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Controlled production trials of conôro, A natural condiment

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Abstract

Fermentation trials of kapok, baobab, and okra seed powders were conducted using microbial strains of Bacillus and lactic acid bacteria isolated from the natural culinary condiments « Conôro » produced in the localities of Bondoukou, western of Côte d'Ivoire. Microbiological, organoleptic, and physicochemical characteristics were determined. These results indicate that the microbial loads of lactic acid bacteria and Bacillus are N= 1.5×10^8/100 g and N=9.1×10^8/100 g with an inoculum volume Vi=10 mL, yielding a culinary condiments with optimal parameters for evaluating the effect of selected potential starter microbial strains. The levels of physicochemicals compounds are high and similar to those of "Conôro" condiments produced under natural conditions. The various culinary condiments produced with bacterial strains can be used as seasonings to enhance the taste of meals. They can also be used to address nutritional deficiencies among malnourished populations in certains regions of the world.

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Introduction

Fermentation is a metabolic process that produces chemical changes in organic substrates through the action of microorganisms (enzymes). It is form of food preservation and improve food nutritional and organoleptic qualities (Omobolanle *et al.*, 2018); in addition, it allows food diversities (Amadou *et al.*, 2011). The condiments are substances intended to season that is to say to raise the taste of food or culinary preparations including sauces. The condiments are on the market either prepare or raw. Usually, in west Africa, many condiments of food flavorings are prepared through traditional methods of fermentation, most often of plant origin, it can be of animal origin or mineral as well (Roberfroid, 2000; Mtasher *et al.*, 2018). In Côte d'Ivoire, there is "Conoro," a natural condiment produced from plant seeds and consumed by many populations in the Bondoukou region. The production of this natural condiment is achieved through spontaneous fermentation of plant seed powder. This spontaneous fermentation leads to the growth of certain pathogenic microorganisms. The aim of this study is to produce natural condiments "Conoro" using bacterial strains of Bacillus and lactic acid bacteria isolated from "Conoro."

Materials and methods

The material consists of seeds from Kapok tree (*Ceiba pentandra* L.), baobab tree (*Adansonia digitata* L.), and okra (*Abelmoschus esculentus* (L.) Moench) harvested at physiological maturity in the Bondoukou region in western Côte d'Ivoire.

Sampling

Seeds of baobab (*Adansonia digitata* L), kapok tree (*Ceiba pentandra* L), and okra (*Abelmoschus esculentus* (L.) Moench) were harvested at physiological maturity in the Bondoukou Department in the Gontougo region, Northeastern Côte d'Ivoire, respectively from the localities of Bondoukou, Laoudi-Bâh, and Kouassi N'dawa. The collected fruits were crushed, and then the seeds were placed in jute bags and transported to the Biocatalysis and Bioprocess Laboratory at Nangui Abrogoua University (Abidjan, Côte d'Ivoire) for analysis. Additionally, "Conôro" fermentations were collected from traditional "Conôro" producers.

Production of baobab, kapok, and okra powders

A separation sorting was performed on 2 kilograms of baobab, kapok tree, and okra seeds to select healthy seeds, which were then washed with tap water. After washing, the seeds were dried in a ventilated drying oven (Biobase, China, Shandong) at 45°C for 72 hours. The dried seeds were ground using a blender (Binatone BLG-555, China, Hong Kong), then sieved using an AFNOR sieve (NFX 11504, 500 µm). The obtained powders were packaged in dry boxes, labeled, and sealed. They were stored in a desiccator at 25°C (AOAC, 1995).

Four (4) formulations of natural "Conôro" were obtained either singly or in combination using natural "Conôro" starters collected from producers in the localities of Bondoukou, Laoudi-Bâh, and Kouassi N'dawa. Ninety grams of each single or combined powder were mixed with 10 grams of starters (Coulin *et al.*, 2006).

