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Effects of three *Parkia biglobosa* seeds peeling methods as pretreatments on derived products quality

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Abstract

The objective of the present study was to study the effect of three seed peeling methods on the physicochemical characteristics of *Parkia biglobosa* seeds. Methods used were the traditional peeling with mortar (TPM), the peeling with abrasive wheel (PAW) and the peeling with Engelberg dehuller (PED). The results showed that the peeling of 13 kg of seeds with TPM required about 2820 ± 170.88 ml of water and 380.67 ±17.93 g of ash, and that of PED needed 591.67 ± 173.23 ml of water. However, the PAW did not require water for the same amount of seeds. No significant differences were recorded neither for the yields of the peeling methods, nor for the weight of thousand peeled seeds. High breakage rates were recorded for the PED (12.50 ± 2.53%). The ratios of the weight of thousand peeled seeds compared to the weight of thousand whole non-peeled seeds are all lower than 1. High broken seeds rate of the PED can lead to a loss of production when processing the seeds into soumbala. Kernels from broken seeds may be lost in the washing step of cooked peeled kernels. The ratios of the weight of thousand seeds and the rate of variations (15.85-16.30%) of the peeled seeds compared to the whole seeds showed considerable loss of the teguments of seeds after the different peeling methods. This could contribute to the optimization of the cooking of the *P. biglobosa* seeds and the processing of cooked seeds.

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Introduction

Soumbala is a popular traditional food condiment made from *Parkia biglobosa* seeds also known as African locust bean. Widely used in West Africa, it is well appreciated for its nutritional values (Ganou *et al.*, 2004; Azokpota *et al.*, 2006; Camara *et al.*, 2016). However, the traditional processing of *P. biglobosa* seeds into soumbala is both energy- and time-consuming. African locust bean are very dry and hard in their raw state (Razavi *et al.*, 2007). This hardness, which increases during storage, is attributed to the seed coat consisting of a shell, induced by the insoluble polysaccharides (pectins, celluloses, hemicelluloses) that protects the kernel and a thick coat that in turn covers the hard seed shiny peeled. *Parkia. biglobosa* seeds are so hard that their germination can be difficult. Therfore, its germination is promoted by soaking seeds in concentrated sulfuric acid (98%) for three minutes. They are then washed either with a large quantity of water or immersed for four seconds in boiling water to softening the shell, before leaving them to soak overnight (Lamien *et al.*, 2011). In addition, they require pretreatment that is often thermal or hydrothermal pretreatment (Bup *et al.*, 2008). The energy required to hull 30 kg of *P. biglobosa* seeds is equivalent to that spent during a brisk lopsided walk of about 2 hours under a hot sun (Gutierrez *et al.*, 2000).

To overcome the constraints inherent to the traditional Soumbala production process, the peeling of *P. biglobosa* seeds is practiced by some processors. This is an alternative practice that aim to facilitate the production of soumbala in Burkina Faso. It can even optimize the soumbala production process (Coulibaly/Diakité *et al.*, 2020). However, *P. biglobosa* peeling practice is poorly documented, and its impact in the final product remain unknown. The present study aims to evaluate the performance of three different *P. biglobosa* seeds peeling methods in Burkina Faso.

Material and methods

Three peeling methods were compared by studying their effect on the physicochemical characteristics of peeled seeds of *P. biglobosa*.

Site of the study

The study was conducted in Bobo-Dioulasso, Burkina Faso. The experiments were conducted at two local millers in the city to assess the three peeling methods, and at a soumbala production unit.

Parkia biglobosa seeds

Parkia biglobosa seeds originated from Orodara (Fig. 5A) were purchased at Ouezinville market, Bobo-Dioulasso. These seeds were mixed to obtain a homogeneous sample.

Screening of P. biglobosa seeds

The first step of the study consisted to screen *P. biglobosa* seeds after reception in order to separate mature seeds in different calibers. Homogeneous sized seeds are required for the efficiency of peeling operation unit and to minimise breakage (Ahouansou, 2012). The seed sorting was performed manually, using an sieve with a medium mesh size of 71 mm diameter.

Peeling tests by the three peeling methods

The three methods used were: traditional mortar peeling (TPM), abrasive wheel dehuller (PAW) and peeling with Engelberg dehuller (PED). The physicochemical characterization of *P. biglobosa* peeled seeds were conducted in triplicate and each testing involved 13 kg of sorted seeds, weighed using a scale (TCS Platform). A survey was administered to the equipment owners and one equipment manufacturer to obtain more details on the equipment.

