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Process of *soumbara* (food condiment) from nere (*Parkia biglobosa*) production in Côte d'Ivoire: Newtrends, updates and effects on quality and preference of the food

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Abstract

The aim of this study is to establish and update the soumbara production diagram and consumer preferences for this product. A soumbara production survey was conducted among 750 soumbara producers in 25 villages, with 30 producers per village. A soumbara preference test was conducted on a panel of 108 tasters to determine the most popular product in terms of taste, colour, smell and texture. Scores ranging from 1 to 5 were assigned to these criteria. The soumbara produced in the Korhogo area was the most popular, followed by that from Ferkessédougou and Boundiali. The least popular soumbara was that produced in Katiola. The results revealed two soumbara production processes. Furthermore, principal component analysis (PCA) identified four (4) groups. The first group consisted of the production areas of Odienné and Katiola. The second group consisted of the production area of Boundiali, The third group comprised the production area of Ferkessédougou, and finally, the fourth group comprised the production area of Korhogo.

Keywords: Soumbara; Production surveys; Soumbara production process

1. Introduction

In Côte d'Ivoire, as in other countries in the sub-region, *soumbara* is known by various names such as dawadawa/iruau in Nigeria and Ghana, afitine/sonru/iruau in Benin [1] and nététu in Senegal [2]. *Soumbara* is an affordable source of protein (34-42%), fat (21-37%), carbohydrates (15-17%), minerals (calcium, phosphorus and iron), vitamins (B1 or thiamine, B2 or riboflavin and/or niacin) and essential amino acids for low-income populations [3]. Furthermore, *soumbara* production is a source of income for producers, who are generally illiterate women. Today, *soumbara* production is booming due to growing demand and the income generated by this activity for its main players [4]. This food ingredient is becoming increasingly popular due to its high nutritional value [5]. It is rich in vitamins, particularly B vitamins (thiamine, riboflavin and niacin) [2], as well as minerals such as calcium, iron and phosphorus. In addition to this, certain medicinal properties are attributed to fermented *P. biglososa* seeds, namely lowering blood pressure [6]. The processing of néré seeds into various types of condiments involves technologies that are mostly based on traditional production methods [7 ; 8 ; 9 ; 10]. These fermented food condiments, obtained by fermenting protein-rich seeds, are highly valued for their high nutritional value and organoleptic properties. These traditional technologies are subject to many constraints [11 ; 12]. Little scientific data exists on these production technologies and their constraints. Knowledge of these would be crucial for improvements in technologies for transforming nere seeds into these fermented condiments. This artisanal process relied on the expertise of small producers who make *soumbara* in small

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manufacturing units, originally intended for domestic consumption. The aim of this study is to update the traditional production process of *soumbara* produced in Côte d'Ivoire.

2. Materials and methods

2.1. Data collection and sampling

From July to August 2024, artisanal *soumbara* processors, randomly selected in 31 localities of 5 towns (Korhogo, Boundiali, Ferkessédougou, Odienné and Katiola) (figure 1) in north parts of Côte d'Ivoire, were administered a questionnaire constructed and validated by a questionnaire expert group. *Soumbara* production in these areas has existed since time immemorial. The products (*soumbara*) from these areas are appreciated by consumers. In collaboration with *soumbara* production units, a meeting was organized with selected groups of processors to explain them the objectives of the study. In addition, each participant was given verbal instructions on how to fill in the questionnaire and any other relevant information. The questionnaire was subjected to a preliminary validation on 15 production units to assess its clarity, the suitability of wording, and the average time needed for its completion. Based on this pilot study, necessary modifications were identified and resolved, whereas its results were not included in the final survey. The final questionnaire has been established and has been submitted to the staff on the different production site. All items were multiple-choice questions or statements with 2-6 possible answer choices including true/false and yes/no statements. The data used in this study were also collected by undisguised observations after obtaining the permission of *soumbara* production units owners to investigate and observe their practices during production in their premises. A total of 930 *soumbara* processors were included in the survey with 30 processors per locality (Tableau1). After the survey, four (4) *soumbara* production units within each city were randomly selected. In all, 20 processors were selected from the five s*oumbara* producing towns and 5 samples per processor were collected from each selected production unit for biochemical and sensory analyses. All *soumbara* samples were collected from selected processors immediately after steaming in plastic bags as proposed by producers for retail selling. They were then transported in an icebox directly to the laboratory for analyses.

