Int. j. adv. multidisc. res. stud. 2024; 4(6):859-865

Received: 22-10-2024
Accepted: 02-12-2024

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Profile Characterization of Cowpea Variety Suitable for Good Kossai: A Cowpea Pancake

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DOI: https://doi.org/10.62225/2583049X.2024.4.6.3523

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Abstract

Cowpea is a legume rich in nutrients that are very important from human nutrition and socio-economic point of view. The transformation of cowpea into Kossai involves several actors for its optimal valorization. This study aims to identify and synthesize the main traits sought by the actors of the links in the Kossai value chain. The methodology consisted of collecting data using a questionnaire administered to populations of 140 cowpea grain producers, 147 Kossai processors/resellers and 146 Kossai consumers selected in 14 sites and 28 focus groups discussions. The results showed that 88% of producers are men, 94% of consumers are men and 100% of processors are women. Actors in the sample have an average age of 46 years and a basic level of education, mainly traditional Coranic school and primary school. Cowpea local varieties are still predominantly used in the production and manufacture of Kossai. The processing of Kossai is done in six stages from winnowing to frying. Kneading and frying are the most delicate stage which requires more attention to obtain good Kossai. Main traits of cowpea variety expected by actors of Kossai value chain are large-caliber clean, white or reddish seed coat and consistency, high yield, precocity, etc. In addition, the grains must be suitable for Kossai manufacturing process, particularly mixing and frying with golden color of the final product. Breeding program of new cowpea varieties suitable for making Kossai should consider a large number of these traits in order to increase diversity, improve and sustain nutritional quality.

Keywords: Cowpea Varieties, Traits, Manufacture, Kossai, Value Chain

1. Introduction

Cowpea, Vigna Unguiculata L. Walpers (Fabaceae), is one of the main food legumes produced in the world, covering an area of more than 12.61 million hectares [1, 2]. Annual global production is estimated at around 5.59 million tons [2], more than 83% of which is produced in West Africa [3, 4] particularly in Nigeria, the leading producer (nearly 75%) and leading importer, followed by Niger, the second largest producer (14%) and leading exporter [5]. On a per capita basis, Niger is the world leading producer, which explains the country's lead in exportation and Nigeria's lead in importation.

In Niger, cowpea is produced on more than 5.886 million hectares in the rainy season mainly in association with millet or sorghum [6], without any fertilizer application. It is also grown on more than 4.6 thousand hectares in the lowlands with supplementary irrigation in monoculture and soil amendments [7]. Early maturing varieties (50 days cycle) or late maturing varieties (more than 90 days cycle) are grown in most of the large production regions [7, 8]. However, its production faces various biotic and abiotic constraints, grouped into two types. The group of insect pests of the crop consists mainly of aphids(*Aphis craccivora*), thrips, borers and pod-sucking bugs that can cause damage ranging from 30% [5] to 100% [9, 10, 12] of production loss. The group of insect pests of cowpea seeds consists mainly of bruchids that can cause up to 70% loss [11]. To deal with some of the production and storage constraints, various methods have been proposed [11, 13, 14]. Chemical control with synthetic insecticides is widely used and is most efficient, compared to other control methods, including integrated pest management [5, 15].

Despite these constraints, cowpea cultivation contributes to socioeconomic development, GDP and household income [9, 13]. Its production has increased quite dramatically these last years, going from 586 thousand tons in 2005 [16] to more than 2.630 million tons in 2021 [8]. Eighty per cent (80%) of this production is intended for export to Western and Central African countries [5]. This improvement in production is more correlated with the increase of cultivated area than with the progress made by research, particularly the varietal selection of cowpea. The average seed yield is 460 kg/ha in 2020 [5, 8], which represents a little more than a third of the potential yield of 1.5 T/ha [12]. The fodder yield is very high [8], around 5.6 tons of dry matter per hectare [17]. Cowpea cultivation also improves the productivity of agricultural land through nitrogen and carbon fixation [18, 19, 20, 21]. It is estimated that some 170 kg of CO_2 per year per ha [5] are fixed by cowpea and restituted to the soil, thus sustainably restoring soil fertility.

Cowpea is a rich food that can be an important tool in the fight against malnutrition and food insecurity [3, 9, 13, 22, 23]. It is a legume rich in protein, lysine, an essential amino acid, and other carbohydrates [5, 9, 22]. It is the basis of several dishes such as sauces, ingredients, main dishes and various products from its processing [24, 25, 26], consumed as family or commercial dishes [27].

Cowpea is appreciated by actors of its sector for its high flour yield and its rapid transformation [19]. It can be transformed into flours and various products, including the manufacture of Kossai. These transformation processes involve several actors from the successive and complementary links of the production to the consumption of Kossai. The actors have preferences in taste and other desirable traits throughout each stage of Kossai manufacturing process which should be considered in varietal selection programs.