Traditional mortar peeling

This peeling process was conducted using a mortar and a pestle (Fig. 1A). It consisted of placing the sorted and winnowed seeds in a mortar, adding ash and water according to the producer's instructions, and peeling by pounding the seeds. Ash was used as an abrasive to facilitate the peeling and also as a protectant to avoid seed breakage. Seeds were considered peeled when touched with a slight friction, or washed, their dandruff peels off and turn shiny black. Seeds were then sun-dried, sieved or winnowed to remove the detached coat and ash. They were finally crushed and winnowed to remove the remaining coat and ash.

Peeling with abrasive wheel dehuller

The tests were carried out using the abrasive wheel dehuller (Fig. 1B). To peel the seeds, they were introduced into the hopper of the dehuller and dehulled without water nor ash.

Peeling in the Engelberg dehuller

Parkia biglobosa seeds were moistened with quantfied water prior being placed in the Engelberg dehuller hopper for peeling (Fig. 1C). A test sample was introduced to adjust the blades using the adjustment screws in order to have the right medium of peeling and to minimise seeds breakage.

Chemical composition of whole seeds

The chemical composition of *P. biglobosa* kernels was evaluated to provide information on their characteristics. Dry matter content, total protein, total lipid and total ash were determined according to AOAC methods (AOAC, 1984). The carbohydrate content was determined by the differential method between the weight of the sample and that of lipids, proteins, ash and water.

Characterization of the peeling parameters

The main peeling parameters were evaluated with reference to the peeling of a test sample (WS) and the additives required for the peeling methods. It included the weight of seeds from each peeling method (PS), the efficiency of each peeling method by means of performance parameters such as peeling yield (PY) and peeling time (PT), the amount of residue and loss (ARL), and the amount of water (AWP) and ash (AAP). Peeled seeds were winnowing to separate them from residues and any crumbled seeds (ARL), before weighing them using a scale (TCS Platform Scale). The yield was calculated based on the weight of peeled seeds relative to the weight of the sample according to the formula below. The time, amount of water and ash for peeling were evaluated using a stopwatch and a scale, respectively.

$$PY = \frac{PS}{WS} X100$$

PY : peeling yield; PS : peeled seeds

WS : weight of sample

Physical characteristics of peeled and non-peeled P. biglobosa seeds

The weight of a thousand seeds was carried out for whole seeds and peeled seeds. It was determined according to NFV03 (AFNOR, 1991). One hundred seeds were weighed. The total weight of 1000 seeds was obtained by multiplying the weight of 100 seeds by ten.

The sphericity index (SI) of seeds was determined using a caliper according to the method adopted by Koura *et al.*, 2014) through the dimensions of 100 randomly selected seeds. These dimensions are: length, width and thickness. They were taken horizontally for length and vertically for width and thickness for each seed. The sphericity index was determined on the whole seeds of *P. biglobosa* and those peeled resulting from the various methods of peeling. The sphericity index was calculated according to the following formula:

$$SI = \frac{(L.W.T)^{\frac{1}{3}}}{L}$$

L = lengh

W = width

T = Tickness

SI= sphericity index

The volume of one seed was determined according to the method reported by Djivoh (2009). Then, 50 seeds were immersed into a 250 mL capacity test tube containing distilled water up to the 150 mL mark. Then, the the graduation was read 5 seconds later. The volume of the 50 seeds will result from the difference between the initial level (150 mL) and the new level water leader al. The volume of one seed was next computed by dividing the obtained volume by 50. This operation was repeated three times.

Characterization and quality of peeled seeds

The peeled seeds obtain according to the three methods were characterized following some quality criteria of appreciation: the rate of entirely peeled seeds (EPS), the rate of partially peeled seeds (PPS), the rate of broken seeds (BS), the rate of non-peeled seeds (NPS), the rate of whole kernels (WK) and the weight of 1000 seeds (WTS). This consisted in taking after homogenization of sample, 100g of seeds from each peeling method, to separate them manually according to these criteria and to weigh them with a precision scale (OHAUS IR Sensor).

The rates were then calculated according to the weight of the test sample. The criteria for assessing peeled seeds are described in Table 1.

The weight ratio of 1000 peeled seeds to the weight of 1000 unpeeled seeds were evaluated.

