Assessment of the sanitary quality of precooked cereal-based foods produced in Ouagadougou, Burkina Faso

Abstract

Small-scale cereal-based food production companies have recently been growing in Ouagadougou. The promoters of these companies do not always apply good hygiene practices (GHP) during their activities, which can lead to the production of food of unsatisfactory quality, which can threaten the health of consumers. In view of this observation, this study was initiated with the aim of assessing the sanitary quality of four pre-cooked cereal-based foods produced in Ouagadougou's city. Thus, 27 samples of these foods (rice and maize couscous, millet and sorghum *dègue*) were collected and sent to the laboratory. Microbiological and physicochemical analyses using standard methods were performed on these samples. The results obtained show that for all the samples of the four foods, the pH varies from 6.20±0.02 to 7.79±0.01 while the water content varies from 4.80±0.72% to 9.19±0.01%. The dry matter content of the samples was between 90.00±0.01% and 95.20±0.07%. The water and oil absorption capacities of the samples vary from 130.26±5.10% to 162.02±4.20% and from 90.09±0.00% to 115.05±7.03% %. The loads of Total Aerobic Mesophilic Flora (TAMF) and Yeasts and Molds (YM) vary, respectively, from $1.33±0.71x10^2$ CFU/g to $1.24±0.54x10^4$ CFU/g and from <10 CFU/g to $2.20±0.14x10^3$ CFU/g. For most samples, total coliforms (TC) and Thermotolerant Coliforms (TTC) loads were less than 10 CFU/g. *Salmonella-Shigella* was absent from all samples. Referring to the standards, for all the germs studied, 100% of the rice couscous samples, 83.34% of the millet *dègue* samples, 66.66% of the sorghum *dègue* samples, and 77.78% of the maize couscous samples presented satisfactory microbiological quality.

Keywords: Precooked foods, cereals, quality, microbiology, physico-chemistry, Ouagadougou

Introduction

Cereals occupy a primordial place in the global agricultural system. They are considered to be the main source of human and animal nutrition [1]. In Africa, cereals (maize, rice, sorghum, millet, fonio) constitute a staple diet for most populations [2]. According to the results of the 2013 agricultural campaign, cereal production in Burkina Faso mainly focused on maize, rice, sorghum, millet, and fonio [3]. The demographic explosion in urban centers and lifestyles changing are creating new demands on city dwellers. They are on the lookout for quality products, but they are also looking for cereals that are easy and quick to prepare [4]. Thus, the proliferation of artisanal structures for the production of precooked cereal-based foods has occurred in urban centers. However, the inability to observe the requirements for their preparation, packaging, and storage subjects them to microbial contamination, which poses a health risk to consumers [5], [6]. Therefore, some of these structures often produce food whose quality is not always satisfactory, exposing consumers to food-borne diseases. Foodborne diseases affect 600 million people each year worldwide, and 420,000 peoples die from them, including 125,000 children under the age of five [7]. In Africa, annually, 91 million people suffer from foodborne diseases and approximately 137000 die from them, representing 1/3 of global mortality due to foodborne diseases [7]. Similarly, according to Tabassum et al. [8], foodborne diseases are an important cause of morbidity and mortality because millions of people fall ill and many die after ingesting food unfit for consumption. In addition, the production of poor quality food results in a loss of competitiveness and money for food production structures and consumer mistrust [9]. In view of these problems linked to unsanitary foods, this study was initiated to assess the sanitary quality of precooked cereal-based foods produced artisanally in Ouagadougou.

Materials and methods

Sampling

Samples were obtained from production sites located in Ouagadougou, Burkina Faso. Therefore, 27 samples of the four precooked cereal-based foods (rice and maize coucous, sorghum and millet *dègué*), initially packaged in bags of 500g, were taken during different productions. These samples were then transported and stored in the laboratory for physicochemical and microbiological analyses.

Physico-chemical analyses

pH

The pH was determined according to the AOAC [10] method using a pH meter (HANNA instruments). Thus, 10 g of each sample were taken and introduced into a beaker containing 50 mL of distilled water. The pH meter electrode was then rinsed with distilled water and introduced into the mixture after homogenization. The pH value was read on the pH meter screen after stabilization. For each sample, measurements were made in triplicate.