Notwithstanding the increase in its production, its nutritional quality and its socio-economic importance, cowpea sector concerns its main stakeholders since there are still many issues and constraints that inhibit its optimal valorization by type of processed products. This is particularly the case in the Kossai value chain. To address some of these constraints, varietal selection programs have focused on the development of stable varieties with high yield [9, 28, etc.] and adapted to the biological and physical conditions of agro-ecological zones [29], etc. Breeding programs are often based on the "top and down" approach (knowledge transfer from "scientists" to producers). This approach is often criticized because it is based on the stabilization of varieties with traits desired by the research team and does not consider the quality and acceptability of the finished products by the main actors in the different value chains. This results in the low adoption of improved varieties. Breeding programs must take into account not only the agronomic performance of the improved variety but also the quality of the products and the attributes sought by the actors in the value chains [28, 29], to facilitate the acceptability of innovations. This work mainly aims to synthesize the attributes of cowpea to obtain good Kossai based on the preferences of the Kossai value chain mains actors.

2. Materials and methods

The methodological approach used is mainly based on the bibliography and data collection through surveys of the main actors in the value chain of the cowpea pancake "Kossai"

2.1 Bibliographic research

The bibliographic research consisted of the synthesis of scientific articles and technical reports. It was completed by the consultation of main experts in the production and processing of cowpea. The cross-synthesis made it possible to identify and represent the zones of large cowpea production, manufacturing and consumption of Kossai. They served as a basis for us to properly structure the interview guides and to organize focus groups and questionnaires for individual interviews.

2.2 Study area

Agricultural statistics are the basis for the selection of the study area. They clearly showed that the regions of Maradi and Zinder are the main regions for cowpea production and Kossai consumption in their rural and urban zones. Four departments had been chosen systematically not only based on empirical knowledge of the quality and quantity of the Kossai consumed but also on the existence of sufficient numbers of actors to enable data collection by link in the Kossai value chain. On the other hand, 8 villages were randomly selected (2 in each department) using the Excel spreadsheet. However, this choice was readjusted in the field due to accessibility constraints and insecurity mattes in some villages (Fig 1).

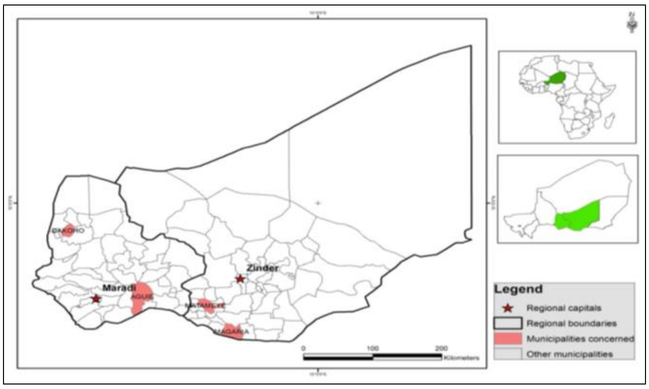

Fig 1: Map of study area

2.3 Sampling

At the first level, the main links in the Kossai value chain were selected to take into account the concerns of all stakeholders. At the second level, a random draw was made at each link to select the stakeholders to be interviewed.

The sample size was limited mainly by the budgetary constraint. Taking this constraint into account, 70 questionnaires to be administered were selected per link at the level of each region, i.e. 140 questionnaires per link. A total of 420 questionnaires for the three links in the two regions.

In addition, two focus groups were organized, one with consumers and another with processors/resellers. They were organized in the 8 villages, 4 departmental municipalities and the 2 urban municipalities selected for this study.

2.4 Data Collection, processing and analysis method

Two data collection tools were developed as part of the primary data collection: Interview guides were used for data collection in focus groups and questionnaires for individual interviews. The data thus collected were aggregated by link, i.e. 140 questionnaires for the producer link, 147 for the processor link and 146 for the consumer link. A total of 433 individual questionnaires were filled out in the two regions. Similarly, the data collected by focus groups were aggregated by consumer and processor links. Fourteen consumer focus groups and 14 processor focus groups were conducted at the designated data collection sites.

Table 1: Sampling for data collection on the Kossai value chain

Value chain actors	Maradi	Zinder	Totals
Consumers	70	76	146
Processors	70	77	147
Producers	72	70	142
Focus group consumer	7	7	14
Focus group processors	7	7	14

The collected data were cleaned using an Excel spreadsheet. Qualitative, descriptive analyses and summaries were produced by type of data collected and by link. Then, they were synthesized and harmonized to define the main results specific to the attributes sought by all the actors in the Kossai value chain.

