Technological, physico-chemical and sensory changes during cowpea processing into shô basi, a couscous-like product from Sahelian Africa

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Abstract

Shô basi is a traditional Sahelian couscous-like product obtained essentially by dehulling and milling white cowpeas, granulating the moistened resulting flour, steaming, and sun-drying the obtained granules. To comply with market demand and ensure continuous production year-round, processors are simplifying and shortening the dehulling step. From full wet dehulling, they moved to partial dry elimination of cowpea hulls. Such a practice could have an impact on the comprehensive quality of shô basi. Therefore, this study evaluated the effect of the unit operations on physico-chemical and sensory traits of cowpea during shô basi production. Six productions of couscous including full dehulling (FD) or partial dehulling (PD) methods were carried out. Production yield, color, proximate composition, phenolic compounds, degree of disintegration, and swelling were determined. Thereafter, the sensory traits of both shô basi were assessed. Although FD induced a higher dry matter loss than partial dehulling, the overall yield of shô basi production was not affected \((p < 0.05)\) by the method of dehulling implemented. The intermediate and end products from FD showed brighter cream color than those from PD. Irrespective of processing method, cowpea processing into shô basi affected significantly \((p < 0.05)\) protein, fiber, and polyphenol contents. In comparison with PD method, shô basi from FD variant had the lowest fat, mineral, and fiber contents. However, sensory traits of high quality of shô basi were preferentially associated to shô basi from FD method. Thus, this dehulling method should be promoted among consumers and thereby led to increased profitability of shô basi production and trading.

KEYWORDS
dehulling, legume, proximate composition, sensory quality
1 | INTRODUCTION

Cowpea (Vigna unguiculata L. Walp), is a legume of interest in developing tropical countries where prevalence of protein-energy malnutrition is rather high. Cowpea was recognized by many authors (Madodé et al., 2012; Olivera-Castillo et al., 2007; Towo et al., 2003) as a good source of macronutrients (proteins and dietary fiber), micronutrients (calcium and iron), and vitamins. However, cowpeas contain antinutritional compounds (polyphenols, phytates, saponins, oxalates, protease inhibitors, lectins, etc.) (Olivera-Castillo et al., 2007; Owalabi et al., 2012; Sererama et al., 2012), and oligosaccharides that limit the bioavailability of nutrients and consequently digestive problems after consumption (Madodé et al., 2013; Onyesom et al., 2005). Cowpea is processed in various forms in different countries (Madodé et al., 2011; PAFASP, 2017; Timitey et al., 2021). These forms could be couscous (shô basi), fritters (akara), steamed paste (fari), boiled beans (abobo, red-red, and atassi) or infant flours. Among these forms, cowpea couscous is produced and consumed in Burkina (PAFASP, 2017), Niger (Abdoulaye, 2013), and Mali (Timitey et al., 2021).

Traditional couscous production encompasses five main operations: dehulling, milling, granulation of the moistened flour, steaming, and drying of granules. Among these unit operations, wet dehulling is the most important because it enhances the digestibility, the nutritional value and reduces the beany flavor of cowpea products (Amonsou et al., 2009; Odededjì & Oyeleke, 2011). Implementing wet dehulling adequately requires skills that most producers do not have. Recent surveys in three regions of Mali (Ségou, Koulikoro, and Bamako) showed that most producers introduced dry dehulling in replacement of wet dehulling to overcome the difficulty of drying cowpea cotyledons during rainy and cold seasons (Timitey et al., 2021). Therefore, the couscous produced using the traditional and the modified methods differ from each other in color, texture, odor, and taste. Many studies (Akissoé et al., 2015; Madodé et al., 2011; Sacca et al., 2012) on cereal and legume processing showed that sensory, physicochemical and technological properties of the final product are strongly affected by unit operations. In the case of sorghum couscous, the best lightness and desired particle size were obtained with dehulling rates between 20 and 30% (Aboubacar et al., 2006). The effect of processing on couscous quality was also highlighted by Benatallah et al. (2008) and Demir et al. (2010) who showed a decrease in swelling index, disintegration degree and homogeneity of granules of cereal couscous enriched with legumes. For cowpea couscous, in addition to the dehulling method, other main operations like granulation, steaming, and drying could influence the quality of the product. To our knowledge, no validated information has been gathered on the effect of cowpea processing on the characteristics of derived shô basi. Hence, this study assessed the technological quality of cowpea and the physico-chemical changes observable on cowpea using both shô basi production methods, and filled the gap of knowledge concerning the sensorial traits of shô basi.