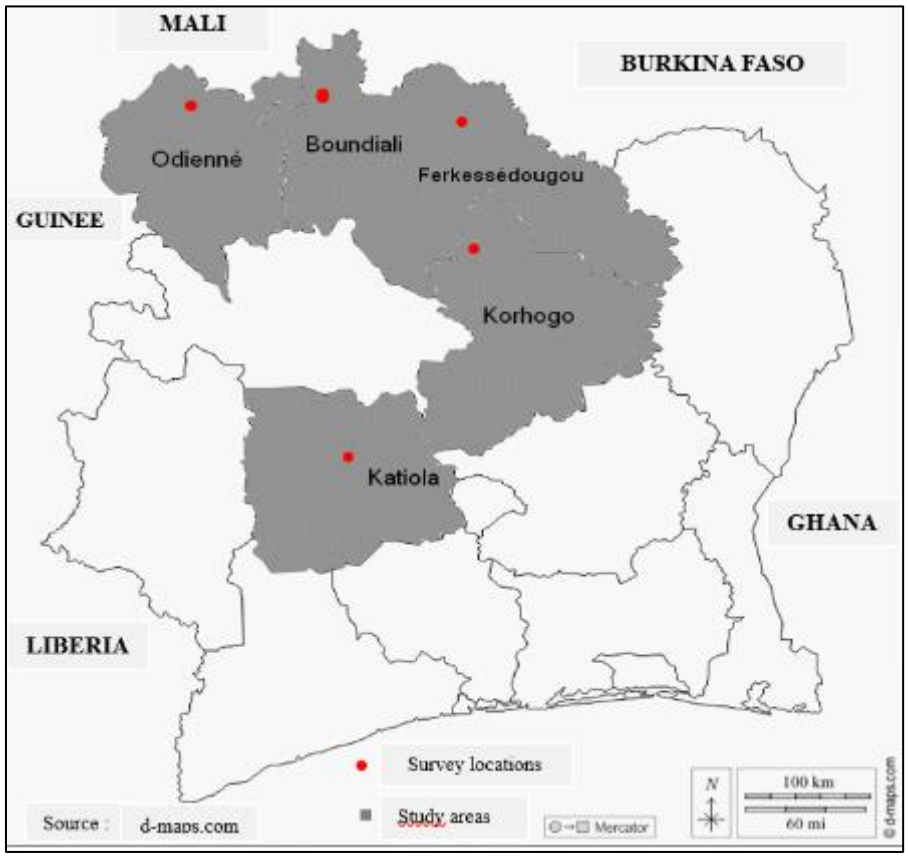


Figure 1 Geographical location of survey sites on the map of Côte d'Ivoire

Table 1 Areas, villages and number of women producers interviewed during the survey

Areas	Villages	Numbers of villages	Number of women producers per village	Total
Korhogo	Waranfèré, Gnalélékaha, Torogokaha, Zienkolo, Dasingbôho	5	30	150
Boundiali	Nondara, Tombougou, Ndara, Guémou, Wozomon	5	30	150
Odienné	Kimbirla, Logbanasso, Namasso, Magala, Kortouba	5	30	150
Ferkessédougou	Korokounouvogo, Tchébingué, Worosantyakaha, Toufogo, Nanbonkaha	5	30	150
Katiola	Kouadianinabogo, Bamoro, Bounadougou, Groumania, Yaossédougou	5	30	150
Total		**25**	**150**	**750**