3. Results

3.1 Sociological characteristics of the actors

The ethnic group, education level and marital status of the sampled actors are summarized in Fig 2. The average age of the group of producers is 50 years. They are 88% men and only 12% women. They farm an average of 5 ha in associated crops mainly with millet and sorghum for the quality of the harvested products. Half of the producers practice other activities such as small trade, hand crafts etc.

All the processors groups are women, with an average age of 45. Fifty-seven per cent (57%) of them do not produce cowpea for their Kossai. They buy small quantities from producers or retailers. Forty-five (45%) of women processors are housewives and 51% engage in income-generating activities.

The consumer group is composed of 94% men and only 6% women. They are on average 42 years old. Kossai is often consumed in the morning for breakfast (93%), more by children and seniors, often at home (67%) and sometimes in the evening as a snack. Consumers often buy Kossai on the street where the manufacturers fry them.

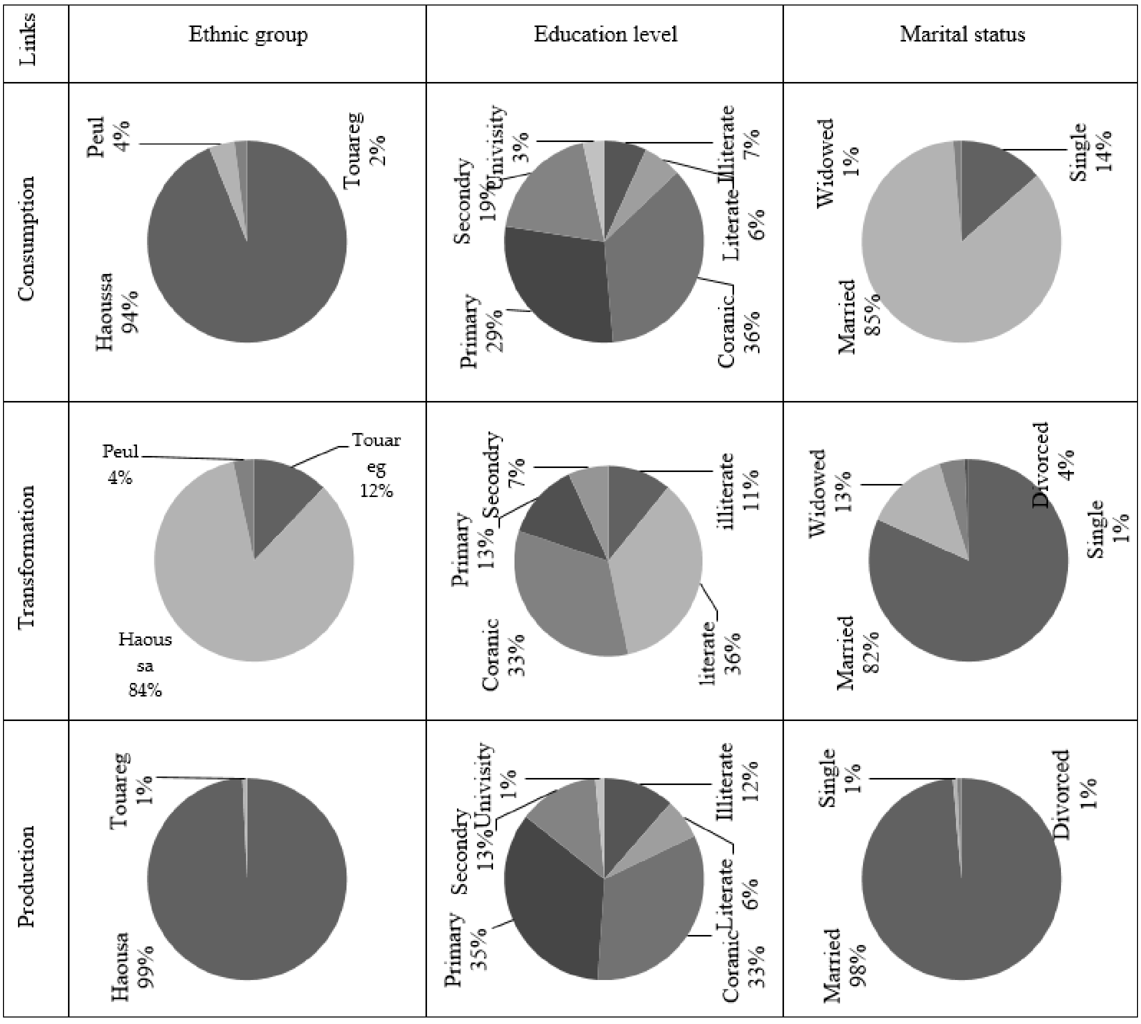

Fig 2: Main sociological characteristics of data collection groups by links

3.2 Choice of cowpea varieties for cultivation

Producers cultivate all local and improved varieties. More than 63% of producers have used improved varieties at least once in their field, including IT 90, KVX, TN 5-78, etc. Each producer takes into account several parameters to sow two to three varieties in their plots in order to mitigate the risk of zero production and diversify their production. The choice of varieties is mainly based on agronomic parameters, production cycle, yield and economic criteria, including demand and price. For example, demand for red cowpea is high on the markets and its selling price is more attractive compared to white cowpeas. Some producers cultivate early maturing varieties to meet the high demand for cowpea in the period preceding the peak of the cowpea harvest season. In addition, various control strategies are combined to avoid periods of high proliferation of crop pests. Thus, early or late maturing varieties, depending on the case, are sown to control crop enemies. The varieties used are generally distinguished by yield, by the color of the seed coat, by the color of the hilum and by the earliness of the production cycle. However, most producers believe that varieties with such characteristics are not resistant to diseases and are often attacked by insects.

3.3 Varieties used for making good Kossai

Kossai value chain actors combine several quantitative and qualitative traits to recognize varieties suitable for making Kossai. The color of the seed coat and hilum are the main traits for recognizing good varieties for Kossai manufacturing. The white or red color of the seed coat and light or black color of the hilum are the main attributes sought for in seeds for making good Kossai. In addition, the seed must be hard, smooth, heavy, oval or elongated in shape and medium to large in size.

