Original Research Article

Health and nutritionalqualities of precooked sauces producedusing local ingredients

Abstract

Precooked sauces are sauces that are partially or fullyprepared, allowingconsumers to reducepreparation time as well as energycosts. The aim of thisstudywas to evaluate the physicochemical and microbiologicalquality of precooked okra and kapok sauces produced in Ouagadougou. So, 7 samples of okra (OS) and kapok (KS) sauces fromdifferent production batcheswereanalyzed. Physicochemical and microbiologicalanalyzeswerecarried out using standard methods. The results of physicochemicalanalyzesrevealed a significantdifferencebetween pH values, acidity and ash ($p<0.05$). The pH of the sauce samplesrangedfrom 5.45±0.01 to 6.23±0.04. SampleKS2 presented the lowest water content (7.31±0.14%) and KS2 the highest water content (8.53±0.06%). The highest contents of ash, lipids, proteins, carbohydrates, acidityweresrespectively 25.05±0.07% (KS2), 39.68% (OS3), 46.15% (KS2), 29.39% (OS4) and 7.6±1.56% (OS4). The energy valuesrangedfrom 275.38 Kcal/100 g (KS2) to 555.14 Kcal/100 g (OS3). The results of the microbiologicalanalyzesrevealthat 57.14% of the sauces analyzedwere of unsatisfactoryquality for total mesophilicaerobic flora, sporulating flora and yeasts and molds. Regarding total coliforms, thermotolerantcoliforms and *Escherichia coli*, 100% of the sampleswere of satisfactoryquality. An absence of *Salmonella* and *Shigella* wasobservedin 100% of the samplesanalyzed. This studyrevealedthatfor all the germsstudied, 5 of thesamples of precooked okra and kapok saucesanalyzedwere of unsatisfactoryquality and 2 of acceptable quality.

Keywords: Precooked sauces, Healthquality, Nutritional composition, Okra, Kapok

INTRODUCTION

Nowadays, ready-made foods are increasingly in demand due to social and cultural changes. Ready-made foods are defined as partially or fullypreparedfoods for whichsome of the time, energy or cooking skills are taken care of by the manufacturer. According to Hernández-Carrión et al. [1], ready-made foods can bepre-cookedfoods, preparedmeals and variousprocessedproductsthatjustrequireheatingbeforeconsumption. Amongtheseproducts, wefind sauces which can be in the form of liquid, paste, emulsion or suspension based on

spices[2]. A sauce is a culinarypreparationobtainedfrom a mixture of condiments and vegetables. It can be warm, hot or cold intended to beservedwith a fermented or non-fermentedfoodsuch as early, rice, fonio, *attièké* and *placali*[3].

Recently, with new eating habits, sauces have undergone a greatevolution in their production processes, their compositions and theirdiversity. Thus, whenpreparing sauces, we note the use of differentingredientssuch as spices, leaves, tomatoes, salt, herbs, mixtures of herbs, garlic, onions and parsleycontributing to improve the organolepticquality of the latter [3] [2]. Theyconstitute sources of essential nutrients for human nutrition. So, in the production of sauces, food additives and ingredients like vegetables are used. Indeed, vegetables are essential in ourdailydiet. These are rich in nutrients. Sauces are preparationsrich in beta-carotene, iron, zinc, and calcium. This richnesscomesfrom the ingredientsused. Indeed, leafyvegetables are rich in proteins, fiber, minerals, vitamins and antioxidantsimproving the health of consumers[4]. Baobab leaf sauces are rich in beta-carotene (4856µg/100g of driedmaterial) and calcium (2260mg/100g of dry material) according to Nebié[5]. Thus, theyplay an important role in the diet of populations around the world.Vegetables are rich in protein, fiber, minerals and antioxidants. Theyalsoconstitute a source of vitamins, thusimproving the health of consumers[5]. In addition to theirrichness in nutrients, vegetables are available, adapted to our agro-economic conditions and at low production costs[6].