Preparation of starter cultures

One hundred µL of each bacterial suspension (lactic acid bacteria and Bacillus) were revitalized in nutrient broths and streaked onto nutrient agar plates for 24 to 48 hours at 30°C. Microbial suspensions were prepared in Buffered Peptone Water from 10-1 to 10-6 dilutions. After decimal dilutions, 100 µL were spread onto respective media. Petri dishes were incubated for 24 to 48 hours, and colonies were counted. Microbial loads were calculated after colony enumeration (CFU/g).

Preparation of inoculum concentrations

Microbial suspensions of 10^6 CFU/mL were prepared for each strain from an optical density of 0.2 nm after microbial enumeration (Omodoro and Aderibigbe, 2013). Each suspension was used to inoculate 100 g of each seed powder for fermentation for 72 hours at 30 °C. The microbial loads of lactic acid bacteria and Bacillus were 1.5 x 10^8 CFU/mL and 9.1 x 10^8

CFU/mL, respectively. Different inoculum volumes corresponding to different microbial loads were prepared as follows:

1. 5 mL of OD 0.2 nm of strains BK4 and BA37 were used to inoculate 100 g of seed powder.
2. 10 mL of OD 0.2 nm of strains BK4 and BA37 were used to inoculate 100 g of seed powder.
3. 20 mL of OD 0.2 nm of strains BK4 and BA37 were used to inoculate 100 g of seed powder.

These fermentation tests allowed us to select, based on a sensory analysis test, the ideal microbial cell load and inoculum volume for the controlled production of natural "Conôro" culinary condiments.

Chemical analysis

Proximate analysis

The moisture content, crude protein, crude fat and crude fibre were determined using the AOAC official method (2005).

Determination of pH

A 10 per cent (w/v) flour – water suspension for each sample was prepared and allowed to settle at room temperature (30 2°C) for 15 min in a clean beaker (200 mL). The pH metre was switched on and allowed for 15 min to stabilize. The electrodes were standardized chemically, and using buffer solution of pH 4, 7 and 9.9, the electrode was then inserted into the test suspension and the pH value read and recorded (Onwuka, 2005). Analysis was conducted in triplicate.

Determination of total titratable acidity

Titratable acidity was determined by weighing 10 g of sample (dry basis) into a mixer containing 100 cm3 distilled water. The mixture was blended for 5 min. The suspension was filtered and 25 cm3 of the filtrate was titrated against 0.1 M NaOH using three drops of phenolphthalein indicator. The titre value was used to calculate the titratable acidity, using the weight of the molar mass of tartaric acid as the equivalent weight of acid (Banigo and Muller, 1972).

Data analysis

Statistical analyses of the various results of physicochemical, mineral, and phytochemical parameters were conducted using STATISTICA 7.1 software. One-way analysis of variance (ANOVA) was performed, and mean comparisons were conducted using the Duncan multiple range test at a significance level of 5%.

Results and discussion

Microbial inoculum size

Tables 1, 2, 3, 4 and 5 presents the mean scores obtained for color, aroma, taste, texture, and overall appreciation of broths obtained from controlled fermentation trials. These trials were conducted to determine the microbial loads to be added to the seed powders to obtain a broth with the best organoleptic characteristics. Thus, different microbial loads (N) and inoculum volumes (IV) were used to inoculate 100 g of seed powder. After 72 hours of fermentation, the analysis of the organoleptic characteristics of the Conôro culinary broths obtained showed that microbial loads of $N=1.5x10^8$/100 g (lactic acid bacteria) and $N=9.1x10^8$/100 g (bacillus) with Vi=10 mL yielded a high-quality culinary broth with the highest ratings for color, aroma, taste, texture, and overall appreciation compared to natural Conôro culinary broth.

The results presented in the following tables demonstrated that regardless of the type of powder used, microbial loads of $N=1.5x10^8$/100 g and $N=9.1x10^8$/100 g with an inoculum volume of Vi=10 mL produced a culinary broth with optimal parameters for evaluating the effect of selected potential microbial starter strains.

This preliminary analysis of organoleptic characteristics based on microbial load led to the selection of loads $N=1.5x10^8$/100 g and $N=9.1x10^8$/100 g with an inoculum volume of Vi=10 mL, thus allowing for the attainment of optimal parameters for assessing the impact of starter microbial strains on the characteristics of Conôro culinary condiments.