Dry matter and water content

To quantify the dry matter, 5 g of each sample were introduced into an empty crucible of known mass. The whole mixture was placed in an oven at 105°C for 4 h. Then, each sample was cooled and the crucible mass containing the sample was weighed. For each sample, measurements were made in triplicate. The dry matter content was calculated using the following formula:

$$\text{MS (\%)} = \frac{\text{MF} - \text{M0}}{\text{PE}} * 100$$

Legend : MF : Mass of crucible and sample in g ; PE : Test portion in g ; M0 : Mass of empty crucible in g

The water content H (%) was deduced using the following formula:

H (%) = 100 - MS (%)

With: MS (%) : dry matter ; H (%) : water content

Water absorption capacity (WAC)

The water absorption capacity was determined according to the method described by Rodriguez-Ambriz et al. [11].

Oil Absorption Capacity (OAC)

The Oil absorption capacity (OAC) was determined according to the method described by Lin and Zayas [12].

Microbiological analyses

Preparation of culture media

The culture media used in this study were prepared according to the manufacturer's instructions. The obtained preparations were homogenized and sterilized at 121°C for 15 min (except *Salmonella-Shigella* medium). These preparations were then poured into Petri dishes.

Preparation of dilutions and Seeding

Under sterile conditions, 10 g of each sample were added to 90 mL of physiological water. The mixture obtained (dilution 10^{-1}) is then diluted in a cascade up to dilution of 10^{-4}.

For each sample, 0.1 mL of the appropriate dilutions was inoculated onto the culture media previously poured into the Petri dishes and spread using a sterile pipette. These Petri dishes were turned over and incubated at the time and temperature indicated in Table 1.

Table 1. Microorganisms, culture media and incubation conditions

Microorganism	Standard	Culture medium	Temperature and incubation time
TAMF	ISO4833(2003) [13]	PCA	37 °C for 24 hours
TC	ISO4832(2006) [14]	EMB	37 °C for 24 hours
TTC	ISO4832(2006) [14]	EMB	44 °C for 24 hours

YM	NF V08-059 (2002) [15]	SCA	30 °C for 120 hours
SS	ISO6579(2002) [16]	SS Agar	37 °C for 120 hours

TMAF: Total Mesophilic Aerobic Flora; TC: Total Coliform; TTC: Thermotolerant Coliforms; YM: Yeasts and Molds; SS: *Salmonella-Shigella*; PCA : Plate count Agar, EMB : Eosin Methylen Blue, SCA : Sabouraud Chloramphenicol Agar, SS : *Salmonella-Sighella*

The search for *Salmonella–Shigella* was carried out following the steps below:

- Pre-enrichment: 25 g of each sample were introduced into 225 mL of buffered peptone water and incubated at 37°C for 24 h.

- Enrichment in liquid selective medium: 1 mL of the pre-enriched broth was introduced into 9 mL of Rappapport-Vassiliadis (RV) broth and incubated at 37°C for 24 h.

- *Salmonella–Shigella* isolation: A Pasteur pipette dipped in the enrichment medium was used to inoculate *Salmonella–Shigella* agar (SS agar). The plates were then incubated at 37°C for 24 h.

Enumeration

The number of microorganisms in CFU/g of each sample was determined according to standard ISO 4833-2 (2013) [17]:

- For Petri dishes with a number of colonies between 15 and 300, the following formula was used:

$$N\left(\frac{\mathrm{CFU}}{\mathrm{g}}\right) = \frac{\sum \mathbf{C}}{\mathbf{V(n1 + 0.1n2)d}}$$

N : number of microorganisms in CFU/g of product

∑C : sum of colonies

V : volume of inoculum placed in each Petri dishes in mL

n1 : number of Petri dishes retained at the first dilution n2 : number of Petri dishes retained at the second dilution

d : lowest dilution rate retained

- For Petri dishes whose colony sum is less than 15, the following formula was used:

$$N = \frac{\sum C}{V * d * n}$$

- For Petri dishes in which no colonies were observed, the number of microorganisms was considered to be less than 1/d (N< 1 / d).