2.2. Sample analysis

Thirty grams of *soumbara* sample were blended with 70 ml of sterile distilled water and filtered through a Whatman filter paper. The pH was determined on 30 ml of the filtered solution using a pH-meter (pH-meter P107, Consort, Bioblock Scientific, Illkirch, France). The determinations were carried out in triplicates and the mean value recorded. The sensory analyses of *soumbara* samples based on preference test were carried out according to the method described [13]. Volunteers for sensory evaluation panels were sought among students (with at least master level) of the faculty of Food Sciences and Technology from University Nangui ABROGOUA. The panel consisted of 108 assessors, 54 females and 54 males (age range: 23–32). The consumers received no training, however, their cultural attachment to *soumbara* was considered as an advantage for judging the food product. The sensory assessments were held in one session in two classrooms of the faculty at ambient temperature (28–30 °C) and in day light. Seven fresh cooked *soumbara* samples from each production area (at approximately 28±2 °C) were analyzed in this session. Samples were coded by numbers of 3 uncertain numbers in order to hide their origin from the tasters. The products (approximately 100 g) were presented in white porcelain plates with three random digits code according to a monadic profile and after the tasting, samples were classified according to the procedure described [14]. Samples were classified from the most preferred at the lesspreferred. The most prefered was noted 1 and the less prefered was noted 5. Traditionally, *soumbara* is consumed with sauce or condiments. However, for these tests, samples were tested without sauce to avoid the effect the sauce on the assessment.

2.3. Statistical analysis

Data were analyzed using Epi Info 2004 statistical software (Division of Public Health Surveillance and Informatics Epidemiology Program Office, MS K74, Atlanta, Georgia 30341-3717). Descriptive statistics, such as frequency distribution, mean and percentages were employed for the analysis. One-way analyses of variance based on DUNCAN multiple tests with significant level α=0.05 were performed in order to compare biochemical and sensory profiles of *soumbara* samples and also to determine significant differences between them. The software used for the statistical evaluation was XLSTAT (Addinosoft Inc.). This software was also used for the regrouping of *soumbara* according the origin and their quality characteristics. The relationship between *soumbara* varieties and biochemical and sensory attributes was illustrated by Principal Component Analysis (PCA).

3. Results

3.1. Traditional production process

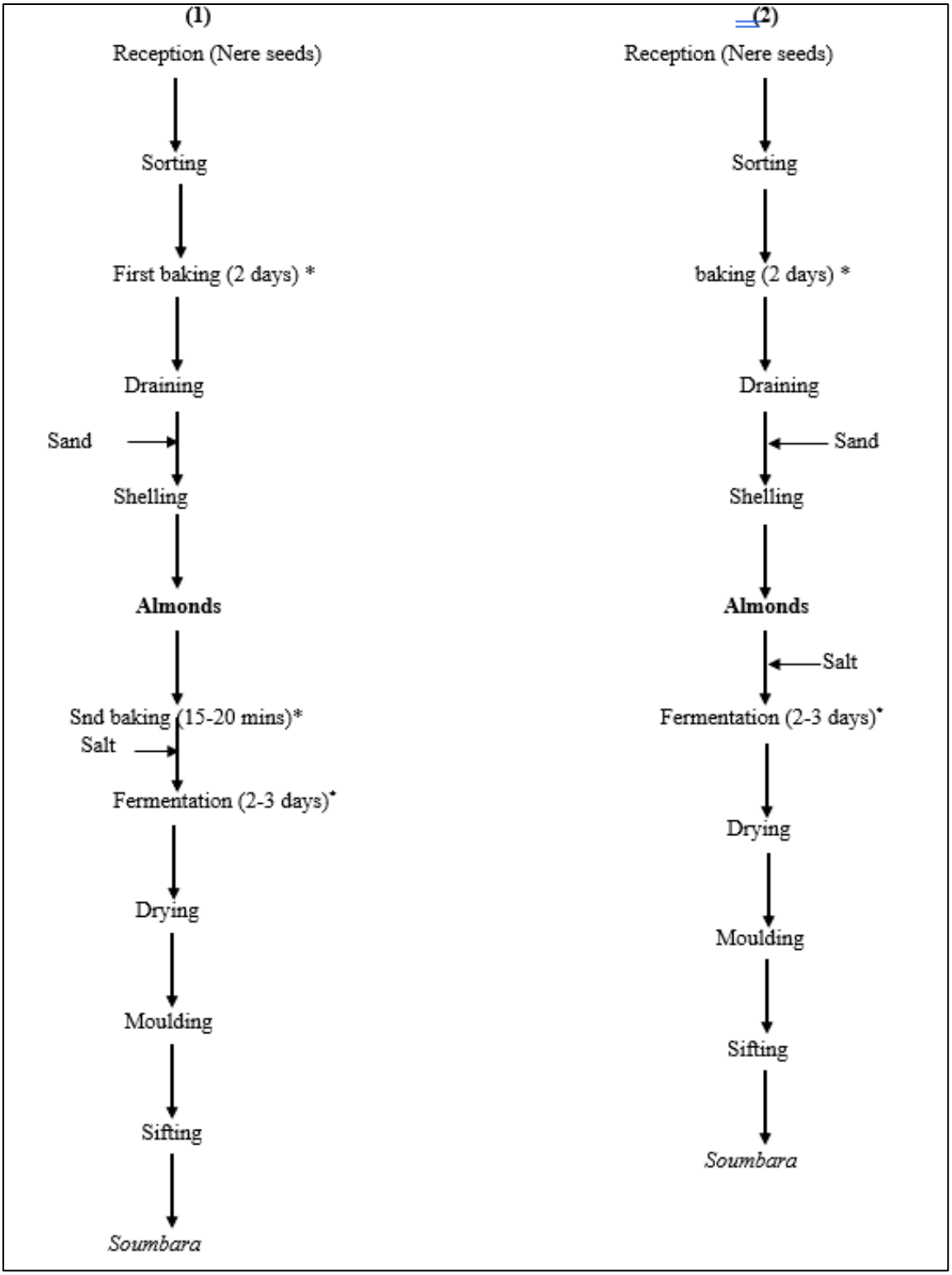
In general, the 750 production sites visited used mature néré seeds to prepare *soumbara*. There are two distinct *soumbara p*roduction processes. The first process is practised in the production areas of Odienné, Korhogo, Ferkessédougou and Katiola. This process involves the following steps: harvesting dried néré, sorting, cooking, draining, shelling, washing, fermenting, drying and grinding to obtain *soumbara* powder before marketing. The second process is carried out in the Boundiali area. This process is similar to the first, but the producers carried out a second cooking process. Regardless of the process, the fermentation time, age of the seeds, origin, drying location, draining time, cooking