Table 1. Acceptability scores of descriptors obtained during the hedonic test of the condiment with kapok powder

		Color	Aroma	Taste	Texture	Overall appreciation
	Negative control	5,50±1,28^{a}	4,83±1,34^{a,c}	4,50±1,27^{a}	5,38±1,28^{a}	4,95±1,38^{a}
	Positive control	5,48±1,45^{a}	4,03±1,36^{c}	4,53±1,85^{a}	5,32±1,43^{a}	4,95±1,49^{a}
Ba37	IV = 5 ml	6,70±0,82^{a}	5,90±1,37^{a}	5,85±1,41^{a,b}	6,72±1,13^{a,b}	6,45±1,24^{a}
	IV = 10 ml	7,38±0,69^{b}	8,12±0,65^{b}	7,43±0,82^{b}	7,15±0,76^{a,b}	8,05±0,57^{c}
	IV = 20 ml	6,40±0,90^{a}	5,93±1,36^{a}	5,72±1,41^{a,b}	6,73±1,20^{b}	5,75±1,28^{a}
BalBk4	IV = 5 ml	6,70±0,80^{a}	6,33±1,39^{a}	6,10±1,11^{a}	6,88±0,95^{a}	6,48±0,93^{a}
	IV = 10 ml	7,13±0,62^{b}	8,00±0,67^{b,c}	6,88±0,81^{b}	7,12±0,95^{b}	7,50±0,92^{b,c}
	IV = 20 ml	6,73±0,87^{a}	5,83±1,25^{a}	5,53±1,34^{a}	6,77±0,95^{a}	6,03±1,17^{a}

IV : Inoculum Volume; Ba37 : Bacillus 37 ; BalBK4 : Lactic acid bacteria BK4

Table 2. Acceptability scores of descriptors obtained during the hedonic test of the condiment with baobab powder

		Colorr	Aroma	Taste	Texture	Overall appreciation
	Negative control	5,42±1,20^{a}	4,68±0,40^{a,c}	4,35±1,31^{a}	5,33±1,12^{a}	5,05±1,03^{a}
	Positive control	5,54±1,04^{a}	4,07±1,22^{c}	4,60±1,06^{a}	5,30±1,07^{a}	4,95±1,24^{a}
Ba37	IV = 5 ml	6,60±0,02^{a}	5,79±0,75^{a}	5,65±1,32^{a,b}	6,77±1,57^{a,b}	6,40±1,18^{a}
	IV = 10 ml	7,40±0,57^{b}	8,20±1,01^{b}	7,49±0,26^{b}	7,25±0,36^{a,b}	8,15±0,17^{c}
	IV = 20 ml	6,32±0,88^{a}	5,89±1,27^{a}	5,76±1,20^{a,b}	6,77±1,28^{b}	5,74±1,08^{a}
BalBk4	IV = 5 ml	6,65±0,70^{a}	6,07±1,39^{a}	6,16±1,01^{a}	6,82±1,33^{a}	6,55±0,83^{a}
	IV = 10 ml	7,22±0,02^{b}	8,16±0,22^{b,c}	6,82±0,61^{b}	7,42±0,75^{b}	7,40±1,01^{b,c}
	IV = 20 ml	6,67±0,40^{a}	5,87±1,33^{a}	5,42±1,15^{a}	6,70±0,86^{a}	6,17±1,10^{a}

Table 3. Acceptability scores of descriptors obtained during the hedonic test of the mixed kapok and baobab condiment