Results and discussion

Physico-chemical characteristics

pH

During this study, very little variation in pH was observed for the three types of food (Table 2). For these foods, the average pH were 6.30±0.01, 6.33±0.06 and 6.25±0.02 respectively for rice couscous, millet dèguè and sorghum *dèguè*. However, maize couscous has the highest pH, with an average of 7.49±0.17. The relatively high pH of maize couscous can be explained by the frequent use of potash during maize flour production. The pH values obtained during this study are higher than those reported by Angaman et al. [18] and Koné et al. [19], with values of 4.92 and 4.75 in germinated and non-germinated flours, respectively. The pH values obtained during this study are similar to those reported by Sika et al. [20] and Houssou et al. [21], which were respectively 6.75±0.25 and 6.78±0.02 in maize flour summplemented with *safou* (*Dacryodes edulis*) and *yêkè-yêkè* (maize couscous). The pH of the samples studied are generally close to neutral pH, which can be a favorable factor for microbial growth and therefore food spoilage.

Water content

The rice couscous samples had very low water contents of approximately 5% (Table 2) with an average of 5.05±0.26%. The millet and sorghum *deguè* samples had similar water contents with respective averages of 5.87±0.27% and 6.39±0.32%. The maize couscous samples presented the highest water content, with an average of 8.57±0.27%. This significant variation in water content can be explained by the drying conditions. Other authors have reported water contents similar to those recorded in this study. Thus, after the analysis of three flour samples, a humidity varying from 8.30±0.10% to 8.60±0.17% was reported by Yapi et al. [22]. Similarly, Houssou et al. [21] found a water content of 8.25±0.05% in *yêkè-yêkè*. Water contents lower than those obtained in this study, ranging from 3.33 g/100g to 4.66 g/100g), were also reported by Kone et al. [19] in infant flours composed of dehydrated *attiéké* and cashew nuts. N'Goran et al. [23], obtained results from white flours indicating average water content values of between 21.0±10.16% and 39.7±2.02%. Humidity levels below 10% are recommended to preserve the cereal-based product for a reasonable period [24]. Thus, the samples of the foods studied could be easily preserved.

Dry matter

The dry matter content was very high in rice couscous, millet, and sorghum dèguè, with respective averages of 94.94±0.26%, 94.12±0.27% and 93.59±0.32%. For maize couscous, the dry matter content was relatively lower, with an average of 91.42±0.27%. However, these contents are sufficiently high to allow good conservation of this product. Other authors have reported dry matter contents close to those of the present study with values of 91.09±0.99% in germinated corn flour [18] and 92.80±0.57% [20] in maize flour supplemented with *safou*.

Water absorption capacity

The WACs of the samples of the four foods are presented in Table 2. WACs vary little from one sample to another and from one food to another. The WAC values obtained during this study are similar to those reported by Kaur and Singh [25], Ghavidel and Prakash [26], and Angaman et al. [18], respectively, with 128% in cowpea yam flour, 136% in chickpea flour and 116.766±0.462% in sprouted maize flour. However, Gampoula et al. [27] reported a WAC of 191.58% in yam-based infant flour. Indeed, foods with high water absorption capacity have more hydrophilic constituents such as polysaccharides [18]. According to

Nelson-Quartey et al. [28], the presence of lipids in food reduces the binding capacity of water to particular substances, thus limiting WAC.

Oil absorption capacity

The oil absorption capacities of the analyzed couscous samples are presented in Table 2. The OAC values are similar for the two types of couscous and vary from 90.09±00% to 115.05±07.03%. The values obtained during this study are similar to those reported by Angaman et al [18] and Gampoula et al. [27], respectively 109.37±9.261% in sprouted maize flour and 93.33% in yam-based infant flour. However, other authors found higher OAC of 167.78±4.61% to 188.62±6.62% in foods [22].

According to Assielou et al. [29], a high oil absorption capacity is due to the presence of non-polar amino acids in flours. Oil absorption capacity is important in food design because fat acts as a flavor preserver, increases the palatability of foods, and enhances mouthfeel [30] [31]. In addition, OAC is an important property in food preservation because it prevents the development of oxidative rancidity [32].