The rate of change (V) of thousand-seed weight on peeled seeds on the raw material was calculated according to the following formula:

$$V = \frac{WTUS - WPS}{WPUS} X100$$

WTUS : weight of thousand seeds non-peeled

WTPS : weight of thousand peeled seeds

WPS: weight of peeled seeds

Statistical analysis of the data

In order to compare the different peeling methods, the analysis of variance test followed by the comparison of means was performed on three peeling repetitions of each method. These tests were performed using R Studio software version 1.3.959. Significance was accepted at $P < 0.05$.

Results

Description of peeling equipment used

Mortar

It is a manual dehuller that require the use of water because the peeling operation is carried out on humidified seeds. The mortar is a wooden device traditionally used to grind, crush or dehull materials with a pestle (Fig. 1A). Locally made, the mortar contains a hollow to hold the material to be pounded with a long, thick-edged, rounded device called a pestle.

Table 1. Description of qualities criteria of peeled seeds.

Criteria	Description
Completely peeled seeds	These are seeds which, after peeling don't contain any film
half peeled seeds	These are seeds that, after peeling has a thin film on part of the seed
Broken seeds	These are seeds broken during peeling
Non-peeled seeds	These are seeds that have not been peeled during the peeling operation
Whole kernels	These are whole kernels obtained from peeling operation
Weight of thousand seeds	It is the weight of thousand peeled seeds

Abrasive wheel dehuller

This is an electric dry process of dehulling huller (Fig. 1B), using dry seeds. It is commonly used locally to dehull rice, fonio, cowpea, millet, sorghum and maize. *Parkia biglobosa* peeled seeds from it can be conserved for more than a year. It is used by traders for the peeling of cereals and legumes intended for export to neighboring countries (mainly Ivory Coast and Mali). Made in China, the only abrasive wheel dehuller existing in the city, is a versatile one. It consists of a support or frame, a hopper, a feed screw, a trapdoor or adjustment flap, a dehulling chamber in which the abrasive wheel is located. The latter is based on artificial diamond. Its rough surface facilitates the removal of the seed coat from the friction without breaking the seeds. A vertically mounted shaft on which the abrasive wheel is arranged and passing longitudinally through the dehulling chamber is mounted on two bearings. At one end of the shaft is mounted a receiving pulley. The peeling chamber has a flap for the discharge of the peeled seeds.

Table 2. Percentage **c**hemical composition of unpeeled *P. biglobosa* seeds.

Parameters	Dry matter	Protein	Lipids	Ash	Carbohydrate
Content	94.51 ±0.11	36.78 ±0.94	27.65 ±0.54	4.38 ±0.015	25.7 ±0.40

The excessive release of flakes during the peeling of the seeds remains the major difficulty with this equipment.

Engelberg sheller

It is an electric husker, with wet way (Fig. 1C). It is used by millers in districts to dehull cereals (maize, paddy rice, millet, sorghum, etc.). The resulting seeds are very hot and have a short shelf life unless they are winnowed and dried. It is manufactured locally. It is essentially made up of a support or frame, a feeding hopper, a trap door or adjustment flap, a dehulling chamber in which the shaft is located. The latter, equipped with a feed screw and passing longitudinally through the dehulling chamber, is mounted at the front and rear on two bearings. At one end of the shaft is mounted a receiving pulley. The shaft is made of iron. The dehulling chamber has a discharge opening for the peeled seeds, which is also equipped with an adjustment flap. In the chamber is also mounted an adjustable blade according to the size of the seeds.

Table 3. Physical characteristics of unpeeled *P. biglobosa* seeds.

Parameters	Weight of thousand seeds (g)	Length (mm)	Width (mm)	Thickness (mm)	Sphericity index	Average volume (ml)
NPS	281.95 ±4.92	8.25 ± 0.8	6.7 ±0.7	3.32 ±0.6	0,69 ±0,06[a]	0.53 ± 0.01
TPM	236 ±2,82[a]	7,09 ±0,7[c]	5,56 ±0,7[b]	2,94 ±0,7[b]	0,69 ±0,08[a]	-
PAW	236,37 ±5,16[a]	7,42 ±0,6[b]	5,79 ±0,8[bc]	3,09 ±0,6[b]	0,69 ±0,06[a]	-
PED	237,25 ±2,76[a]	7,07 ±0,7[c]	5,49 ±0,7[c]	3,06 ±0,6[b]	0,69 ±0,06[a]	-
Pvalue		2,20E-16	2,20E-16	0,01981	0,6249	

NPS : seeds non-peeled

TPM : traditional peeling of seeds with mortar

PAW : peeling with a wheel

PED : peeling of seeds with Engelberg husker.