2 | MATERIAL AND METHODS

2.1 | Plant material

White cowpea variety “sangarak” was purchased from a seed producer in Ségou region (Mali) and stored by the hermetic triple packaging system at room temperature (28°C to 30°C) prior processing.

2.2 | Process characterization

Shô basi was produced by the two processing methods identified, one involving full wet dehulling (FD) and the second involving partial dry dehulling (PD) (Figure 1). Both methods were implemented as described by Timitey et al. (2021). For each dehulling method, three different productions were carried out by a skilled processor using 4 kg of cowpeas.

Apart from the raw material, samples were collected at the end of the following unit operations: dehulling (cotyledons), washing, drying, milling, granulation (granules), steaming, and drying. All collected samples were analyzed immediately after sampling for dry matter and color. In addition, cowpea seed flour and dry shô basi were stored at 4°C for proximate composition, phenolic compounds content, swelling index, density, and degree of disintegration.

2.3 | Proximate composition and physico-chemical properties of raw cowpea and derived shô basi

Dry matter was determined by oven drying at 105°C to constant weight according to AOAC methods 27.005, 27.007 (AOAC, 1984).

Proximate composition was determined through protein, crude fat, ash and total fiber. Protein contents (N × 6.25) were determined by the method of Kjeldahl according to ISO standard 3188. Crude fat, ash, and total fiber contents were determined, using AACC methods 30-25.01, 08-01, and 32-10, respectively (AACC method, 1984).

Color parameters, lightness index, L* (100 = white; 0 = black), and yellowness b* (+, yellow; −, blue) of samples were determined using a Chroma Meter (Konica Minolta C.R-210, Japan) calibrated with a white ceramic as reference. The method described by Abu and Minnaar (2009) was used to evaluate lightness of the raw material and intermediate products. For the end product, the method of Yüksel et al. (2017) was used.

Particle size was determined according to Guezlane (1993) method, using a vibrating plate (RETSCH type, AS 200) and modified as follows: 100 g of the sample was shaken for 10 min at the speed of 40, through 2.1-, 0.63-, and 0.18-mm screen sieves.

Swelling index (SI) was determined according to the method described by Guezlane and Abecassis (1991) whereas the density assessed using Yüksel et al. (2017) procedure.

Degree of disintegration was determined, using the method of Benatallah et al. (2008) whereby the disintegration represents the fine particles (<0.63 mm) with a diameter smaller than that of a 0.63-mm
sieve used and the loss (%) of these fine particles expresses the degree of disintegration.

Total phenols content was determined by the method of Singleton and Rossi (1965). The HCl-methanol (1%) extract was treated with Folin–Ciocalteu reagent and carbonate. Then, the colored product was read by spectrophotometry (UV/vis Spectrophotometer 6850, Jenway, UK) at 760 nm. Total phenols content was expressed as gallic acid equivalent/mg of sample dry weight basis.

2.4 Sensory analysis

Dry shô basî (500 g) stored at 4°C was moistened with water (700 ml) before being steam cooked with gaz cooker during 15 min. The Check-All-That-Apply (CATA) and hedonic tests were carried out on the cooked shô basî with a panel of 44 consumers including 20 Malians. The tests focused on shô basî obtained with fully dehulled cowpeas (FD) and that with partially dehulled (DP). For CATA test, appearance, texture, odor, and taste attributes (20) selected from previous study (Timitey et al., 2021) was used by the panel to describe the samples. In addition to overall liking, the three most relevant descriptors from the CATA test were used for the hedonic test.