Indeed, sauces play an important role in the diet of several populations around the world and particularly in Africa. Thus, in Burkina Faso, several sauces are produced and verypopularwith local populations, namelysticky sauces (kapok flower, fresh and dry okra, fresh and dry baobab leaves, fresh and dry *bulvanka*), leaf sauces (sorrel, *borombourou*, *kénébdo*), seed sauces (sesame, pistachio, cowpea, palm seed), vegetable sauces (tomatoes, zucchini, onions, cabbage), peanut sauce, fish sauce, mayonnaise, soy. Likewise, in Burkina Faso, the cultural diversity of sauces constitutes an ethnicidentity for certain populations or certain regions. This diversity of sauces isalsoobservedduring the seasons. In the central region of Burkina Faso, the consumption of kapok-based sauce is dominant. As for the Sahel region, the consumption of baobab sauce and okra ispredominant.

In Burkina, the sauce production technologypassed down fromgeneration to generationisexperiencing innovations with the production of precooked sauces. However, thisactivityisembryonic and littleknown to the general public. Thus, withincreasingurbanization and administrative activities, the consumption of precooked sauces allowsworkers and certain households to reduce the time of theirpreparation, the

heaviness of certain tasks and to increase the conservation time of the latter [6]. It is in thiscontextthatmany structures worktoday in the field of the production of precooked sauces in order to facilitatewomen in theirhouseholdtasks and to guarantee the health of increasinglynumerousconsumerswho are demanding on quality.However, the sannitary and nutritionalquality of precooked sauces producedis not welldocumented. So, the aim of thisstudywas to evaluate the nutritional and microbiologicalquality of precooked okra and kapok sauces produced in Ouagadougou.

MATERIAL AND METHODS

Determination of the physicochemicalcharacteristics of precooked sauces

pH and titratableacidity of the sauces analyzed

The pH wasdeterminedaccording to the AOAC method [7] using a pH-meter (HANNA instruments). The titratableacidity wasdeterminedaccording to the French standard NF V05-101 [8]. The following formula wasused to calculate the acidity value.

$$\mathbf{AT\ (mEq/100g) = \frac{N1.V1}{m.Vo} * 10^5}$$

With: AT = total acidity; N1 = 0.1 N NaOHtiter; m = mass in g of the precooked sauce; V0 = volume of the supernatant; V1 = volume of the NaOH solution poured at the equivalence.

Water content

The water content of the precooked sauce sampleswasdetermined by drying according to standard NF V03-707 [9]. The different sauce sampleswereweighedbefore and afterbeing put in an oven at a temperature of 105±02°C for 4 hours. The following formula wasused to calculate the water content (WC):

$$\mathbf{\%\ WC = \frac{M1-M2}{PE} * 100}$$

With: PE = test portion in g; M1 = mass in g of the crucible and the samplebefore drying; M2 = mass in g of the crucible and the sampleafter drying.

Ash rate

The ash rate wasdeterminedaccording to standard ISO-2171 [10] by incineration. A quantity of eachsamplewasweighedbefore and after passing it in an oven at 550°C for 24 hours. The following formula wasused for the calculation:

$$\% \text{ Ash} = \frac{M2 - M0}{M1 - M0} * 100$$

With: M1 = test portion and crucible; M2 = final weight (crucible + calcinedsample); M0 = emptyweight of the crucibles.

Determination of carbohydratess

The precooked sauce powderswereused for the determination of carbohydratessusing the method of Montreuil and Spik[11]. The absorbances (opticaldensity) wereread at 492 nm with a spectrophotometer (Biobase, BK-UV1000). The carbohydrates content wasdeducedfrom the standard curve of carbohydrateswith D-glucose as the referencecarbohydrates.

Proteincontent

The protein content wasdetermined by the Bradford method[12]. The Bovine SerumAlbumin (BSA) wasused as a standard for producing the calibration curve (y = 0.2744 X + 0.0035; R2 = 0.997). The resultswereexpressed in µg per 100 mg of sampleaccording to the followingformula:

$$C = \frac{c * D}{ci} * 100$$

With: C = Protein concentration in µg/100mg of sample or in%; c = concentration of the sampleread on a standard curve; D = dilution factor of the samplesubjected to the assay; ci = initial concentration of the solution to bedosed.

Lipid content

The differentialmethodwasused to determine the lipid content [13]. The following formula wasused to calculate the lipidlevel:

% Lipids = 100 - (% water + % Ash + % Protein + % Carbohydrates)

With: % Lipids = lipid water content; % water = water content; % Protein = protein content; % Carbohydrates = carbohydrate content; % Ashes = ash rate.