Peeling diagram of the different methods

Peeling with mortar

It's a manual peeling, requiring human physical effort. About 380.67 ±17.93 g of ash with 2820 ± 170.88 mL of water were used during each peeling operation of *P. biglobosa* seeds. This method of peeling was restrictive and required more working time. Fig. 2 and Fig. 5B show the traditional peeling diagram of *P. biglobosa* seeds in mortar and the resulting peeled seeds, respectively.

Abrasive wheel dehuller

The abrasive dehuller is an electric dry dehuller. An electric motor drives the shaft supporting the abrasive wheel through a belt. The seeds introduced in the hopper go down in the dehulling chamber where the abrasive wheel rotating at high-speed mixes them and removes the film from the seeds when they come into contact with the rough surface of the wheel. The nature of the grinding wheel and its rough surface prevent the seeds from breaking during peeling. In addition, the friction between the seeds during the peeling process contributes to the removal of the coat. Fig. 3 and Fig. 5C show the peeling diagram and the peeled seeds.

Engelberg dehuller

This dehuller (Fig. 1C.) is wet powered and runs on electric power, which drives the shaft via a belt. The seeds are sprayed with water before being introduced into the hopper and driven by the feeding screw into the dehulling chamber.

Table 4. Main parameters of different peeling methods.

Traitement	PS (kg)	PY (%)	ARL (kg)	PT (min)	AWP (ml)	AAP (g)
TPM	12.18 ±0.29[a]	93.69 ±2.20[a]	0.82 ±0.29[a]	52.03 ±2.05[a]	2820 ±170.88[a]	380.67 ±17.93[b]
PAW	11.50 ±0.39[a]	88.46 ±3.00[a]	1.50 ±0.39[a]	8.99 ±3.49[b]	0[c]	0.00[a]
PED	11.00 ±0.93[a]	84.59 ±7.16[a]	2.00 ±0.93[a]	6.84 ±1.32[b]	591.67 ±173.23 [b]	0.00[a]
p-valeur	0.1317	0.1315	0.1317	<0.001***	<0.001***	<0.001***

TPM : traditional peeling of seeds with mortar
PAW : peeling with a wheel
PED : peeling of seeds with Engelberg husker
NPS : Non-peeled seeds of *Parkia biglobosa*
PY : peeling yield
ARL : residues-losses
PT : peeling time
AWP : peeling water
AAP : peeling ash
*** : highly significant
0 : variable not recorded.

The screw feeder forces the seeds to pass through the blades, which interspace was adjusted beforehand according to the size of the seeds.

The high speed of the shaft allows the blade to eliminate the coat of the seeds. Its peeling diagram is presented in Fig. 4 and the peeled seeds in Fig. 5D.

Proximate composition of whole Parkia biglobosa seeds

The proximate composition of the raw material used in the study is presented in Table 2. Mean values of dry matter, protein, lipids, ash and total carbohydrate content were 94.51 ± 0.11%, 36.78 ± 0.94%, 27.65 ±0.54% and 25.7 ± 0.40% respectively.

Table 5. Main characteristics of peeled *P. biglobosa* seeds according to the qualification criteria fixed.

Treatment	EPS (%)	PPS (%)	BS(%)	WK (%)	NPS (%)	WTS (g)
TPM	76.39[b]	23.60 ±0.88[a]	0.00[b]	0.00 [b]	0.00	236.00 ±2.82
PAW	77.66 ±0.39[b]	21.48 ±0.52[b]	0.07 ±0.03[b]	0.65 ±0.13[a]	0.00	236.37 ±5.16
PED	85.04 ±1.84[a]	2.35 ±0.60[c]	12.50 ±2.53[a]	0.00[b]	0.00	237.25 ±2.76
p-value	< 0.001***	< 0.001***	< 0.001***	< 0.001***	--	0.9166

BS: % broken seeds
NPS : % Non-peeled seeds
WTS: weight of thousand seeds
***= highly significant
0: variable not recorded
TPM: traditional peeling of seeds with mortar
PAW: peeling with a whell
PED: peeling of seeds in Engelberg sheller
EPS : % of seeds fully peeling
PPS : % seeds half peeling.

