Phaseolus vulgaris* L.) Germplasm for Seed Physical and Culinary Traits. *Journal of Applied Horticulture*, **16**, 54-58. https://doi.org/10.37855/jah.2014.v16i01.08