Energy value

The theoreticalenergy value of eachsamplewascalculatedaccording to the methoddescribed by Merrill and Watt [14]. Let P, G and L be the respective contents of proteins, carbohydrates and lipids per 100 g of dry matter of the pre-cooked sauce sample to beanalyzed. The energy value of the samplewasdetermined by the followingformula:

Energy value (Kcal/100 g) = P *4 Kcal + G * 4 Kcal + L * 9 Kcal

Microbiologicalqualityassessment

Preparation of diluents, stock solution and decimal dilutions

The preparation of the diluent, stock solution and decimal dilutions wascarried out according to ISO-6887-1 (2017) [15]. Physiological water wasused for the preparation of the stock solution and decimal dilutions. The stock solution wasprepared by introducing a mass of 10 g of eachsample of precooked sauces into a bottlecontaining 90 mL of sterilephysiological water. The stock solution obtained, corresponding to the 10^{-1} dilution, wasused to carry out the decimal dilutions. Thus, a volume of 1 mL of the stock solution wastaken and thenintroducedinto a tube containing a volume of 9 mL of physiological water to obtain the 10^{-2} dilution. The same process wasused to carry out the other dilutions until the 10^{-5} dilution wasobtained.

Seeding

The surface seedingmethodwasused. Seedingwasdone by taking 100 µL of the appropriate solution, previouslywellvortexed, whichwereplaced in Petri dishes and spread using a rake-shaped Pasteur pipette. For eachappropriate dilution by rotating the Petri dishes in several directions. A non-inoculated plate wasconsidered a negative control for each culture medium. All manipulations werecarried out understerile conditions to avoidany contamination. Plates wereincubated at appropriatetemperatures and times.

Enumeration of total mesophilicaerobic flora

Plate Count Agar (PCA) medium wasused for the enumeration of the total mesophilicaerobic flora, after incubation of the inoculated Petri dishes at 37°C for 24 h (ISO-4833,2013) [16].

Enumeration of sporulating flora

The enumeration of the sporulating flora wasdone by heating the appropriate dilutions for 10 min at 100°C.Aftercooling the tubes, seedingwascarried out on PCA medium. Incubation wascarried out at 37°C for 24 h.

Enumeration of total, thermotolerantcoliformsand E. coli

Total, thermotolerantcoliforms and *E. coli*werecounted on Eosinmethyleneblue (EMB) agar after 24 hours of incubation at 37°C for total coliforms NF ISO 4832 -V 08-015 (2006) [17] and 44°C for E. coli and thermotolerantcoliforms NF ISO 4832 -V 08-015 (2006) [17].

Enumeration of yeasts and molds

Sabouraud medium withchloramphenicolwasused for the enumeration of yeasts and molds. Incubation of the seeded Petri disheswascarried out at 30°C for 72 to 120 h (ISO-21527-2, 2008) [18].

Research of Salmonella and Shigella

The search for *Salmonella* and *Shigella*wascarried out according to standard ISO-6579 (2017) [19].

Pre-enrichment

A mass of 25 g of eachprecooked sauce wasintroducedinto 225 mL of buffered peptone water contained in a vialthenincubated at 37 °C for 24 h.

Selectiveenrichment

A volume of 1 mL of the pre-enriched solution wastaken and introducedinto a tube containing 9 mL of Rappaport-Vassiliadis (RV). The mixture wasincubated at 37°C for 24 h.

Isolation

For the isolation of *Salmonella* and *Shigella*, a volume of 0.1 mL of the enriched solution wasinoculated on *Salmonella-Shigella* agar (SS agar). Incubation wasdone at 37°C for 24 h. The presumed Salmonella strainspresentedcolorless, transparent, non-lactose fermenting colonies with H_2S production, with or without a black center. Shigella werecolorless.

Expression of results

The number N of microorganisms per gram of samplewascalculatedaccording to the ISO-7218 standard (2015) [20].

Plates containing a number of colonies between 15 and 300 wereselected for the enumeration of TMAF and sporulating flora. The number N of microorganismswascalculatedusing the followingformula:

$$\mathbf{N}=\frac{\sum \mathbf{c}}{\mathbf{v}.(\mathbf{n1}+\mathbf{0},\mathbf{1n2}).\mathbf{d}}$$

With: N= the total number of microorganisms in colony-forming units/g of the sample (CFU/g); ∑c= the sum of colonies on the Petri dishesretained; d = dilution rate of the first dilution; n1= number of boxes retained at the first dilution; n2= number of Petri dishesretained at the second dilution; n= number of Petri dishes.