Physical characteristics of P. biglobosa whole and peeled seeds

Table 3 shows the physical characteristics of the *P. biglobosa* seeds used for the peeling tests and the peeled seeds from different peeling methods. The weight of 1000 seeds, a criterion of selection of the varieties of cereals and leguminous plants informs on the size of the grains, its density and its degree of filling during the development in the field. This average weight was 281.5 ± 4.92. The axial dimensions of seeds are respectively for length, width, thickness 8.25 ± 0.8 mm, 6.7 ± 0.7 mm and 3.32 ± 0.6 mm. From these dimensions, the shape of seeds was deduced corresponding to the sphericity index which was 0.69 ± 0.06. An average seed volume of 0.53 ml was also noted.

Table 6. Ratio and rate of variation of weight of thousand peeled seeds compared to non-peeled seeds.

Provenance Seeds	WTS (%)	Ratio of WTS (%)	Rate of variation (%)
NPS	281.95	--	--
TPM	236.00 ± 2.82	0.84 ± 0.01	16.30 ± 1.00
PAW	236.37 ± 5.16	0.84 ± 0.02	16.17 ± 1.83
PED	237.25 ± 2.76	0.84 ± 0.01	15.85 ± 0.98

NPS : non-peeled seeds

TPM : tradition*al* peeling of seeds with mortar

PAW : peeling with a wheel

PED: peeling of seeds with Engelberg sheller

WTS: weight of thousand seeds.

The peeled seeds have the physical parameters that vary from 236 ± 2.82 to 237.25 ± 2.76 g for the mass of a 1000 seeds, from 7.07 ± 0.7 to 7.42 ± 0.6 mm for the length, from 5.49 ± 0.7 to 5.79 ± 0.8 m for the width and from 2.94 ± 0.7 to 3.09 ± 0.6 mm for the thickness and at sphericity index of 0.69 ± 0.6 to 0.69 ± 0.8.

Main parameters of the methods of peeling

The main parameters of peeling studied are shown in Table 4. The weight of peeled seeds (PS) ranged from 11.00 ± 0.93 kg to 12.18 ± 0.29 kg. The highest weight value of peeled seeds was observed in the traditional mortar sheller (TPM), which had less waste and residues (ARL). The peeling yields (PY) varied from 84.59 ± 7.16% to 93.69 ± 2.20% with the highest yield noted at TPM. The peeling times (PT) ranged from 6.84 ± 1.32 min to 52, 03 ± 2.05 min. The longest PT was recorded at TPM and the lowest at the Engelberg (PED) sheller. The abrasive wheel sheller (PAW) did not require water (AWP) for peeling the seeds.

The quantity of peeling water (AWP) varied for the other two methods from 591.67 ± 173.23 mL to 2820 ± 170.88 mL with the highest one recorded at TPM. PAW and PED do not require ash in their peeling process. An average of 380.67±17.93 g of ash was recorded at TPM.

Characteristics of peeled P. biglobosa seeds

The main characteristics of peeled seeds according to qualification criteria are recorded in Table 5. The average rate of fully peeled seeds varied from 76.39 ± 0.88 to 85.04 ± 1.84%. The PED has the highest rate of peeled seeds whereas the TPM method has the lowest one. Moderately peeled seeds (PPS) ranged from 2.35 ± 0.60 to 23.60 ± 0.88% with the highest rate attributed to TPM and the lowest to DE. Broken seeds (BS) were observed in two peeling methods ranging from low levels of 0.07 ± 0.03% recorded with the PAW to high levels of brokenness of 12.50 ± 2.53% recorded with PED. TPM peeling method did not record any broken seeds. PAW method of peeling resulted in a whole kernel rate of 0.65 ± 0.13%. None of the peeling methods reveaded none peeled seeds (US). The weight of 1000 seeds (WTS) varied from 236.00 ± 2.82 g to 237.25 ± 2.76 g. The highest WTS was recorded with PED and the lowest with TPM.

Fig. 1. Peeling equipment. A-Mortar and pestle, B-Abrasive wheel dehuller, C-Engelberg dehuller.

Rate of change of 1000 seeds weight and ratio of 1000 peeled seeds weight to raw material weight

The average ratio of weight of 1000 seeds are equal and are all lower than 1 (0,84). The rate of variation of 1000 seeds weight varied from 15.85 to 16.30%. The highest rate of variation is recorded with TPM and the lowest with PED. These results are recorded in Table 6.