Table 2. Physico-chemical characteristics of precooked foods

Food	Sample	Water content (%)	Dry matter (%)	WAC (%)	OAC (%)	pH
Rice couscous	**E1**	4.80±0.72[a]	95.20±0.72[a]	157.02±5.00[a]	105.01±10.00[abc]	6.29±0.00[c]
	E2	5.53±0.61[a]	94.47±0.61[a]	154.04±4.02[ab]	110.02±08.01[ab]	6.29±0.01[c]
	E3	5.13±0.61[a]	94.87±0.61[a]	138.02±5.00[c]	95.01±11.00[c]	6.33±0.01[a]
	E4	4.87±0.50[a]	95.13±0.50[a]	136.05±7.03[c]	112.03±09.02[ab]	6.31±0.01[b]
	E5	4.93±0.61[a]	95.07±0.61[a]	162.02±4.20[a]	102.01±00.00[bc]	6.32±0.01[ab]
	E6	5.07±0.70[a]	94.93±0.70[a]	145.08±6.06[bc]	115.05±07.03[a]	6.31±0.01[b]
Maize couscous	**E1**	8.37±0.04[a]	91.63±0.04[a]	145.29±4.01[de]	110.11±10.01[b]	7.79±0.01[f]
	E2	8.32±0.02[a]	91.68±0.02[a]	150.30±6.01[e]	100.10±00.00[b]	7.50±0.01[d]
	E3	8.45±0.02[a]	91.55±0.02[a]	135.27±5.01[ab]	110.15±10.04[b]	7.41±0.01[c]
	E4	8.46±0.16[a]	91.54±0.16[a]	140.28±0.00[cd]	110.31±11.01[b]	7.37±0.01[b]
	E5	8.40±0.03[a]	91.60±0.03[a]	130.26±5.01[a]	100.10±00.00[b]	7.38±0.01[b]
	E6	8.60±0.00[b]	91.40±0.00[b]	135.27±5.01[ab]	90.09±00.00[a]	7.36±0.01[b]
	E7	8.65±0.12[bc]	91.35±0.12[bc]	135.27±5.01[bc]	100.10±09.01[b]	7.38±0.01[b]
	E8	9.19±0.01[d]	90.00±0,01[d]	130.26±0.00[a]	90.09±00.00[a]	7.26±0.02[a]
	E9	8.76±0.01[c]	80.24±0.01[c]	140.28±5.01[bc]	101.10±00.00[b]	7.72±0.02[e]
Millet *dèguè*	**E1**	5.66±0.47[a]	94.33± 0.47[a]	150.03±0.00[a]	ND	6.36±0.04[a]
	E2	6.06±0.60[a]	93/93±0.60[a]	150.03±0.00[a]	ND	6.20±0.02[a]
	E3	5.87±0.30[a]	94.13±0.30[a]	150.03±0.00[a]	ND	6.37±0.02[a]
	E4	6.33±0.50[a]	93.67±0.50[a]	150.03±0.00[a]	ND	6.39±0.01[a]
	E5	5.73±0.37[a]	94.27±0.37[a]	150.03±0.00[a]	ND	6.32±0.00[a]
	E6	5.60±0.56[a]	94.40±0.56[a]	150.03±0.00[a]	ND	6.34±0.02[a]
Sorghum dèguè	**E1**	6.53±0.71[a]	93.46±0.71[a]	160.32±06.53[a]	ND	6.23±0.02[c]
	E2	6.27±0.88[a]	93.73±0.88[a]	145.29±11.23[a]	ND	6.29±0.01[a]
	E3	6.33±0.71[a]	93.67±0.71[a]	148.32±02.51[a]	ND	6.23±0.01[c]
	E4	6.93±0.71[a]	93.07±0.71[a]	150.30±12.24[a]	ND	6.27±0.01[ab]
	E5	6.40±0.66[a]	93.60±0.66[a]	160.15±03.16[a]	ND	6.23±0.00[c]
	E6	5.93±0.71[a]	94.06±0.71[a]	150.12±05.23[a]	ND	6.25±0.00[bc]

In the same column, for each type of food, the values which have the same superscript letter are not significantly different at the threshold of p=0.05

Principal component analysis

Figure 1 illustrates the correlation of the variability of physicochemical and technological parameters depending on the different samples of precooked foods used in this study. Principal component analysis shows that the parameters taken into account in our study can be represented on two axes depending on the different samples considered. The two axes summarize 90.34% of the information in Figure 1. The F1 axis represents 75.28% of the observed variability and the F2 axis, 15.06%.