Plates containing a number of colonies between 03 and 150 wereselected for the enumeration of total coliforms, thermotolerantcoliforms, *Escherichia coli* and yeasts and molds. The following formula wasused:

$$\mathbf{N} = \frac{\sum c}{\mathbf{n.v.d}}$$

For boxes containing no colonies, the following formula wasused:

$$\mathbf{N} < \frac{\mathbf{1}}{\mathbf{d}}$$

Statisticalanalysis of data

XLSTAT software version 2019 wasused for the statisticalanalysis of the data. Analysis of variance (ANOVA) wasused to compare the differentmeans of the microbiological and physicochemical variables using the Tukey test at the probabilitythreshold p = 0.05. The principal component analysis and the correlation matrix werecarried out using the software R version 4.3.2

RESULTS AND DISCUSSION

Physico-chemicalcharacteristics of pre-cooked sauces

The physicochemicalcharacteristics and nutritional composition of the precooked sauces are recorded in Tables I and IIrespectively. The valuesof the differentparametersvariedfrom one sauce to another. The statisticalanalysisrevealedthatthereis a significantdifferencebetween the average valuesof pH (p=0.0001), acidity (p=0.0001), ash (p=0.0001), but that There is no significantdifferencebetween the water content values(p=0.127).

Table I: Physico-chemicalcharacteristics of the sauces analyzed

Sample	pH	Acidity (%)	Water content (%)	Ash rate (%)
Okra sauce 1	5,55±0,02^{a}	4,00±1,42^{ab}	8,17±1,17^{a}	10,36±0,00^{b}
Kapok sauce 1	5,45±0,01^{a}	6,10±1,56^{cd}	8,53±0,06^{a}	18,92±0,00^{d}
Okra sauce 2	5,83±0,08^{b}	5,00±0,00^{bc}	7,87±0,76^{a}	15,47±0,18^{c}
Okra sauce 3	5,99±0,10^{bc}	6,00±3,55^{cd}	7,62±1,35^{a}	3,20±0^{a}
Okra sauce 4	6,07±0,23^{cd}	7,60±1,56^{d}	7,64±0,51^{a}	15,25±0,89^{c}
Okra sauce 5	6,23±0,04^{d}	2,80±0,57^{a}	8,37±0,06^{a}	19,16±0,23^{d}
Kapok sauce 2	6,07±0,03^{cd}	5,00±1,42^{bc}	7,31±0,14^{a}	25,05±0,07^{e}
P-value	<0,0001	<0,0001	0,127	<0,0001

Legend: In the samecolumn, values withidenticalletters are not significantlydifferent at the probabilitythreshold p = 0.05.

Table II:Nutritional composition and energy value of the sauces analyzed

Samples	Proteins (%)	Carbohydrates (%)	Lipids(%)	Energy value (Kcal)
Okra sauce 1	24.10	20.46	36.92	510.46
Kapok sauce 1	41.96	15.42	15.18	366.08
Okra sauce 2	27.47	27.00	22.19	417.59
Okra sauce 3	28.56	20.93	39.68	555.14
Okra sauce 4	33.21	29.39	14.51	381.00
Okra sauce 5	26.74	21.67	24.06	410.18
Kapok sauce 2	46.15	20.53	0.96	275.38

pH and acidity of precooked sauces

The average pH valuesof the differentsamplesanalyzedvariedfrom 5.45±0.01 (KS1) to 6.23±0.04 (OS5). Sassi et al. (2021) [21]reported a pH of 5.02 in soy-based sauces, slightlylowerthanthose in thisstudy. The variation in pH couldbe due to the activity of microorganismsduring the soaking of the differentrawmaterials or to the composition of the differentrawmaterialsused. Regardingacidity, itvariedbetween 2.80±0.56% (OS5) and 7.60±1.56% (OS4). This variation couldbeexplained by the composition of the differentrawmaterialsused. Nebié (2016) [5]reportedaciditylevelsbetween 2.93±0.43% and 20.52±2.54% for sauces. These valueswere in generalhigherthanthoseobtainedfromthisstudy. High acidity valuescouldinhibit the growth of pathogenic and spoilagemicroorganisms and improve the preservation of sauces.