		Color	Aroma	Taste	Texture	Overall appreciation
	Negative control	5,60±1,15^{a}	4,81±1,14^{a,c}	5,10±0,70^{a}	5,45±1,77^{a}	5,05±1,30^{a}
	Positive control	5,39±2,03^{a}	4,13±1,06^{c}	4,45±1,35^{a}	5,28±1,04^{a}	4,79±1,19^{a}
Ba37	Vi= 5 ml	6,78±0,29^{a}	6,00±1,90^{a}	5,90±1,10^{a,b}	6,60±1,28^{a,b}	6,45±1,24^{a}
	Vi= 10 ml	7,40±0,61^{b}	8,09±0,65^{b}	7,54±0,82^{b}	7,50±0,22^{a,b}	8,24±1,13^{c}
	Vi= 20 ml	6,45±0,60^{a}	5,89±1,26^{a}	5,72±1,41^{a,b}	6,73±1,20^{b}	5,81±1,08^{a}
BalBk4	Vi= 5 ml	6,67±0,20^{a}	6,53±1,61^{a}	5,90±1,21^{a}	6,72±0,05^{a}	6,58±0,93^{a}
	Vi= 10 ml	7,38±0,29^{b}	8,10±0,16^{b,c}	7,28±0,81^{b}	7,39±0,70^{b}	7,63±0,92^{b,c}
	Vi= 20 ml	6,82±0,47^{a}	6,08±1,05^{a}	6,15±0,47^{a}	6,61±0,95^{a}	6,10±1,72^{a}

Table 4. Acceptability ratings of descriptors obtained during the hedonic test of the mixed condiment with kapok, baobab, and okra

		Color	Aroma	Taste	Texture	Overall appreciation
	Negative control	5,50±1,18^{a}	4,69±0,74^{a,c}	6,04±1,32^{a}	5,80±1,28^{a}	5,00±0,4^{a}
	Positive control	5,50±0,41^{a}	4,11±1,39^{c}	5,00±1,67^{a}	5,29±1,34^{a}	4,79±0,50^{a}
Ba37	IV= 5 ml	6,40±0,24^{a}	6,00±1,30^{a}	5,87±1,60^{a,b}	6,77±1,13^{a,b}	6,38±1*2,24^{a}
	IV = 10 ml	7,84±0,47^{b}	8,31±0,36^{b}	7,64±1,60^{b}	7,29±1,20^{a,b}	8,34±1,12^{c}
	IV = 20 ml	6,54±0,90^{a}	6,03±0,07^{a}	5,87±1,81^{a,b}	6,82±1,20^{b}	6,29±1,03^{a}
BalBk4	IV = 5 ml	6,79±1,28^{a}	5,97±1,47^{a}	6,40±1,11^{a}	6,72±0,52^{a}	6,55±0,55^{a}
	IV = 10 ml	7,37±0,25^{b}	7,56±0,27^{b,c}	6,88±0,81^{b}	6,79±0,28^{b}	7,29±1,23^{b,c}
	IV = 20 ml	6,80±1,16^{a}	6,88±1,54^{a}	6,17±1,01^{a}	6,87±0,18^{a}	6,33±1,37^{a}

Table 5. Overall acceptability test

		Color	Aroma	Taste	Texture	Overall appreciation
	Negative control	5,50±1,28^{a}	4,83±1,34^{a,c}	4,50±1,27^{a}	5,38±1,28^{a}	4,95±1,38^{a}
	Positive control	5,48±1,45^{a}	3,93±1,36^{c}	4,53±1,85^{a}	5,32±1,43^{a}	4,95±1,49^{a}
Ba37	IV = 5 ml	6,70±0,82^{a}	5,90±1,37^{a}	5,85±1,41^{a,b}	6,72±1,13^{a,b}	6,45±1,24^{a,b,c}
	IV = 10 ml	7,38±0,69^{a}	8,12±0,65^{b}	7,43±0,82^{b}	7,15±0,76^{a,b}	8,05±0,57^{c}
	IV = 20 ml	6,40±0,90^{a}	5,93±1,36^{a}	5,72±1,41^{a,b}	6,73±1,20^{b}	5,75±1,28^{a,b}
BalBk4	IV = 5 ml	6,70±0,80^{a}	6,33±1,39^{a,b}	6,10±1,11^{a,b}	6,88±0,95^{a,b}	6,48±0,93^{a,b,c}
	IV = 10 ml	7,13±0,62^{a}	8,00±0,67^{b}	6,88±0,81^{b}	7,12±0,95^{a,b}	7,50±0,92^{b,c}
	IV = 20 ml	6,73±0,87^{a}	5,83±1,25^{a}	5,53±1,34^{a,b}	6,77±0,95^{a,b}	6,03±1,17^{a,b}