All varieties are processed into Kossai as long as they are not altered (borer holes, light weighted etc.). Local varieties are the most used in making good Kossai, followed by KVX and TN5-78, the two most exploited improved varieties. Fifty-nine per cent (59%) of processors say they have used improved varieties to make Kossai. These varieties produce white pastes with very fine particles and a golden-coloured, soft and crumbly Kossai. Also, 82% of processors believe that there are varieties that are better than others in terms of making Kossai. Forty-eight per cent (48%) of the consumers do not know the quality of the variety used for the Kossai they consume.

3.4 Main stages of Kossai manufacturing

A good Kossai begins with mastering the manufacturing process. Forty per cent (40%) of processors say that there are variations in processing skills from one person to another, especially the addition of ingredients depending on the locality. The Kossai manufacturing process is done in six stages, cleaning the seed, Hulling, grinding, molding, mixing and deep frying (Fig 3).

Cleaning consists of winnowing the cowpea seeds, sorting them and removing all impurities (bad seeds, stones and other undesirable products).

Hulling consists of separating the seed coat and hilum from the seed. It is done mechanically at the mill (17%) or by hand (83%) with a mortar and pestle or with a crushing stone.

Then, the soaking begins by putting the crushed seeds in water to facilitate the detachment and cleaning of the seed coats, the hilum not yet removed and also to facilitate the turgor of the grains by absorption of water.

At the milling stage, some processors add several ingredients to give a flavor, an aroma to the product. The quantity of ingredients differs according to the tastes sought for in the region the Kossai is manufactured and consumed. These ingredients are mainly onion, salt and occasionally chili (dry or green) and ginger. Milling consists of grinding the crushed and turgid pieces of cowpea in a mill or with a pestle to produce a paste. All processors use mills, the best grinding tool since it produces pastes of finest and most homogeneous particle sizes.

Kneading consists of beating and mixing up the dough with a spatula, usually the traditional gourd ladle, until white dough is obtained, well aerated for frying. At this stage, water and salt are added to the dough to obtain the desired particle size and viscosity.

Frying involves taking portions of the dough with a spoon (traditional or modern) and gently placing them in boiling oil. The main source of energy is wood for frying Kossai. But some (22%) also use cereal crop residues for cooking due to a lack of wood. Wood is the best source of energy for frying Kossai. It gives a low, uniform and steady fire, easy to manage and without waste (does not produce ash or bad smoke odors) susceptible of giving a taste of smoke to the final product. It also allows for quick frying with uniform products. The majority of processors say that the Kossai is well cooked when the portion of dough takes on a golden red color.

All processors prefer to use cowpea dough than cowpea flour dough because it has a better yield. It is easy to work, gives a good Kossai with a better quality, tender and soft. They believe that most of the steps of the manufacture of Kossai are important with more or less equivalent weight. Nevertheless, kneading and frying constitute the most essential steps for a good manufacture of Kossai. Kneading makes it possible to produce homogeneous dough well mixed with the ingredients. Good frying gives well-presented products, of a good golden color, soft and spicy.