For the hedonic test, both products were rated using a 9-level rating scale ranging from extremely unpleasant (score of 1) to extremely pleasant (9). The products were presented to consumers randomly with three-digit codes, and water was available for rinsing the mouth between samples.
2.5 | Data analysis

Physico-chemical technological and overall liking data were subjected to the analysis of variance (ANOVA) followed by the least significant difference (LSD)-Fisher post-hoc test (5% significance level) using Statistica 7 (StatSoft, Tulsa, USA). CATA data were subjected to the Cochran’s Q test. Thereafter, penalty analysis was conducted on the CATA attributes checked by at least 20% of consumers. CATA data were analyzed with XLSTAT (version 2016.02.28451, Addinsoft, Paris, France).

3 | RESULTS AND DISCUSSION

3.1 | Shō basi production yield

The yield of the traditional process (using wet full dehulling or “FD”) and modified process (using dry partial dehulling or “PD”) of shō basi production were 61.5% and 66.7% respectively. There was no significant ($p \geq 0.05$) difference between both processes (Table 1). This unexpected trend can be explained by the similar dehulling rate from full and dry dehulling methods. Indeed, the partial dehulling method is not efficient with high variability of dehulling rate, which is confirmed by the high coefficient variation of dehulling operation (8%) and of overall yield (14%). The overall yields obtained with shō basi (cowpea couscous) were lower than those of wheat couscous (82%), quite similar to those of rice-chickpea couscous (61%), and higher than rice-proteaginous pea couscous (40%) (Benatallah et al., 2008). Intermediate yields after dehulling-calibration and granulating/sieving were the lowest because of the loss during dehulling, milling, and clod formation, respectively. The undesirable clods obtained during granulation cannot pass through a sieve of 2.2–2.8 mm size and are discarded. According to Saad et al. (2011), clod formation is linked with water content of wheat flour during granulation.

### TABLE 1 Mass balance (% dry basis) during shō basi production as affected by dehulling method

| Unit operations     | FD          | PD          |
|---------------------|-------------|-------------|
| Dehulling and calibration | 80.8 ± 7\textsuperscript{a} | 83.3 ± 6.3\textsuperscript{a} |
| Flour steaming      | 99.3 ± 0.3\textsuperscript{a} | 98.0 ± 1.3\textsuperscript{a} |
| Granulating-sieving | 85.7 ± 5\textsuperscript{a} | 92.0 ± 5.1\textsuperscript{a} |
| Couscous steaming   | 91.0 ± 2.8\textsuperscript{a} | 89.7 ± 2.2\textsuperscript{a} |
| Drying              | 98.5 ± 0.3\textsuperscript{a} | 98.6 ± 0.5\textsuperscript{a} |
| Overall yield       | 61.5 ± 3.2\textsuperscript{a} | 66.7 ± 9.3\textsuperscript{a} |

Note: Values with the same letter in the same line are not significantly different ($p > 0.05$).

FD: Shō basi produced from cowpea seeds totally dehulled by crushing and washing; PD: Shō basi produced from cowpea seeds partially dehulled by dry milling and sieving.