Table 6. Levels of pH, titratable acidity, and moisture content of the produced "Conôro"

		pH	TA (meq/100g DM)	H %
CK	Natural condiment	5,74±0,12^{b}	6,13±0,09^{b}	9,20±0,39^{b}
	Condiment BK4	4,77±0,07^{a}	7,07±0,13^{c}	8,69±0,21^{a}
	Condiment ba37	6,35±0,35^{c}	5,27±0,09^{a}	9,06±0,10^{b}
	Condiment BK4+ba37	5,10±0,15^{b}	6,33±0,17^{b}	8,80±0,45^{a}
CB	Natural condiment	5,70±0,27^{b}	6,20±0,23^{b}	9,14±0,9^{b}
	Condiment BK4	4,75±0,14a	7,20±0,03^{b}	9,73±0,2^{b}
	Condiment ba37	6,41±0,05^{c}	5,07±0,19^{a}	9,21±0,30^{b}
	Condiment BK4+ba37	5,17±0,18^{b}	6,30±0,05^{b}	9,66±0,41^{b}
CKB	Natural condiment	5,80±0,32^{b}	6,16±0,14^{b}	9,23±0,15^{b}
	Condiment BK4	4,57±0,7^{a}	7,43±0,10^{b}	9,57±0,24^{b}
	Condiment ba37	6,33±0,04^{b}	5,22±0,19^{a}	9,22±0,16^{b}
	Condiment BK4+ba37	5,20±0,60^{b}	6,15±0,70^{b}	9,46±0,11^{a}
CKBG	Natural condiment	5,66±0,20^{b}	6,32±0,51^{b}	9,28±0,23^{b}
	Condiment BK4	4,60±0,27^{a}	7,57±0,33^{c}	8,71±0,18^{a}
	Condiment ba37	6,26±0,50^{b}	5,72±0,25^{a}	9,29±0,12^{b}
	Condiment BK4+ba37	5,10±0,55^{b}	6,33±0,16^{b}	9,70±0,50^{b}

The means ± standard deviations, marked with different letters on the same line, are significantly different at the 5% threshold according to Duncan's test. TA: Titratable Acidity; DM: Dry Matter; H: Moisture. CK: Kapok Conôro; CB: Baobab Conôro; CKB: Kapok and Baobab Conôro; CKBG: Kapok, Baobab, and Okra Conôro.

Physicochemical composition of the different produced « Conôro »

The following Table 6 presents the results of the biochemical analyses of the different culinary condiments produced. PH results showed a significant difference at the 5% threshold and were slightly acidic regardless of the type of culinary condiments produced. For condiment obtained with starter cultures, the values ranged from 4.77±0.07 to 6.35±0.35 for Kapok condiment; from 4.75±0.14 to 6.41±0.05 for baobab condiment; from 4.57±0.7 to 6.33±0.04 for the condiment composed of baobab and kapok; and from 4.60±0.27 to 6.06±0.50 for the condiment composed of baobab, kapok, and okra. For natural culinary condiment (with the addition of culinary condiment from a previous production), the pH values were 5.74±0.12, 5.70±0.27, 5.80±0.32, and 5.66, respectively, for condiments made from Kapok, baobab, baobab and kapok, and baobab, kapok, and okra powders. The pH values of condiment produced with the BA37 starter were higher than those of condiments produced by other starter cultures and the natural condiments.