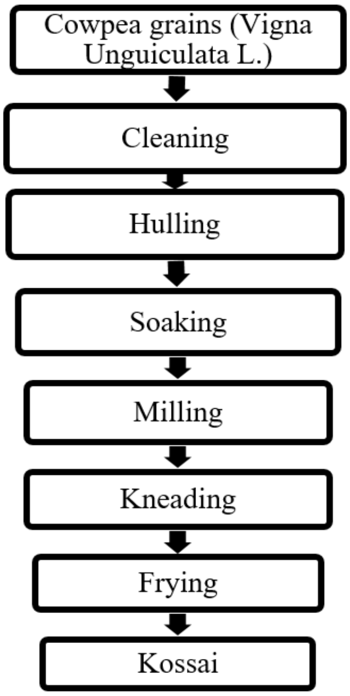

Fig 3: Kossai manufacturing diagram showing the different steps

Kossai manufacturers process an average of 4.5 kg of cowpea per day throughout the whole week. They buy cowpea in small quantities on local markets, from shopkeepers and producers within the village. Sixty per cent (60%) of the processors are interested in the quality (cleanliness, smell) of the cowpea grains they buy. They look for primary qualities of cowpea seeds, such firmness, colors and sizes. They also consider the extent of alteration of the stored seeds by storage insects and are mindful of other long-term storage indicators (such as considerable seed weight loss). They manufacture and sell Kossai every day along the streets. The quality and price of Kossai does not change during the year regardless of the type of cowpea and market conditions. Processors readjust the size of Kossai according to the fluctuation of cowpea price on the market. Eighty-five per cent (85%) of processors are well aware of the qualities sought by consumers. Several qualities are listed, of which the most important are good cooking (well fried), color (golden red), good spice (aromas) and cleanness. The majority (64%) of consumers prefer hot Kossai, with spices (67%) or hot peppers (47%). Others (24%) like warm Kossai in bread. Very few respondents (21%) like cold Kossai. Seventy-two percent of consumers prefer Kossai for its nutritional quality and 28% consume it for other qualitative reasons (pleasure, habits, etc.)

3.5 Cowpea grain attributes for good Kossai by link

Cowpea grains sought for must have some qualities and aptitudes to facilitate its transformation into Kossai. Theses aptitudes vary slightly depending on three main links in the Kossai value chain, namely cowpea producers, Kossai processors/sellers and Kossai consumer. Each group of actors per link constitutes a pole of appreciation of the variety of cowpea, its aptitudes to facilitate the transformation processes and the quality of its Kossai. Most common preferred traits sought for by most of the actors of all the links converge and concern mainly the qualitative characteristics of the seed. The visual attributes sought for by all actors (high frequencies) are the grain consistency, its cleanliness, its flour yield, it's white color coast, the golden color of Kossai as presented in Fig 4.

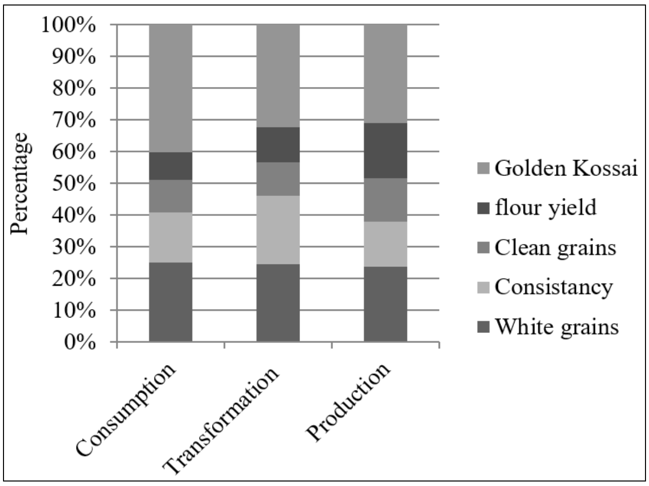

Fig 4: Most frequent attributes according all links

In addition, other less frequent visual attributes such as the round shape of the grains, the color of the hilum, etc. are recorded at the level of all the links. However, some attributes are specific to certain links. Agronomic traits are the main parameters sought for by the actors in the production link. These are early maturing varieties with an average production cycle of 52 days, creeping with a lot of vegetation, with large pods and an average yield of 1,030 tons per ha.

However, industrial traits are characteristics desired by most processors. Seeds must be large in size, oval or round in shape, rich in flours, appropriate nutrients. It should be easily to process into Kossai and less oil-consuming when frying.

In addition to these desired characteristics by producers and processors, there are some organoleptic traits desired by consumers. The Kossai must be golden in color, with a homogeneous texture that is generally smooth or rough to the touch, with a soft, crunchy texture in the mouth. It must give off a pleasant smell deriving from the ingredients used (spices).