time, washing time and husking time varied from one area to another (Figure 2). In the five production areas surveyed, all producers used mature seeds for soumbara production. The néré seeds used for soumbara production came mainly from fields and rural areas. The fermentation period lasted between two and three days maximums according to production areas. Fermentation was carried out for at least 48 hours and no more than 72 hours by producers in the production areas of Odienné, Katiola, Ferkessédougou, Korhogo and Boundiali, respectively. At least 77% of producers in Odienné and Katiola practised fermentation for 72 hours. As for producers in the Korhogo area, 53% also practised this 72-hour fermentation. With regard to drying time, producers used bags plastics, rice bags and often even fabrics for drying (100% of production sites). The drying time varied from more than thirty minutes to often more than a day, depending on the climate. As for cooking, it was carried out in several stages depending on the culture, either two cookings or one cooking. The Boundiali area practised two firings in 48 hours (99% of production sites) while the other four areas carried out a single firing (Table 2). Principal component analysis (PCA) identified four (4) groups. The The first group consists of the production areas of Odienné and Katiola. This group used crates to ferment the product for three days. They used ripe seeds to prepare soumabara. As for the second group, consisting of the production area of Boundiali, the producers in this area used as well as mature seeds for preparation. The third group consisted of the Ferkessédougou production area, where fermentation took place for two to three days with a cooking time of ten hours. For the last group, which is the Korhogo area, the drying time was forty-five minutes with a fermentation time of three days (Figure 3).

Table 2 Percentage (%) of *soumbara* variety used, fermentation time, drying time and cooking time by production area