Regarding titratable acidity, a significant difference was observed for each culinary broth produced (5%). These values, for broths from starter cultures produced with kapok tree seed powder, ranged from 5.27±0.09 to 7.07±0.13 meq/100g DM; from 5.07±0.19 to 7.20±0.03 meq/100g DM for baobab seed powders; from 5.22±0.19 to 7.43±0.10 meq/100g DM for broths of mixed kapok and baobab seed powders; and from 5.72±0.25 to 7.57±0.33 meq/100g DM for broths of mixed kapok, baobab, and okra seed powders. The natural broth had values of 6.13±0.09, 6.20±0.23, 6.16±0.14, and 6.32±0.51 meq/100g DM, respectively, for broths made from kapok, baobab, mixed kapok tree and baobab, and mixed kapok tree, baobab, and okra seed powders. The titratable acidity values of broths produced with the BK4 starter were higher than those produced by other starter cultures and the natural broth.

Regarding moisture content, a significant difference (5%) between the values was observed. Broths from the produced starters had values ranging from 8.69±0.21 to 9.06±0.10 for kapok tree powders; from 9.21±0.30 to 9.73±0.2 for baobab powders; from 9.22±0.16 to 9.57±0.24 for mixed baobab and kapok powders; and from 8.71±0.18 to 9.70±0.50 for mixed baobab, kapok, and okra powders. Water contents for broths produced under natural conditions varied between 9.14±0.9 and 9.28±0.23.

The obtained pH values, slightly acidic, are lower than those obtained by Ojewumi *et al.* (2018) ;

Compaoré *et al.* (2020) ; Guissou *et al.* (2020). These acidic pH values could be attributed to the proteolytic activity of fermentative microorganisms. These microorganisms degrade proteins into peptides and then into amino acids during fermentation (Adeniran *et al.*, 2013; Mohammadou *et al.*, 2018). These amino acids are used by microorganisms as a source of carbon and energy (Allangheny *et al.*, 1996). Additionally, the production of ammonia usually accompanies the fermentation of protein-rich foods like netetu, dawadawa, or soumbala (Omafuvbe *et al.*, 2000; Beaumont, 2002). The pH variation could be attributed to the production of ammonia by the protease deaminase enzyme produced by *Bacillus* spp (Odunfa, 1983; Allanghenry *et al.*, 1996; Ouoba, 2003). The ammonia released during fermentation causes variation in the pH of the final products, resulting in a strong ammonia or pungent odor, which tends to mellow during cooking (Ogunshe *et al.*, 2009). Furthermore, this variation could be due to the presence of lactic acid bacteria, which degrade carbohydrates, leading to acidification (Ojokoh *et al.*, 2013). According to Nout (1994), an acidic pH is unfavorable for the growth of pathogenic microorganisms and is an important asset for long-term food preservation. Therefore, these culinary broths could be preserved for a long time and remain free from any attacks by pathogenic microorganisms.

The titratable acidity values range between 5.07 and 7.57 meq/100g DM. This slight variation in titratable acidity could be explained by the variation in the activities of acid and alkaline production during fermentation. These results are similar to those found by Olagunju *et al.* (2018), who evaluated the effect of fermentation time on physicochemical, mineral, and antinutritional parameters during the production of dawadawa condiment. According to these authors, proteolytic activities occurring on the protein and carbohydrate components of the seeds were hydrolyzed into sugars and organic acids (Surkar and Deshande, 1993). Odumodu and Inyang (2006) also attributed the variation in titratable acidity to the production of acids during fermentation.

In the transfo-conservation strategy, drying is a technique for preserving food products. It is necessary for maintaining product stability. The moisture content of the produced culinary broths is substantially similar and ranges from 8.69±0.21 to 9.73±0.2. These values are lower than the CODEX STAN standard (1985) (13.5%). Thus, low moisture content is correlated with long-term preservation and limits the growth of pathogenic microorganisms such as molds (Aryee *et al.*, 2006). Additionally, these moisture contents are lower than those of Néré and soy soumbalas (Fatoumata *et al.*, 2016). This difference could be explained by insufficient drying and the high water absorption-retention capacity of soybean seeds. These high water contents of these soumbalas would favor the proliferation of microorganisms, leading to deterioration during packaging (Popoola *et al.*, 2007). This high moisture content has an influence on fat oxidation and could explain why soybean soumbala has a lower lipid content. Furthermore, these obtained moisture values are similar to those obtained by Parkouda *et al.* (2008) (7.04 to 8.24%) and Olagunju *et al.* (2018) (8.81 to 9.74%) in fermented or unfermented Hibiscus sabdariffa seeds and raw and fermented tamarind. The moisture content of food products provides an indication of their shelf life. According to Zapkaa *et al.* (2010), low moisture content is important for long-term preservation. Thus, the produced culinary broths, if packaged adequately, could be preserved for an extended period.