4. Discussions

The agronomic attributes sought are identical to the main parameters usually considered in breeding programs (9). The yield must be high, around 1030 kg / ha with heavy seeds, long sizes and large sizes, etc. The production cycle must be early, 56 days on average and which adapt to the agro-ecological conditions of the region considered. This classic scheme is the basis of several works to improve the productivity of Cowpea [19, 29, 30] in stations and in the farming environment by participatory varietal selection (PVS). PVS is a comparative evaluation of the agronomic performances of new varieties created by breeders with those of local varieties. This classic scheme must include from start of breeding at the experimental station all qualitative attributes no less important for users of the final products. Some of these attributes are flour yield, color of the seed coat and color of the hilum.

The results showed that the color of the seed coat plays a key role in the acceptance of cowpea seeds and eating habits [9]. White and red colored seed coats are most appreciated by the actors of the Kossai value chain. These results are consistent with consumer preferences reported in the work carried out in Burkina Faso, Nigeria and Ivory Coast. Preferences vary according to several parameters, sometimes cultural and agro-ecological. White cowpea is appreciated in northern Burkina Faso [31], in northern Nigeria [32] while red remains dominant in central Nigeria [32]. White and red cowpeas are quite popular in northern Ivory Coast [33]. Others do not like the red seed coat but appreciate white or creamy colors [9]. Seed coat colors can certainly be set forth in marketing the product even though color does not give any indication of the industrial characteristics of the product [34]. For marketing reasons, color could definitely serve as an essential trait for improving breeding program. Further work needs to be conducted though to determine the correlation between the color of the seed coat and the industrial and processing properties of cowpea seeds.

In addition to the seed coast color, the cowpea variety must have a good flour yield, flour which absorbs less oil while frying into Kossai. The flours of the desired varieties must produce a golden-colored Kossai, be rich in nutrients and have low oil content. Some of the qualitative attributes have been quantified by the work of [35] which showed that 100 g of Kossai would provide on average a quarter of the Recommended Daily Intake (15-17% in protein, 8-13% in iron, 11% in zinc, 20-26% in magnesium and 16-24% in

vitamin B9). The golden color and the oil content are attributes identified by the actors of the links which constitute the future breeding research to improve the quality of Kossai.
Furthermore, other parameters well appreciated by the actors in the links of the Kossai value chain are little explored in current varietal improvement programs. The consistency of cowpea seeds, their large size and their oval shape are traits often neglected in breeding programs.
The production of Kossai is done in an artisanal way, often by housewives to generate a little personal income. All stages are carried out by hand and using household utensils, except the grinding, which is increasingly done in the mill. The Kossai manufacturing process is divided into 6 stages: Winnowing, hulling, soaking, grinding, kneading and frying, which are similar in most production areas, apart from the addition of variable doses and types of ingredients at certain stages of processing. This result is in accordance with the results of [35] in the manufacture of the cowpea fritter "Ata" in Benin.

5. Conclusion

The actors use all the traditional and improved varieties for the manufacture of Kossai. The transformation process is done in six stages: Winnowing, hulling, soaking, grinding, kneading and frying. Kneading is the most important stage to achieve a better quality Kossai.
The traits sought by the actors are the earliness maturing of the varieties, 56 days cycle on average, high seed yields, around 1030 kg/ha, long pods, well filled with large oval or round seeds, firm, consistent and clean. In addition, the color of the seed coat and the yield of cowpea flour play an important role in its acceptance and preference over other varieties. Suitable varieties must also meet the requirements for the manufacture of good Kossai (less oily and golden in color).
Cowpea breeding programs must consider, in addition to agronomic performance, qualitative trait to create varieties that meet a greater number of characteristics identified by stakeholders in the different links of the Kossai value chain. Future breeding programs must also include the nutritive quality indications inherent to cowpea particularly the protein, vitamins and other antioxidant contents.

6. Acknowledgements

This work was supported by co-financing found from the European Commission and the Bill and Melinda Gates Foundation, "N° FOOD/2019/410-172". This work was facilitated by the Development Smart Innovation through Research in Agriculture (DeSIRA) initiative, including the West Africa Breeding Networks and Extension Empowerment (ABEE) component. Implementation of ABEE project activities was conducted under the coordination of CORAF in collaboration with Institut national de l'Environnement et de la Recherche Agricole (INERA), Institut National de la Recherche Agronomique du Niger (INRAN), Institut Sénégalais de la Recherche Agricole (ISRA), Centre International de la Recherche Agronomique et de Développement (CIRAD) and AfricaRice. We would like to thank all these institutions that supported the completion of this work.
We also thank all investigators who invested to help us in collecting data in the field.