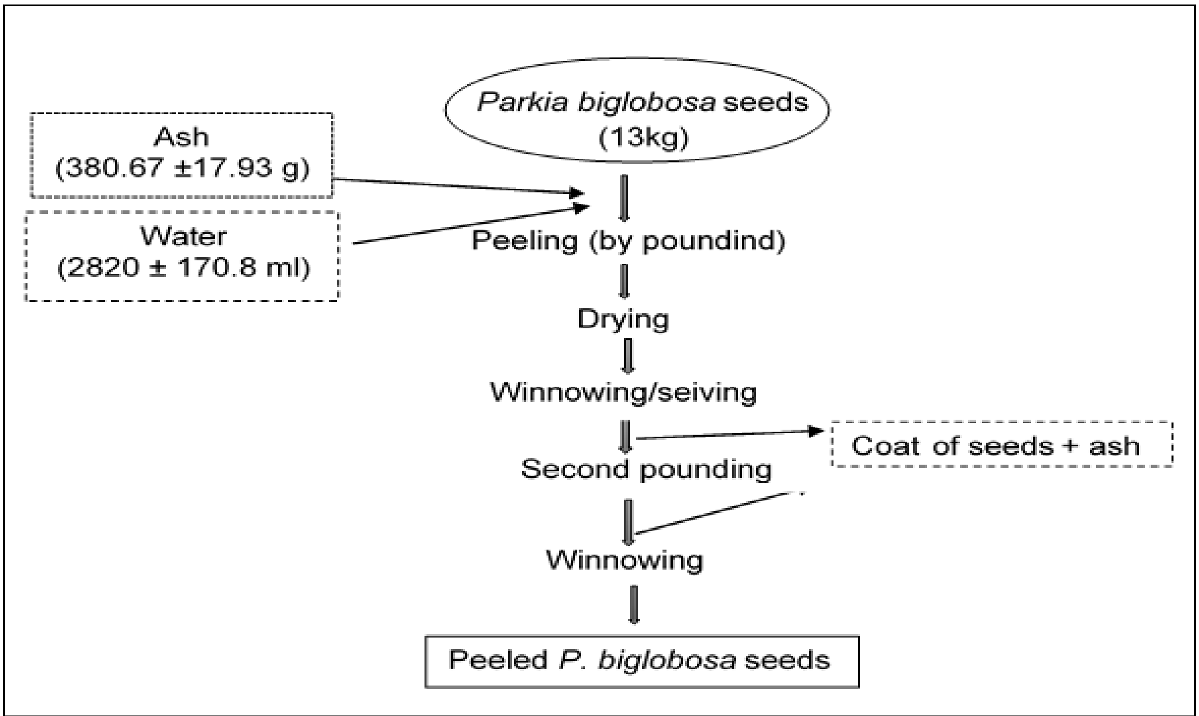

Fig. 2. Diagram of the peeling of *P. biglobosa* seeds in a mortar.

Discussion

Traditional mortar peeling is performed manually while abrasive wheel and Engelberg peeling which are both mechanical were performed using electrical power. The husking chamber of the abrasive wheel sheller consists of a horizontally arranged abrasive wheel, whereas the husking chamber of the Engelberg sheller consists of a vertically arranged shaft or axle connected to the take-up pulley.

The Engelberg dehuller is also a wet dehuller, as well as the mortar dehuller, because they require a prior humidification of the seeds before peeling. On the other hand, the grinder is a dry huller. This type of peeling without the addition of water could be an important element in favor of the conservation of peeled seeds because this environment would be unfavorable to the important biological exchanges, thus avoiding metabolic reactions and attacks of microorganisms (mainly molds) (Cruz *et al.*, 2016). However, ash combined with humidification of seeds plays a role in optimizing peeling (Coulibaly/Diakité *et al.*, 2020) and seed cooking (Somda *et al.*, 2014). It has a preservative effect on peeled seeds by creating an alkaline environment, which is known to inhibit microbial growth. Previous work on *P. biglobosa* seeds reported dry matter, protein, lipid, and ash contents of 86.94- 90.87%, 24.33-33.70%, 19.39-22.56%, and 3.51-4.39% respectively (Koura *et al.*, 2014). The high values of these results are in the same order as ours with slight inferiority in the first three parameters and similarity in total ash content.

Our results are also within the range of protein content (35-40%) reported by (Ganou *et al.*, 2004) but with lipids (30-32%) and carbohydrate (16-24%) contents respectively higher and slightly lower than ours. The differences in results may be attributed to the variety of *P. biglobosa* involved and the composition of the soil on which the plant grew.