Proteins, lipids and fibers

The protein contents of the culinary broths showed a significant difference at the 5% significance level (Table 7). For the starter cultures, they ranged from 28.95±0.54 g/100g DM to 29.68±0.17 for the broth with kapok tree; between 28.04±0.2 and 28.64±0.13 for the broth with baobab; between 29.41±0.16 g/100g DM and 30.65±0.17 g/100g DM for the mixed broth of kapok tree and baobab; between 30.12±0.20 and 31.27±0.13 for the mixed broth of kapok tree, baobab, and okra. Culinary condiments produced under traditional conditions had protein contents ranging from 29.30±0.68 g/100g DM to 31.31±0.72 g/100g DM for all seed powders.

Table 7. Levels of proteins, lipids, and fibers content of the produced "Conôro"

	(g/100g Dm)	Protins	Lipids	Fibers
CK	Natural condiment	29,94±0,38^{a}	26,33±0,06^{a}	15,22±0,67^{a}
	Condiment BK4	29,68±0,17^{a,b}	26,43±0,07^{a}	15,41±0,23^{a}
	Condiment ba37	28,95±0,54^{b}	26,61±0,07^{b}	15,76±0,65^{b}
	Condiment BK4+ba37	29,51±0,75^{a}	27,25±0,06^{c}	15,22±0,35^{a}
CB	Natural condiment	29,30±0,68^{b}	24,23±0,07^{b}	16,26±0,22^{b}
	Condiment BK4	28,64±0,13^{a,b}	23,28±0,08^{a}	16,38±0,23^{b}
	Condiment ba37	28,04±0,2^{a}	25,7±0,09^{c}	15,49±0,40^{a}
	Condiment BK4+ba37	28,52±0,26^{a,b}	26,24±0,08^{d}	15,97±0,59^{a}
CKB	Natural condiment	31,31±0,72^{b}	25,06±0,05^{a}	15,32±0,09^{a}
	Condiment BK4	30,65±0,17^{a,b}	25,26±0,04^{b}	15,68±0,27^{a}
	Condiment ba37	29,41±0,16^{a}	25,36±0,17^{a}	15,92±0,64^{a}
	Condiment BK4+ba37	29,84±0,32^{b}	26,61±0,15^{c}	15,59±0,14^{a}
CKBG	Natural condiment	32,15±0,13^{d}	26,40±0,10^{a}	14,49±0,12^{a}
	Condiment BK4	31,27±0,13^{c}	27,62±0,04^{b}	14,64±0,46^{a}
	Condiment ba37	30,68±0,13^{b}	26,47±0,31^{a}	15,17±0,85^{b}
	Condiment BK4+ba37	30,12±0,20^{a}	28,50±0,20^{c}	14,89±0,10^{a}

The means ± standard deviations, marked with different letters on the same line, are significantly different at the 5% threshold according to Duncan's test. TA: Titratable Acidity; DM: Dry Matter; H: Moisture. CK: Kapok Conôro; CB: Baobab Conôro; CKB: Kapok and Baobab Conôro; CKBG: Kapok, Baobab, and Okra Conôro. BK4 : Lactic acid bacteria strains ; ba37 Bacillus strains"

The lipid contents of the different culinary broths produced differed significantly at the 5% threshold. For the starter cultures, the contents ranged from 26.43±0.07 g/100g DM to 27.25±0.06 g/100g DM for broths with CK, from 23.28±0.08 g/100g DM to 26.24±0.08 g/100g DM for broths with CB, from 25.26±0.05 g/100g DM to 26.61±0.15 g/100g DM for broths with CKB, and from 26.47±0.10 g/100g DM to 28.50±0.20 g/100g DM for broths with CKBG. Those produced under traditional conditions had contents ranging from 24.23±0.07 g/100g DM to 26.40±0.10 g/100g DM.