7. References

1. Xiong H, Shi A, Mou B, Qin J, Motes D, Lu W, *et al*. Genetic diversity and population structure of cowpea (*Vigna unguiculata L.* Walp). PLoS One. 2016; 11(8):e0160941.
2. FAO FAOSTAT, 2014. http://faostat3.fao.org/download/Q/QC/E 1/04/2014.
3. Alene AD, Coulibaly O, Abdoulaye T. The world cowpea and soybean economies: Facts, trends, and outlook. Lilongwe, Malawi: Institut International d'agriculture tropicale, 2012, 44.
4. Rawal V, et Navarro DK. The Global of Economy Pulses. Rome, FAO, 2019.
5. SOFRECO UE. Analyse prospective de la chaine de valeur niébé au Niger 2021-2030, 2022.
6. Ministère de l'Agriculture et de L'Elevage. Direction des Statistiques Rapport d'évaluation de la campagne agricole d'hivernage 2018 et Perspectives Alimentaires 2018/2019, 2019, 45.
7. Ministère de l'Agriculture et de L'Elevage. Direction des Statistiques, Rapport définitif de l'Enquête sur les Productions Irriguées, 2020/2021, 2021, 38.
8. Ministère de l'Agriculture et de L'Elevage. Direction des Statistiques, Rapport d'évaluation de la campagne agricole d'hivernage 2021 et Perspectives Alimentaires 2021/2022, 2021, 45.
9. Stoilova T, Pereira G. Assessment of the genetic diversity in a germplasm collection of cowpea (*Vigna unguiculata* (L.) Walp.) using morphological traits, African Journal of Agricultural Research. 2013; 8(2):208-215. Available online at: http://www.academicjournals.org/AJAR DOI: 10.5897/AJAR12.1633 ISSN 1991-637X ©2013 Academic Journals
10. Issoufou OH, Boubacar S, Adam T, Boubacar Y. Identification des insectes, parasites et évaluation économique de leurs pertes en graines sur les variétés améliorées et locale de niébé en milieu paysan à Karma (Niger). International Journal of Biological and Chemical Sciences. 2017; 11:694-706.
11. Issa SA, Kadri A, Adam T. Typologie des insecticides utilisés de stockage de Niébé «Vigna unguiculata (L.) Walp.» comme moyens de prévention contre «Callosobruchus maculatus (Fab.)» (Coleoptera: Bruchidae) au Niger International Journal of Innovation and Applied Studies. 2020; 31(1):34-42. ISSN 2028-9324 © 2020 Innovative Space of Scientific Research Journals http://www.ijias.issr-journals.org/
12. Omoigui LO, Kamara AY, Batieno J, Iorlamen T, Kouyate Z, Yirzagla J, *et al*. Guide sur la production de niébé en Afrique de l'Ouest. IITA, Ibadan, Nigeria, 2018, 65.
13. Mehinto JT, Atachi P, Elégbédé M, Douro Kpindou OK, Tamò M. Efficacité comparée des insecticides de natures différentes dans la gestion des insectes ravageurs du niébé au Centre du Bénin. Journal of Applied Biosciences. 2014; 84:7695-7706. ISSN 1997–5902, http://dx.doi.org/10.4314/jab.v84i1.1
14. Maimouna AH, brahim B, Sitou L, Manuele A Laouali, Saadou M, Barry P. Essai comparatif de l'utilisation des extraits du Neem et du virus entomopathogène MaviNPV dans la gestion des insectes ravageurs du niébé en milieu paysan au Niger, Int. J. Biol. Chem. Sci.