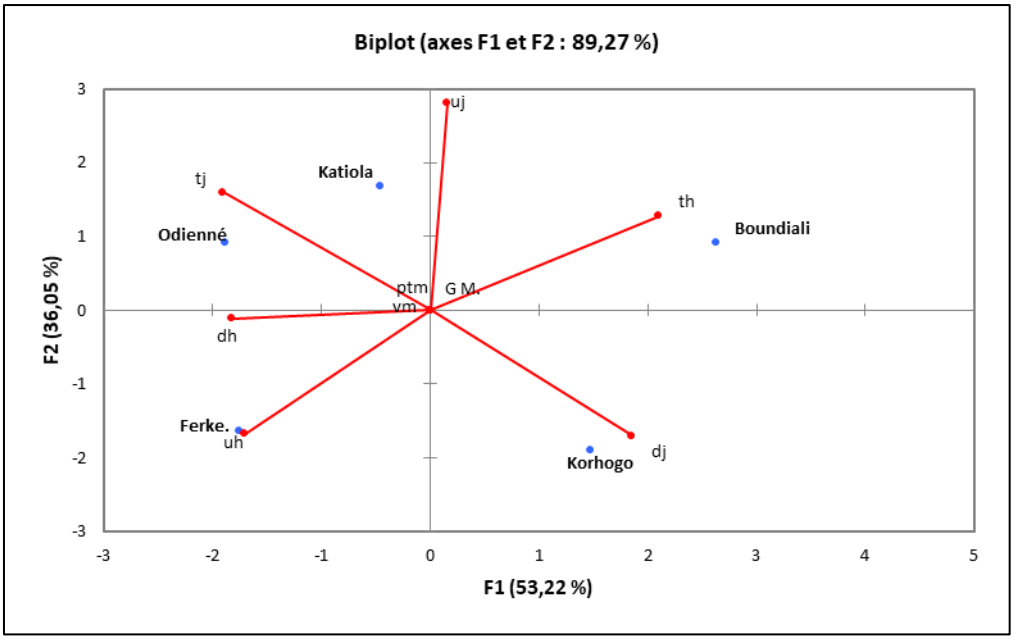
		Production areas				
Settings		**Odienné**	**Boundiali**	**Korhogo**	**Ferke.**	**Katiola**
Variety of seeds	G.M GNM.	100%^{a} 0%^{b}	100%^{a} 0%^{b}	100%^{a} 0%^{b}	100%^{a} 0%^{b}	100%^{a} 0%^{b}
Fermentation time .	24h 48h 72h	1%^{a} 22%^{b} 77%^{c}	1%^{a} 38%^{b} 61%^{c}	0%^{a} 47%^{b} 53%^{c}	0%^{a} 28%^{b} 72%^{c}	1%^{a} 22%^{b} 77%^{c}
Drying time	20 min +30min	0%^{a} 100%^{b}	0%^{a} 100%^{b}	0%^{a} 100%^{b}	0%^{a} 100%^{b}	0%^{a} 100%^{b}
Cooking time	1 h 10 h 48 h	25%^{a} 40%^{b} 35%^{c}	0%^{a} 1%^{b} 99%^{c}	14%^{a} 26%^{b} 60%^{c}	56%^{a} 23%^{b} 21%^{c}	6%^{a} 27%^{b} 67%^{c}

In the same row and column, mean values followed by an alphabetical letter are statistically different (P ≤ 0.05) (TUKEY treatment 5 4.018417 0.05). Fermentation, Drying, Cooking, M.S: mature seeds, U.M.S. :immature seeds



* Steps where there is a difference

Figure 2 Steps in the production of *soumbara*



tj: three days, ptm: more than thirty minutes, vm: twenty minutes, G M: Mature Seeds, dh: ten hours, uh: one hour, dj: two days, uj: one day, th: thirteen hours

Figure 3 Principal component analysis of the different methods of producing *soumbara* de nere

3.2. Consumer preference for nere soumbara

The preference test on soumbara was carried out on a panel of 108 tasters to determine the most popular product in terms of taste, colour, smell and texture. Scores Scores ranging from 1 to 5 were assigned to these criteria. The soumbara produced in Korhogo was the most popular, followed by those from Ferké and Boundiali. The least popular *soumbara* was the one produced in Katiola. (Table 3).

Table 3 Consumer preference for nere *soumbara*

Production areas	Korhogo	Ferke.	Boundiali	Odienné	Katiola
M.N.	4.04±0,75^{a}	3.43±0,73^{b}	3.33±0,72^{b}	3.17±0,55^{b}	2.68±0,79^{c}
O. P.	+				-

On the same line, average values followed by an alphabetical letter are statistically different (P≤ 0.05) (TUKEY treatment 5 4.018417 0.05). O.P.: Order of Preference, M.N.: Average Score, (+): Most Preferred, (-) : Least Preferred

3.3. pH of soumbara

The *soumbara* used for the panel had basic pH values of 7.92±0.01 in the Ferkessédougou area, 8.04±0.01 in the Korhogo area, and 8.01±0.01 in the Boundiali area. 8.03±0.04 in the Odienné area and 8.0±0.04 in the Katiola area. The differences observed are not significant at the 5% threshold. The results are shown in Table 4.