3.2 | Color changes during shō basi production

The lightness ($L^*$) and yellow index ($b^*$) of sangaraka grains were 92 and 4.7 respectively (Figure 2). Changes in these two parameters during cowpea processing into couscous evolve in opposite directions. Apart from washing and dehulling/washing, for PD and FD methods respectively, while the lightness index decreases, the yellowness index increases for all unit operations. After washing, a great decrease of lightness was observed for both dehulling methods. However, for the FD method, before washing, dehulling was carried out with water. The effect of water on color was more pronounced for yellowness index with the highest decrease rate. Browning has been reported to be caused by the oxidation of carotenoids and phenolic compounds in wheat with enzymes (Feillet et al., 2000; Fu et al., 2013). After drying, both color parameters increased to reach a level similar to that of the
raw material. Thus, the drying destroyed the role of water on the color of cowpea during its washing and dehulling/washing. Thereafter, all following operations contributed to decreasing the $L^*$ value and to increase the $b^*$ index. This trend is expected because the succession of hydrothermal operations reinforces the browning, hence the reduction of lightness. However, the browning observed in this study is more pronounced than the previous results on cereal-based couscous reported by Celik et al. (2004) and Demir et al. (2010). These authors reported, in couscous produced from cereal or cereal combined with legumes, a positive correlation between browning and legumes ratio. They explained that the higher protein content and phenolic compounds of legumes promote enzymatic and non-enzymatic browning. As far as legume was the only raw material used to produce shô basi, protein and phenolic compounds contents should be high, and consequently, shô basi should have a low whiteness index.

Our study revealed that, although browning occurs in both processes, product from FD method had the highest yellow index and lightness index when compared to produce from the DP method. After all, the color of couscous from FD method is brighter as liking by consumers. So browning occurring here gives a yellow-clear product.

3.3 | Proximate composition and total phenols content of shô basi

The proximate composition components, for example, fat (1.1 g/100), mineral (3.1 g/100 g), protein (21.4 g/100 g), fiber (2.6 g/100 g), and carbohydrate (62.3 g/100 g/100 g) contents of the cowpea variety processed into shô basi were in the range in west African cowpea varieties as reported by Giami (1993), Henshaw (2008), Madodé et al. (2012), and Oyeyinka et al. (2013). But Appiah et al. (2011) observed a higher content of fat (2.5–3.9 g/100 g), protein (26.5–29 g/100 g), and fiber (3–3.2 g/100 g). This variability can be related to environment, genetic, and production conditions. Fiber and total phenol contents of derivative shô basi decreased significantly no matter the processing method implemented (Table 2). Fat and mineral contents increased significantly ($p < 0.05$) when shô basi is obtained from PD method, while protein content increased in both methods. Indeed similar increasing was obtained by other authors when cowpea was dehulled (Odededji & Oyeleke, 2011; Olopade et al., 2003). This increase can be explained by the concentration of protein as hulls are removed from the beans. On the other hand, similar protein, carbohydrate, phenol content, and energy value were obtained between two processing methods. As expected, the trend of these proteins and phenol contents is in agreement with our previous finding, whereas the protein content was previously higher in both methods, 24.7 and 25.2 g/100 g, respectively, for FD and PD (Timitey et al., 2021). According to Sebetha et al. (2010), protein content of cowpea seed should be affected by variety and season. Thus, the diversity of cowpea varieties used in the previous study and that of “sangaraka” (from seed producers in this study) explains this difference.

| TABLE 2 | Proximate composition (g/100 g, db), energy (kcal) and total phenolic content (mg AG eq/100 g) of cowpeas and shô basi | | |
|---------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| Type of product | Technology | Fat content | Mineral content | Protein content | Moisture content | Fiber content | Carbohydrate | Phenolic compounds | Energy |
| Cowpea | 1.1 ± 0.1 | 31 ± 0.03 | 22.4 ± 0.8 | 9.6 ± 0.1 | 2.6 ± 0.3 | 62.3 ± 0.8 | 99.5 ± 9 | 344.6 ± 1 | |
| Shô basi | FD (full dehulling) | 1.03 ± 0.2 a | 31 ± 0.1 a,* | 22.7 ± 0.6 a, * | 9.2 ± 0.1 a, * | 1.5 ± 0.1 a, * | 62.6 ± 2.4 a | 46.6 ± 11.7 a, * | 349.9 ± 8.9 a, * |
| | PD (partial dehulling) | 1.5 ± 0.1 b, * | 3.3 ± 0.1 b, * | 22.5 ± 0.3 a, * | 7.8 ± 2.6 a, * | 1.9 ± 0.3 a, * | 62.9 ± 2.8 a | 56.2 ± 7.1 a, * | 355.8 ± 10.3 a, * |

Note: Values with the same letter in the same column are not significantly different ($p > 0.05$).