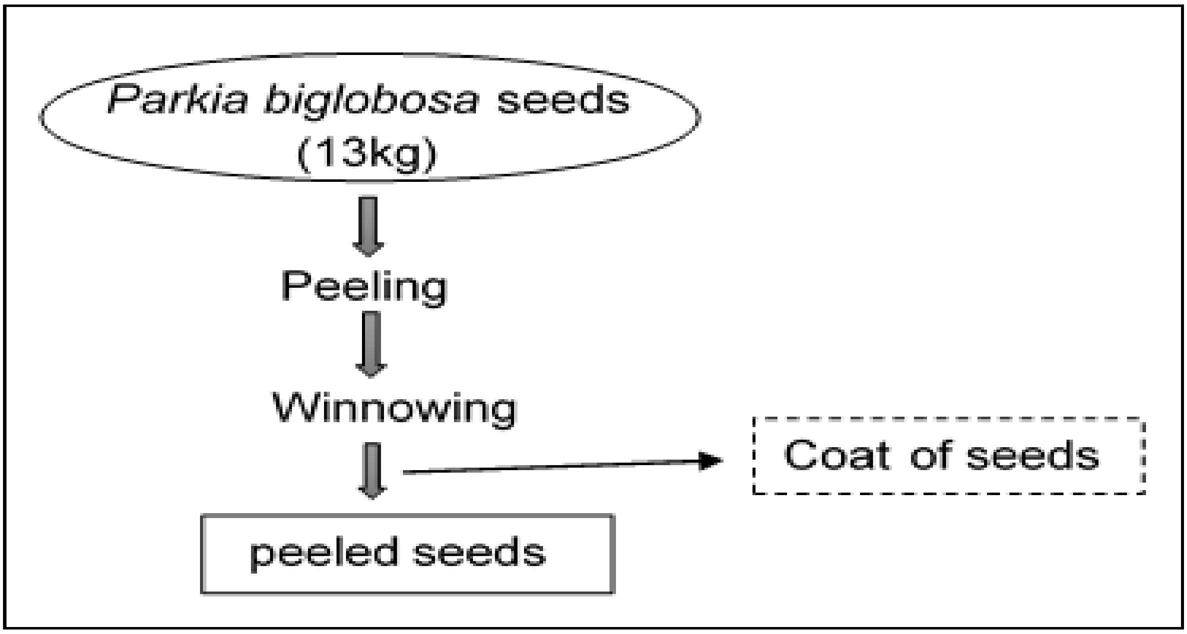

Fig. 3. Diagram of peeling of *P. biglobosa* seeds in a abrasive wheel dehuller.

Previous works carried out on *P. biglobosa* seeds from six counties in Benin have shown that the average weight of one 1000 seeds ranged between 175 and 265g (Djivoh, 2009; Koura *et al.*, 2014). Our results of axial dimensions was similar to those of Koura *et al.* (2014) who found values between 7.51 and 8.90 mm in length, 5.96 and 7.13 mm in width, 3.29 and 3.88 mm in thickness with a sphericity index of 0.69 and 0.75.

The axial dimensions of sphericity index found in this study were among the best axial dimensions known to date. These results could be due to the selection of large seeds during the sorting operation. Based on the main parameters of the peeling methods (peeled seeds (PS), residue-loss (ARL) and yield (PY)), no significant differences were observed. Concerning the peeling time (PT), the traditional mortar huller (TPM) was significantly different from the others, mainly attributed to its manual nature, which is laborious.

In addition, the quantity of water used for peeling in TPM is significantly different from Engelberg dehuller (PED), while wheel dehuller does not use water. Ash was used to optimize the peeling operation in TPM, however, this is not a mandatory condition to the method (Diakité, 2009); (Coulibaly/Diakité *et al.*, 2020).