Water content of the sauces analyzed

The average water content valuesof the analyzedsamplesvariedbetween 7.31±0.14% (KS2) and 8.53±0.06% (KS1). This variation maybe due to the condition of the rawmaterialsused. Tiendrebeogo et al. (2021) [22]reported water contents varyingbetween 11.72±0.13% and

98.81±0% for*kilishi* sauces. These water contents werehigherthanthoseobtained in thisstudy. The low water content of the samplesstudiedis an advantage for the conservation of pre-cooked sauces. In fact, the low water content prevents the development of microorganisms.

Ash rate of the sauces analyzed

The average valuesof the ash content of the differentsamplesanalyzedvariedbetween 3.20±0.00% (OS3) and 25.05±0.07% (KS2). This significant variation couldbe due to the differentrawmaterials and ingredientsused. Nebié (2016) [5] and Tiendrebeogo et al. (2021) [22] reportedash rates varyingrespectivelybetween 1.11±0.06% and 3.74±0.06%; 8.81±0.11% and 14.56±0.18%. These valueswerelowerthanthoseobtained in thisstudy. The high proportion of ash in certain samplesindicatessignificantmineralization of these sauces.

Protein content of the sauces analyzed

The average valuesof protein contents of the different sauces analyzedvariedbetween 24.10% (OS1) and 46.15% (KS2). This variation couldbe due to the quantities of rawmaterialsused, the addition of fish and Soumbaladuring production. These contents obtainedwerelowerthanthosereported by Tiendrebeogo et al. (2021) [22]. The latter reported valuesvaryingbetween 20.00±3.01% and 69.72±3.54% for *kilishi*sauces.

Carbohydrates content of the sauces analyzed

The carbohydrates contents of the precooked sauce samplesrangedfrom 15.42% (KS1) to 29.39% (OS4). The carbohydrates contents obtainedduringthisstudyweregenerallylowerthanthoseobtained by Tiendrebeogo et al. (2021[22]). Theseauthorsreported valueswhichvariedbetween 0.96±0.48% and 52.97±3.51%. The differenttreatmentscarried out during the preparation of sauces and the compositions of these sauces couldexplain the variations in thecarbohydrates content of the different sauces.

Lipid content of the sauces analyzed

The lipid contents of the sauce samplesanalyzedvariedbetween 0.96% (KS2) and 39.68% (OS3). The lipid contents variedfrom one sample to another, thiscouldbe due to the composition of the rawmaterialsused. These valuesweregenerallyhigherthanthoseobtained by Tiendrebeogo et al. (2021) [22]whoreported valuesthatvariedbetween 12.47 ±0.55% and 25.01±0.25% in a study on kilishi sauce bases.

Energy value of the sauces analyzed

The energy valuesof the precooked sauces analyzedrangedfrom 275.38 Kcal/100 g (KS2) to 555.14 Kcal/100 g (OS3). This variation couldbeexplained by the composition of the rawmaterialsused, in particular the lipid content. Tiendrebeogo et al. (2021) [22]reported an energy value of *kilishi*sauce bases, varyingbetween 327.70±52.06 Kcals/100 g and 1715.72±16.37 Kcals/100 g. The energy valuesobtainedduringtheirstudy are higherthanthoseobtainedduring the presentstudy.

Principal component analyzes of precooked sauce samples

The principal component analysisnotedthat the two axes F1 and F2 report 72.12% of the information on the samplesanalyzedconcerning the physicochemicalparameters. SamplesOS1 and OS3 are stronglycorrelatedwithenergy value and lipid content whilesampleOS5 isstronglycorrelatedwithcarbohydrates content, acidity and pH. Figure 1and 2present the result of the principal component analysisandcorrelation matrix respectivelyof the physicochemical and nutritionalcharacteristics of precooked sauces.