Table 4 pH of *soumbara* in different production areas

Products	Korhogo	Ferke	Boundiali	Odienné	Katiola
pH	8,04±0,01^{a}	7,92±0,01^{a}	8,01±0,01^{a}	8,03±0,04^{a}	8,0±0,04^{a}

On the same line, mean values followed by an alphabetical letter are not statistically different (P≤ 0.05) (TUKEY treatment 5 4.018417 0.05)

4. Discussion

The objective of this study was to establish and update the *soumbara* production diagram and consumer preferences for this product. Néré seeds are collected from fields and markets. This production process is divided into two stages production. A stage in which the first firing varies between two days and the second firing between 15 and 20 minutes.

A second stage in which the firing lasts two to three days. They are then sorted and prepared for more than two to three days. These results corroborate with those of [7], who found that néré seeds undergo an initial cooking process lasting 24-40 hours, followed by a second process lasting 2-4 hours. After cooking, the néré seeds are then shelled in mortar and pestle with the addition of sand. The production of *soumbara* by reducing the cooking time has facilitated the processing of cooked seeds and resulted in a higher quality soumbara [15]. The pre-treatment of néré seeds before cooking by pounding them in a mortar with sand is added, followed by water, to facilitate shelling [4 ; 15 ; 16 ; 17]. Fermentation varies from two (2) to three (3) days with the addition of certain preservatives such as salt and ash. These preservatives have been added to accelerate fermentation. This fermentation varies from one area to another. It also varies within the same country depending on local expertise (endogenous training, ascending/descending transmission, solutions local constraints, marriage and alliance practices in certain localities), dietary habits, or according to short- or long-term use of the product [18 ; 19 ; 9 ; 10]. The kernels obtained are fermented with the addition of salt to accelerate fermentation and inhibit unwanted germs [20]. This hypothesis is supported [21], who stated that clean grains or cotyledons are fermented for 72 hours. Fermentation and, above all, cooking are important points to control [22 ; 23]. Next, the fermented seeds are collected and dried in the sun on sacks. This result is consistent with that of [24], who highlighted these as constraints and limitations of the traditional process. Passive solar drying is a laborious activity because it requires a great deal of care and availability. In addition, the dried seeds are crushed in a mortar with a pestle and then sieved to obtain *soumbara*. The *soumbara* obtained is packaged in plastic bags for sale. Principal Component Analysis (PCA) enabled us to group soumbara production into four (4) groups. The first group consists of Katiola and Odienné. The Odienné area is closer to Guinea, while Katiola is close to neighbouring Burkina Faso, from which they have adapted to their habits. The second group includes the Boundiali area, which is closer to Mali, where producers rely on their expertise. Then there is the third group (Ferkessédougou) and the fourth group (Korhogo), which are in turn located near Burkina Faso, with which they share the same culture and expertise. The *soumbara* produced in the area of Korhogo is more popular with consumers, followed by soumbara produced in the Ferkessédougou, Boundiali and Odienné areas. As for the Katiola area, it is less popular with consumers.

5. Conclusion

The aim of this study was to establish and update the *soumbara* production diagram and consumer preferences for this product. The study shows two production processes. Principal Component Analysis (PCA) enabled us to group soumbara production into four (4) groups. The *soumbara* produced in the Korhogo area is preferred by consumers, followed by that from the Katiola area, which is less preferred by consumers.

Compliance with ethical standards

Disclosure of conflict of interest

The authors hereby declare that there is no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [Koumé Kohi Alfred], upon reasonable request.

Author Contributions

The work was carried out in collaboration among all authors. KOUAME Kohi Alfred designed the study, TANOH Koffi Roger performed the statistical analysis, drafted the protocol, and wrote the first draft of the manuscript, BOUATENIN Koffi Maizan Jean Paul managed the analyses of the study, YARDJOUMA Silué and KOUSSEMON Marina managed the literature searches.

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