2019; 13(2):950-961. ISSN 1997-342X (Online), ISSN 1991-8631 (Print). Available online at: http://www.ifgdg.org
15. Rabo Y, Ali Abdou M, Abdou L, Mahamane A. Effets comparés de quelques biopesticides et d'un pesticide chimique (cyperméthrine 10 EC) sur les insectes ravageurs et maladies parasitaires du Niébé, *Vigna unguiculata* (L.) Walp (Fabaceae), Rev. Mar. Sci. Agron. Vét. 2021; 9(4):710-717.
16. Idrissa A. Etude de marché des produits de la transformation du niébé. SNV Smart Development Works, 2013, 70.
17. Mahamadou MA, Salissou I, Abdou DG, Adama S, Germain JS. Estimation des rendements et de la rentabilité économique de production de trois cultures: le sorgho, le niébé et la dolique à Djirataoua (Maradi – République du Niger). Journal of Applied Biosciences. 2017; 117:11642-11650. ISSN 1997-5902, https://dx.doi.org/10.4314/jab.v117i1.1
18. Schneider A, Huyghe C. Les légumineuses pour des systèmes agricoles et alimentaires durables, Éditions Quae, 2015.
19. Blade SF, Shetty RVS, Terao T, Singh BB. Recent developments in cowpea cropping systems research, Advances in cowpea research,. Copublication of IITA – JIRCAS. IITA, Ibadan, Nigeria, 1997, 114-128.
20. Giller KE. Nitrogen Fixation in Tropical Cropping Systems. Wallingford: CAB International, 2001.
21. Udvardi M, Poole PS. Transport and metabolism in legume-rhizobia symbioses. Annual Review of Plant Biology. 2013; 64:781-805. Doi: 10.1146/annurev-arplant-050312-120235
22. da Silva AC, Santos DdC, Teixeira Junior DL, da Silva PB, dos Santos ARC. Cowpea: A Strategic Legume Species for Food Security and Health, Legume Seed Nutraceutical Research. IntechOpen, 2019. Available at: http://dx.doi.org/10.5772/intechopen.75158.
23. Singh BB, Chambliss OL, Sharma B. Recent advances in cowpea breeding. Advances in Cowpea Research, Copublishing of IITA - JIRCAS, IITA, Ibadan, Nigeria, 1997, 30-49.
24. Akissoe FL. Consommation des plats traditionnels à base de niébé au Bénin et impact des procédés de transformation sur la qualité nutritionnelle des plats fréquemment consommés (cas des beignets de niébé). Médecine humaine et pathologie. Thèse, Université Montpellier; Université d'Abomey Calavi (Bénin), 2021, 280.
25. Ibrahim IR, Dansi A, Salifou M, Ousmane A, Alzouma A, Alou W. Farmers' practices, utilization, conservation and marketing of Bambara groundnut (*Vigna subterranea* (L.) Verdc.) in Dosso Region, Western Niger. Genetic Resources and Crop Evolution. 2018; 65(7):1907-1914. Available https://doi.org/10.1007/s10722 018-0664-z 14.
26. Hama MO, Amadou I, Daou C, Zhang M. Optimization of the preparation treatment to obtain the desired quality canned cowpea (*Vigna unguiculata*, TN 5-78) variety grown in Sahel region. Songklanakarin Journal of Science and Technology. 2020; 42(3):688-696. Doi: 10.14456/sjst-psu.2020.87
27. Issoufou A, Oumarou SS, Mahamadou EG, Mounkaila AH, Abdoul-Aziz Saidou S. Popularization of traditional processing of cowpea into couscous (Beroua) in the west (Dogondoutchi) and mid-south (Maradi and Zinder) of Niger, Asian Food Science Journal. 2020; 19(1):10-16. Article no.AFSJ.62724 ISSN: 2581-7752
28. Ouendeba B, Siaka Sogoba B. Le mil *Pennisetum glaucum* (L.) R. Br. au Niger: Généralités et résultats de la sélection. Ressources génétiques des mils en Afrique de l'Ouest: Diversité, conservation et valorisation: Actes de l'atelier "diversité, conservation et valorisation des ressources génétiques des mils". Paris (FRA), Niamey: IRD, ICRISAT, 2004, 33-43. (Colloques et Séminaires). ISSN 0767-2896 Diversité, Conservation et Valorisation des Ressources Génétiques des Mils: Atelier, 2002/05/28-29, Niamey.
29. Pasquet RS, Baudoin JP. le Niébé, Amélioration des plantes tropicales, ClRAD et ORSTOM 1997, 1997, 483-505. ISSN 1251-7224 ISBN 2-87614-292-9 ISBN 2-7099-1374-7.
30. Moussa AA, Traoré B, Boubacar Gaoh BS, Abdoussalam I. On-farm participatory evaluation and selection of crop varieties at climate changes in Southern Niger. African Journal of Agricultural Research. 2023; 19(6):572-587.
31. Batieno TB. Genetic analysis of drought tolerance in cowpea. Ph.D. Dissertation. Univ.of Ghana Legon, 2015, 131.
32. Stanton WR. The analysis of the present distribution of varietal variation in: Maize sorghum and cowpea in Nigeria as an aid to the study of tribal movement. The Journal of African History. 1962; 3(2):251-262.
33. Assouman JSK, Diarrassouba N, Yao SDM. Preliminary study on morphological diversity of cowpea accessions [*Vigna unguiculata* (L.) Walp.] collected in the North of Côte d'Ivoire. International Journal of Current Research in Biosciences. 2021; 8(9):1-12. Doi: https://doi.org/10.20546/ijcrbp.2021.809.001
34. Anzara GR, Akaza MJ, Abessika Yao KG. Etude du déterminisme génétique de la couleur du tégument des graines du niébé [*Vigna unguiculata* (L.) Walp.], REV. RAMRES. 2024; 12(01):35-40. ISSN 2424-7235.
35. Akissoé L, Madodé YE, Hemery YM, Donadjè BV, Icard-Vernière C. Hounhouigan DJ, *et al*. Impact of traditional processing on proximate composition, folate, mineral, phytate, and alpha-galacto-oligosaccharide contents of two West African cowpea (*Vigna unguiculata* L. Walp) based doughnuts. Journal of Food Composition and Analysis, 2021, 32. available online at: https://doi.org/10.1016/j.jfca.2020.103753