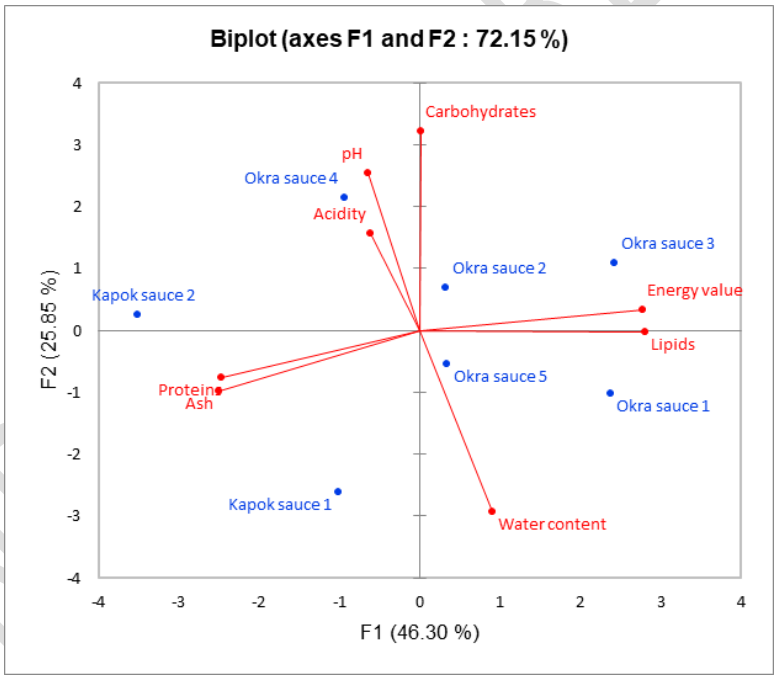

Figure 1. Result of principal component analysis of the physicochemical and nutritionalcharacteristics of precooked sauces

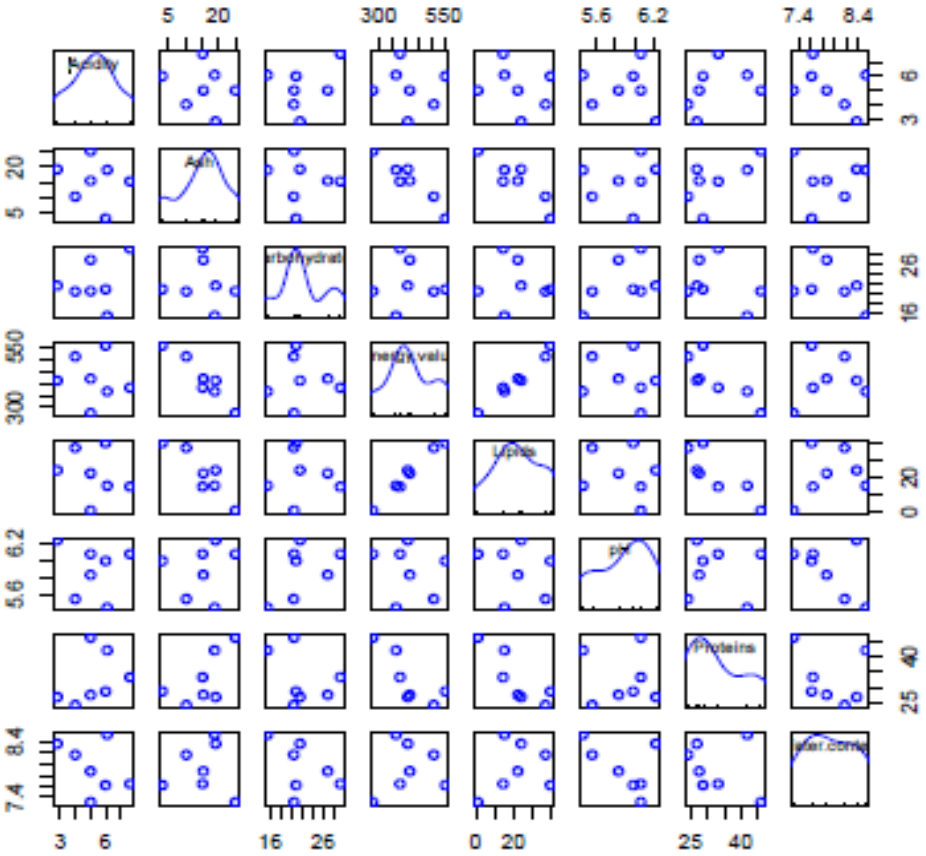

Figure 2. Correlation matrix of physicochemical and nutritionalcharacteristics of precooked sauces