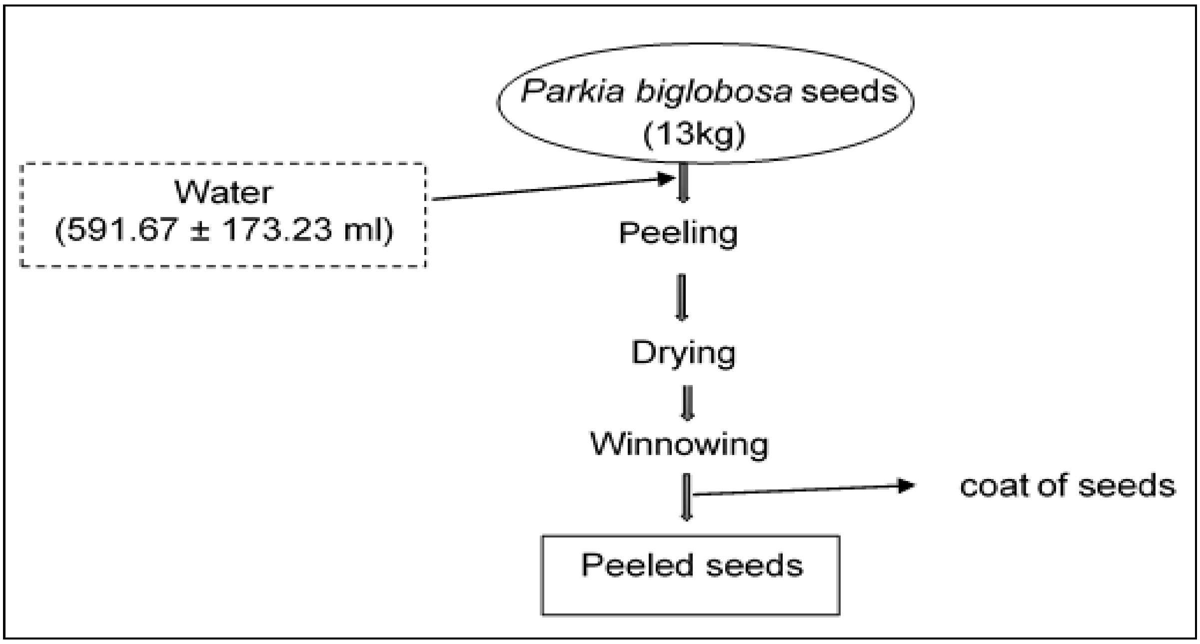

Fig. 4. Peeling diagram of *P. biglobosa* seeds in the Engelberg dehuller.

Fig. 5. *Parkia biglobosa* seeds.

A-P. biglobosa whole seeds, *B*-Seeds of *P. biglobosa* peeled in mortar, C-Seeds of *P. biglobosa* peeled with an abrasive wheel dehuller, *D*-Seeds of *P. biglobosa* peeled in the Engelberg dehuller.

The main characteristics of peeled P. biglobosa seeds according to the qualification criteria based on the three peeling methods showed significant differences ($p < 0.001$) except for the content of non-peeled seeds (NPS) and the weight of 1000 seeds (WTS) ($p > 0.05$). The content of fully peeled seeds (EPS) and broken seed rate (BS) are significantly higher with Engelberg dehuller (PED) than the others. This may be explained by the inadequate adjustment between the axis and the friction blades of the DE exerting too much mechanical pressure on seeds during the rotation. The metalic material of the peeling chamber and the rate of seeds humidification during the peeling could also lead to high seed breakage.

The axial dimensions of the seeds have a close relationship with the design of the equipment (Ahouansou, 2012). A high shattering rate during peeling could result in losses during soumbala production at the washing stage of the cooked peeled seeds. None of the peeling methods revealed non-peeled seeds and the weight of a 1000 seeds were not significantly different at the 5% level, reflecting the similarity of their peeling efficiencies. The decrease in seeds weight after peeling could be due to the loss of all or part of the seed coat, suggesting that all the peeling methods were efficiental. These results reflect the important place of the teguments on the surface of the seed. Of the three methods of peeling, the grinding method could be recommended to the processors because, in addition to having similar peeling advantages to the mortar method, it is less laborious (no human power needed) and provides clean kernels that are less prone to microbial development. Additionally, peeling *P. biglobosa* seeds contributes to the optimization of soumbala production by reducing cooking and processing times, and more importantly, by providing products of better quality (Coulibaly/Diakité *et al.*, 2020).

Conclusion

This study characterized three methods of peeling *P. biglobosa* seeds: the traditional peeling with mortar, the peeling with abrasive wheel and the peeling with Engelberg dehuller. A diagram of each method was established. There were no significant variations in peeling efficiency between these methods, but there was a significant increase in the rate of broken seed with the Engelberg dehuller approach, which could lead to product loss during soumbala processing. The traditional peeling with mortar had a high labour time due to its manual and arduous nature. The peeling with abrasive wheel presented the best kernel quality and therefore can be recommended to processors.

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Conflict of interest

The authors declare that they have no conflicts of interest in relation to this article.

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