The fiber contents of the different culinary broths produced varied significantly at the 5% threshold. The results of broths produced with starter cultures ranged from 15.22±0.35 to 15.76±0.65 g/100g DM for CK; from 15.49±0.40 to 16.38±0.23 g/100g DM for CB; from 15.59±0.27 to 15.92±0.64 g/100g DM for CKB; and from 14.64±0.46 to 15.17±0.85 g/100g DM. Broths produced under traditional conditions had results ranging from 14.49±0.12 to 16.26±0.22 g/100g DM.

The protein contents of Conôro culinary broths varied significantly at the 5% significance level. The variation in protein content during fermentation could be attributed to its utilization in various metabolic activities of fermentative microorganisms. Indeed, microorganisms contain proteases capable of proteolysis leading to the release of peptides, amino acids, and ammonia. Additionally, the slight variation in protein content may also be due to a decrease in the carbohydrate ratio in the total mass, resulting in a redistribution of nutrient percentages. Bacillus spp. produce several enzymes, including amylase, fructofuranosidase, glucosidase, and galactanase, to degrade carbohydrates into simple sugars used as an energy source by microorganisms. The protein contents of culinary broths are higher than those reported by Dosumu *et al.* (2012) in okpei (21.35 g/100g DM), woro (25.09 g/100g DM), and pete (26.13 g/100g DM) broths but lower than those of Olagunju *et al.* (2018) (48.05-49.48 g/100g DM). The variation in protein content in the different culinary broths produced may be attributed to enzyme synthesis and substrate degradation during fermentation. Furthermore, the high protein content of culinary broths produced under traditional conditions may be due to structural proteins that are integral components of microbial cells.

The lipid content analysis results of broths obtained with starter cultures (23.28±0.08 - 28.50±0.20) are

lower than those found by Compaoré *et al.* (2020) (37.46-40.67 g/100g DM) for controlled production of soumbala with Bacillus starter cultures (Bacillus subtilis and Bacillus amyloliquefaciens). However, they are similar to those of Ojewumi *et al.* (2016) (15-27g /100g DM), who studied the effect of different starter cultures on proteins contained in African condiments with Parkia Biglobosa seeds. They are also higher than those of Oluseyi and Temitayo (2015) (13.5 to 20.1 g/100g DM) and Ire *et al.* (2020) (20.78-24.29 g/100g DM). This variation in lipid contents may be due to the different activities of lipolytic enzymes in the fermentative environment. Indeed, during fermentation, the activity of lipolytic enzymes is faster and increases with temperature. These lipid contents of the different culinary broths produced may be due to the activity of Bacillus microorganisms. Bacillus spp. produce lipases that hydrolyze lipids into fatty acids. Free fatty acid levels vary during fermentation. This variation could be explained by the predominance of certain Bacillus spp. species such as B. subtilis and B. pumilus, which exhibit variable high lipolytic activity during fermentation.

Soluble fibers constitute the majority of dietary fibers. The fiber contents in "Conôro" culinary broths are significant due to the physiological benefits attributed to dietary fibers. Indeed, the insoluble fraction of dietary fibers activates intestinal peristalsis and participates in the binding between bile acids and water for the prevention of diet-induced diseases. Soluble fibers have the ability to increase viscosity, reduce glycemic response, and contribute to lowering blood cholesterol. The fiber contents of culinary broths obtained are higher than those of Oluseyi and Temitayo (2015) (6-7 g/100g DM) and Olagunju *et al.* (2018) (5.69-8.02 g/100g DM).

Conclusion

This study demonstrated that a specific concentration of bacterial inoculum would yield a "Conôro" of good organoleptic quality. This volume also enabled the production of "Conôro" with desirable levels of physicochemical compounds. Consumption could contribute to improving the nutritional status of populations. Furthermore, microbiological analysis would provide insight into the hygienic quality of the produced "Conôro".

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