Microbiologicalcharacteristics of the sauces analyzed

The microorganismloads of the sauces analyzedvariedfrom one sample to another. The statisticalanalyzesshowedthatthereis a significantdifferencebetween the loads of sporulating flora (p= 0.004) and yeasts and molds (p< 0.0001) of the different sauce samples. However, there are no significantdifferencesbetween the loads of TMAF (p=0.072), total coliforms (p=1.000), thermotolerantcoliforms (p=1.000) and *E. coli* (p=1.000) of the different sauce samples. The microorganismloads of the sauce samplesanalyzed are recorded in Table III.

Total mesophilicaerobic flora

The TMAFloadings of the analyzed sauces variedfrom $6.00\pm0.00x10^4$ CFU/g (OS1) to $5.00\pm0.00x10^5$ CFU/g (OS5). The TMAFloadingsobtained in thisstudywerehigherthanthosereported by De Souza (2020) [3] in cannedtomatoes. The value reported by thisauthorwas $5x10^1$ CFU/g. According to the guidelines for the interpretation of microbiologicalanalysisresultsfrom Luxemburg (2015) [23], 57.14% of the sampleswere of

unsatisfactoryquality and 42.86% of the sampleswere of acceptable quality for the TMAF. Generallyspeaking, thesemicroorganisms come fromdifferent sources such as the environment, handling and cross-contamination. Theirpresence at loadshigherthan standards couldmean a lack of hygiene in the varioustreatments. De Souza (2020) [3] reportedthat the load of microorganismscouldbeinfluenced by severalfactorssuch as the rawmaterialused, the workingenvironment, the equipment and the storage conditions.

Sporulating flora

The sporulating flora loadsvariedfrom $5.00\pm0.00x10^2$ CFU/g (KS1) to $7.00\pm5.00x10^4$ CFU/g (OS5). According to the interpretation guidelines of Luxemburg (2015) [23], the sampleis of satisfactoryqualityif the loadislessthan 10^3 CFU/g. So, in thisstudy 14.29% of the sampleswere of satisfactoryquality, 28.58% of acceptable quality and 57.14% of unsatisfactoryquality. The presence of sporulating flora in the samplescouldbeexplained by the exposure of the rawmaterial to the open air causing the contamination of the rawmaterials by spores. In the absence of adequateheattreatment, spores can germinatewhen conditions become favorable, leading to contamination of the finishedproduct.

Yeasts and molds

The yeast and moldloads of the sauces analyzedvariedfromlessthan 10 CFU/g (OS1, KS1) to $6.00\pm0.30x10^4$ CFU/g (KS2). Thus 28.58% of the sampleswere of satisfactoryquality, 14.29% of acceptable quality and 57.14% of unsatisfactoryqualityaccording to the recommendations of the guidelines for the interpretation of microbiologicalanalysisresultsfrom Luxemburg (2015) [23]. High yeast and moldloads in sauces couldbeexplained by high humidity. However, the presence of yeasts and moldscould alter the organolepticquality of the food by loweringitsmarketability. Da Silva et al. (2021) [2] reportedyeast and moldloadsbelow 10 CFU/g in sweet and sour sauces. Similarly, Anandsynal et al. (2018) [24] reportedloadingsbetween $5x10^1$ and $5x10^2$ CFU/g in sauces and ketchups.

Total and thermotolerantcoliforms

Total and thermotolerantcoliformloadswerelessthan 10 CFU/g in all sauce samplesanalyzed. The coliformloadsreported in thisstudywerelowerthan the valuesrecommended by the guidelines for the interpretation of microbiologicalanalysisresultsfrom Luxemburg (2015) [23]. Theseloadingsobtained are similar to thosereported by Da Silva et al. (2021) [2] and Anandsynal et al. (2018) [24] in sweet and sour sauces and ketchups respectively. Indeed, the

absence of coliforms in a foodtestifies to the absence of recentfecal contamination and compliance withhygienerulesduringmanufacturing. Theseloads of total coliforms and thermotolerantcoliformsdemonstratesatisfactoryquality in terms of health.