*Significant difference between raw material and shô basi.

FD: Shô basi produced from cowpea seeds full dehulled by crushing and washing; PD: Shô basi produced from cowpea seeds partially dehulled by dry milling and sieving.
3.4 | Technological properties of shô basi

The particle size of shô basi was not affected by the processing method (FD or PD). In all cases, the fraction of shô basi sizing from 0.63 to 2.1 mm was the predominant fraction whereas the one below 0.18 mm was minimal (Table 3). Amounts of shô basi collected with low particle size (<0.18 mm) did not allow measuring the degree of disintegration, the density, and the swelling index of shô basi. Codex standard (Codex Alimentarius, 1995) sets that 95% of wheat couscous granules should range between 0.63 and 2 mm. Such fraction proportion was not reached in shô basi obtained from both methods. However, such yield of granules during shô basi production could be obtained by adjusting water quantity during hydration of flour and consequently the hydration of cooked granules. Granule homogeneity is very important for consumers’ acceptability, and they affect couscous quality characteristics (Demir et al., 2010; Merzoua & Loucif, 2011). The observed effect of the particle fraction on technological quality of shô basi is similar to that obtained by Merzoua and Loucif (2011), who reported that swelling index and disintegration degree are enhanced when the particle size is smaller. The disintegration degree of the granules of wheat couscous is lower than that of shô basi, which could be due to the

| TABLE 3  | Technological properties of shô basi |
| Technology | Particle size fraction (mm) | Proportion of each fraction (%) | Disintegration degree (%) | Density (kg/m³) | Swelling index |
|------------|-----------------------------|---------------------------------|---------------------------|----------------|---------------|
| FD         | 0.63–2.00                   | 74.1 ± 2.7                      | 11.9 ± 1.6a*              | 667.4 ± 0.3a* | 2.9 ± 0.0a*   |
| FD         | 0.18–0.63                   | 25.4 ± 2.9                      | 11.5 ± 1.6a*              | 773.0 ± 59a*   | 3.5 ± 0.2a*   |
| FD         | <0.18                       | 0.5 ± 0.4                       |                           |                |               |
| PD         | 0.63–2.00                   | 77.4 ± 4.3                      | 13.7 ± 1.5a1              | 660.3 ± 12.0a2 | 2.8 ± 0.1a2   |
| PD         | 0.18–0.63                   | 22.2 ± 4.5                      | 13.2 ± 0.8a1              | 769.9 ± 0.4a1  | 3.2 ± 0.1a1   |
| PD         | <0.18                       | 0.4 ± 0.3                       |                           |                |               |

Note: FD: Shô basi produced from cowpea seeds totally dehulled by crushing and washing; PD: Shô basi produced from cowpea seeds partially dehulled by dry milling and sieving.

Letters show for each fraction, significant difference between technological method. Numbers show for PD method, significant difference between particles size fraction.

*For FD method, significant difference between particles size fraction.

| Descriptors | PD | FD | p value | Q Cochran’s test |
|-------------|----|----|---------|------------------|
| Presence of small dark spots (black or red) | 39 | 18 | <0.0001 |
| Yellowish color | 0  | 29 | <0.0001 |
| Dark color | 40 | 1 | <0.0001 |
| Dirty white color | 5  | 14 | 0.020   |
| Very dry | 6  | 2  | 0.046   |
| Hard to chew | 7  | 4  | 0.317   |
| Easy to chew | 32 | 35 | 0.366   |
| Detached grains | 12 | 11 | 0.705   |
| Compact grains | 10 | 5  | 0.059   |
| Homogeneous grains | 20 | 25 | 0.132   |
| Sticky | 6  | 5  | 0.564   |
| Fade (no taste) | 6  | 0  | 0.014   |
| Slightly soft | 36 | 13 | <0.0001 |
| Very soft | 1  | 30 | <0.0001 |
| Good to eat | 11 | 19 | 0.033   |
| Taste of cowpea | 11 | 12 | 0.763   |
| Strong beany odor | 24 | 0  | <0.0001 |
| Low beany odor | 16 | 13 | 0.491   |
| Attractive | 0  | 10 | 0.002   |
| Free from cowpea odor | 1  | 30 | <0.0001 |