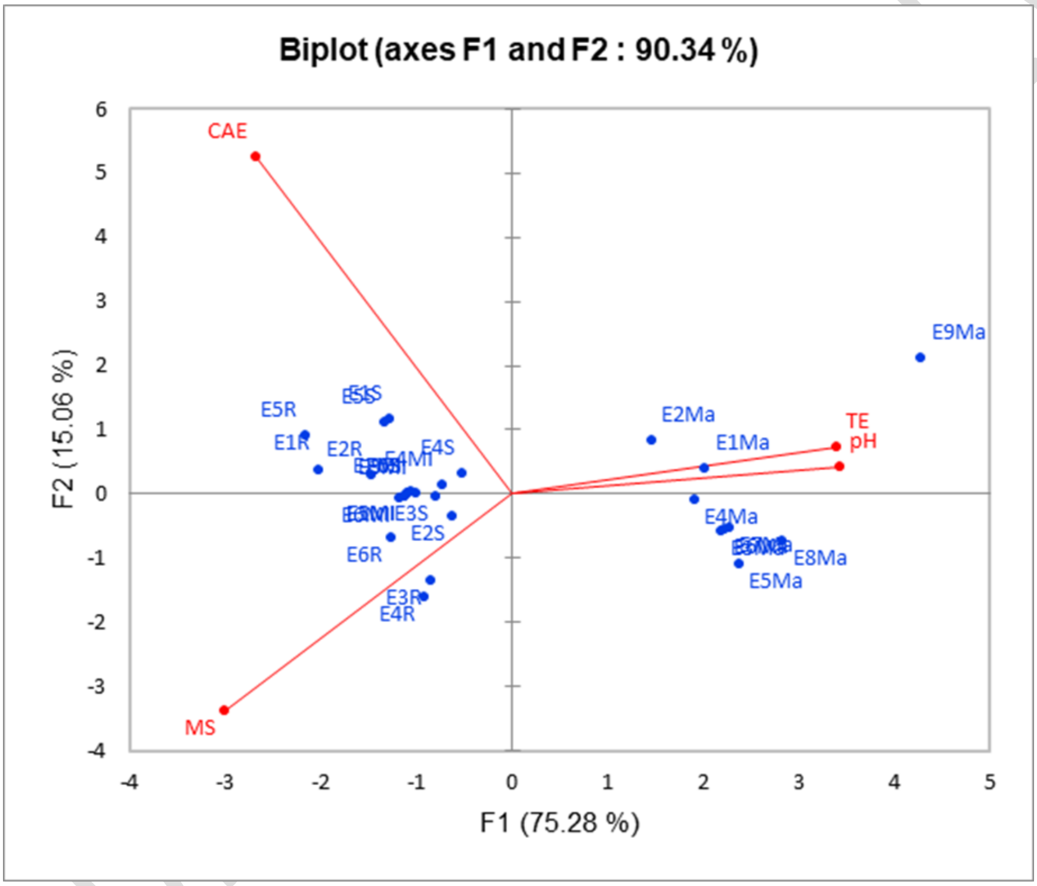

Figure 1: Result of principal component analysis of physicochemical and technological parameters of precooked foods

Microbiological characteristics

Total Mesophilic Aerobic Flora

The results showed that the Total Aerobic Mesophilic Flora **(**TAMF) loads of samples from different foods were relatively similar (Table 3). TAMF loads of rice couscous, millet and sorghum *dègué* samples varied from $1.33 \pm 0.71 \times 10^2$ CFU/g to $8.00 \pm 5.55 \times 10^2$ CFU/g, $1.40 \pm 0.28 \times 10^3$ CFU/g to $2.57 \pm 0.12 \times 10^3$ CFU/g and $1.00 \pm 0.90 \times 10^3$ CFU/g to $6.15 \pm 5.85 \times 10^3$ CFU/g respectively. Maize couscous samples showed relatively higher loadings than the other three foods. This could be explained by the fact that maize couscous samples had higher water contents than other foods. Other authors have found TAMF loadings similar to those recorded in this study. Thus, loads of aerobic mesophilic germs varying from 2.09×10^2 CFU/g to 2.54×10^2 CFU/g were found in flours [20]. Similarly, Houssou et al. [21] obtained TAMF loads of around 4.2×10^4 CFU/g. However, other authors have reported particularly high TAMF loads of 1.8×10^9 CFU/g in flours [23]. The Codex Stan 74 [33] set a limit of 10^5 CFU/g in infant flour. Thus, referring to this limit, all the food samples studied were of satisfactory quality.