Escherichia coli

*E. coli*loadswerelessthan 10 CFU/g in all sauce samplesanalyzed. Theselow*E. coli*loadscouldbeexplained by compliance with GHP and GMP. The *E. coli*loadsobtained in thisstudycorroboratewiththosereported by Da Silva et al. (2021) [2] in sweet and sour sauces. The *E. coli* loadsreported in thisstudywere consistent with the limit value (lessthan 10 CFU/g) set by the interpretation guidelines of Luxemburg (2015) [23]. Theselowloads of *E. coli* in the sauce samplesdemonstrate the good microbiologicalquality of the latter for this type of germ.

Salmonella and Shigella

Salmonella and *Shigella*were absent in 25 g of all sauce samplesanalyzed. Theseresultscompliedwith the requirements of the guidelines for the interpretation of microbiologicalanalysisresultsfrom Luxemburg (2015) [23] whichrecommends an absence of *Salmonella* and *Shigella* in 25 g of a food. The resultsobtained in thisstudyweresimilar to thosereported by Da Silva et al. (2021) [2]. This authorhadobserved an absence of *Salmonella* and *Shigella* in the sauce samplesanalyzed. This absence of *Salmonella* and *Shigella*couldbeexplained by compliance with GHP and GMP rules. Salmonella and shigella are pathogenicmicroorganismswhosepresencein 25 g of a samplemakes the foodunfit for humanconsumption. The sauces analyzed in thisstudy are therefore of satisfactoryqualitywith regard to *salmonella* and *shigella*.

Takingintoaccount all the germsstudied, twosamples (OS1 and OS2) were of acceptable quality and five samples (OS3, OS4, OS5, KS1, KS2) were of unsatisfactoryquality (Table III). Theseresults show the need to train the producers of these sauces in good hygiene practices to improve the healthquality of the sauces.

Table III:Microbiologicalcharacteristics of the sauces analyzed

Sample	Total mesophilicaerobic flora	Sporulating flora	Yeasts and molds	Total coliforms	Thermotolerantcoliforms	*Escherichia coli*	*Salmonella and Shigella*	Global appreciation
Okra sauce 1	$6.00\pm0.00x10^{4a}$	$7.00\pm4.00x10^{3a}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Acceptable
Kapok sauce 1	$2.00\pm0.00x10^{5a}$	$5.00\pm0.00x10^{2a}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Unsatisfactory
Okra sauce 2	$7.00\pm5.00x10^{4a}$	$1.00\pm0.00x10^{3a}$	$5.00\pm0.00x10^{2a}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Acceptable
Okra sauce 3	$6.00\pm3.00x10^{4a}$	$1.00\pm2.00x10^{4a}$	2.00 ± 0.00^{4ab}	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Unsatisfactory
Okra sauce 4	$3.00\pm0.00x10^{5a}$	$3.00\pm0.00x10^{4ab}$	$4.00\pm3.00x10^{4bc}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Unsatisfactory
Okra sauce 5	$5.00\pm0.00x10^{5a}$	$7.00\pm5.00x10^{4b}$	$8.00\pm2.00x10^{3a}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Unsatisfactory
Kapok sauce 2	$3.00\pm1.00x10^{5a}$	$4.00\pm0.1x10^{4ab}$	$6.00\pm0.3x10^{4c}$	$<10^{a}$	$<10^{a}$	$<10^{a}$	Absence/25g	Unsatisfactory
P-value	0.072	0.004	< 0.0001	1.000	1.000	1.000		

In the samecolumn, valueswithidenticalsuperscriptletters are not significantlydifferent at the probabilitythreshold p = 0.05.

Conclusion

The production of precooked sauces is a technique used to facilitate the preparation of sauces. This present report made it possible to determine the nutritional and microbiologicalquality of the sauce samplesanalyzed. SamplesOS1 and KS2 wererich in protein. SamplesOS1 and OS3 had the highestenergy values. The microbiologicalresultsshowedthat the sauces analyzedwere of satisfactoryqualitywith regard to total coliforms, thermotolerantcoliforms, *Escherichia coli* and *Salmonella* and *Shigella*. At the end of thisstudy, itemergedthatmost of the sauces were of unsatisfactoryquality. Thus, itisnecessary to maintain vigilance during production in order to guarantee the healthsafety of the precooked sauces produced and to preserve the health of consumers. In view of the resultsobtained, training staff on Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP)could help guarantee the healthsafety of pre-cooked sauces.

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