Note: FD: Shô basi produced from cowpea seeds totally dehulled by crushing and washing. PD: Shô basi produced from cowpea seeds partially dehulled by dry milling and sieving.
physical and chemical characteristics of the raw material. The low granules cohesiveness or high disintegration degree of shô basi did not relate to the fraction and can be explained by the specific physical and chemical characteristics of cowpea seeds like their highest protein and mineral contents.

3.5 | Relevant descriptors of Shô basi and consumer preferences

Cochran’s Q-test showed that the couscous of both methods are statistically different in terms of color, taste, and odor according to consumers (Table 4). Furthermore, shô basi obtained with fully dehulled cowpeas (FD) is lighter than that obtained with partially dehulled cowpea (PD). The PD couscous is therefore characterized by its darker color, spotted with hull residue, less sweet taste, and pronounced cowpea odor compared with the method involving FD according to the majority of consumers. Similar results were obtained by Timitey et al. (2021) during the diagnostic of shô basi production with processors. Furthermore, Amonsou et al. (2009) showed that the odor of cowpea flour is improved by dehulling. Indeed, cowpea hull volatile compounds should be responsible for its odor and taste. Onigbinde and Onobun (1993) reported that dehulling is a means to enhance the lightness of cowpea products. Phenolic compounds and oxidative enzyme reaction among hydrothermal operations are thus responsible for browning of the end product.

Penalty analysis was conducted on consumer responses to determine mean drop/increase in overall liking, because 20% of consumers at least checked the descriptor of Check-All-That-Apply (CATA) test. Among the 20 studied attributes in CATA tests, five penalized the overall liking (Figure 3). Dark color received the highest mean drop in overall liking. This observation might be explained by the fact that the consumers grant great importance to appearance because the second attribute that penalized the overall liking is the presence of small dark dots. Inversely, the overall liking increased significantly if the consumers considered that the couscous is very soft, free from the cowpea odor, dirty white color, yellowish color, and easy to chew. These quality attributes were associated to shô basi from the FD variant. They could be considered for the improvement of the organoleptic quality of shô basi (Meyners et al., 2013).

The hedonic test carried out with the selected quality attributes showed that the FD method is more appreciated by consumers (Table 5). On the one hand, the couscous from this method is pleasant for its chewiness and non-stickiness and very pleasant for its color and overall liking. On the other hand, PD method is neither pleasant nor unpleasant for its dark color and overall appreciation, and somewhat pleasant for its chewiness and non-stickiness.

4 | CONCLUSION

The main objective of this study was to evaluate the effect of the unit operations on physico-chemical, technological, and sensory traits of cowpea during shô basi production. Globally, fiber and phenol contents of cowpea decreased during shô basi production while protein content increased. Specifically, the partial dry dehulling of cowpea contributed to increase the fat and mineral contents of shô basi.
Inversely, the dehulling method did not affect the technological properties (swelling index, density, and degree of disintegration) of shô basi. Consumers preferred shô basi from full wet dehulling method for its appearance, taste, chewiness, and odor. Thus, this processing technique might be promoted to match the consumers’ preference and the profitability of processors.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL ASSESSMENT AND CONSENT

Samples were prepared according to good hygiene and manufacturing practices. Participants were informed about the purpose of the study and explained that their participation was entirely voluntary, that they could stop the interview at any point, and that the responses would be anonymous. Written consent (signature) was sought from interviewers and consumers participating in this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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