Yeasts and molds

Yeast and mold loadings were generally similar in the samples of the four food types (Table 3). These loads are generally around 10^2 CFU/g. A few rare samples have loads lower than 10 CFU/g. The loads obtained during this study are similar to those reported in other studies. Thus, Sika et al. [20] reported fungal loads that varied between 3.4×10^1 CFU/g and 3.8×10^1 CFU/g. Similarly, Houssou et al. [21] reported a yeast and mold load of 5.0×10^1 CFU/g in infant flour. However, other authors have obtained much higher yeast and mold loads during their studies. Therefore, according to Yao et al. [34], the mold load in the three samples obtained just after grinding of the grains varied from 4.6×10^5 CFU/g to 5.6×10^5 CFU/g.

During a study examining the microbiological quality of flours, yeast and mold loads of $5.6x10^6$ CFU/g and $1.9x10^8$ CFU/g, were reported by N'Goran et al. [23]. According to Codex Stan 74 [33], which sets the limit of 10^3 CFU/g of yeasts and molds in infant flours, 1 sample of maize couscous, 2 samples of millet dègué, and 2 samples of sorghum dègué are of unsatisfactory quality.

Total and thermotolerant coliforms

For all samples of the four foods, the total and thermotolerant coliform loads were less than 10 CFU/g. Only three samples of maize couscous showed higher loads for these two types of bacteria (Table 3). The presence of coliforms in certain samples demonstrates non-compliance with hygiene rules in the production of the foods studied. N'Goran et al. [23] reported much higher total and fecal coliform loads than those of the three maize samples in this study. These loads were $1.3x10^6$ and $7.0\ x10^5$ CFU/g for total and thermotolerant coliforms, respectively. However, during a study on infant flour samples, fecal coliforms were not detected according to Sika et al. [20]. Similarly, total coliform loads <1 were reported in a study by Houssou et al. [21]. Referring to which sets a limit of 10^3 CFU/g for total and fecal coliforms in infant flour, only two samples of maize couscous are of unsatisfactory quality.

Salmonella*–*Shigella

During this study, *Salmonella–Shigella* were not found in any of the samples (Table 3). Thus, all samples of the four foods were of satisfactory quality for *Salmonella–Shigella*. These results are similar to those reported by Sika et al. [20] and Angaman et al. [18]. However, during a study on the evaluation of the sanitary quality of flours, N'Goran et al. [23] demonstrated the presence of *Salmonella* in 2 maize flour samples.

Food	Sample	TMAF (CFU/mL)	TC (CFU/g)	TTC (CFU/g)	YM (CFU/g)	SS (in 25 g)	Global appreciation
Rice couscous	E1	1.90±1.30×10^{2ab}	<10	<10	1.20±0.25×10^{2ab}	Absent	Satisfactory
	E2	4.20±2.40×10^{2ab}	<10	<10	3.86±2.10×10^{2a}	Absent	Satisfactory
	E3	8.00±5.55×10^{2a}	<10	<10	2.00±0.41×10^{2ab}	Absent	Satisfactory
	E4	7.20±5.95×10^{2ab}	<10	<10	3.50±2.86×10^{2ab}	Absent	Satisfactory
	E5	3.71±1.07×10^{2ab}	<10	<10	2.00±0.57×10^{2ab}	Absent	Satisfactory
	E6	1.33±0.71×10^{2b}	<10	<10	1.07±0.23×10^{2b}	Absent	Satisfactory
Maize couscous	E1	1.24±0.54x10^{4}c	7.33±4.10x10^{3a}	5.15±2.27x10^{3a}	1.82±0.80x10^{3b}	Absent	Non-satisfactory
	E2	4.60±2.37x10^{3ab}	3.33±1.44x10^{2b}	1.33±0.58x10^{2b}	2.67±1.15x10^{2a}	Absent	Satisfactory
	E3	4.67±2.62x10^{3ab}	<10	<10	4.67±2.52x10^{2a}	Absent	Satisfactory
	E4	3.21±1.40x10^{3ab}	<10	<10	2.67±1.15x10^{2a}	Absent	Satisfactory
	E5	1.81±1.07x10^{3ab}	<10	<10	4.00±1.73x10^{2a}	Absent	Satisfactory
	E6	9.69±5.55x10^{2ab}	<10	<10	<10	Absent	Satisfactory
	E7	7.51±3.77x10^{3b}	3.57±2.56x10^{3b}	2.67±1.15x10^{2b}	2,67±1.53x10^{2a}	Absent	Non-satisfactory
	E8	4.67±2.02x10^{2a}	<10	<10	2,67±1.53x10^{2a}	Absent	Satisfactory
	E9	1.33±0.57x10^{2a}	<10	<10	<10	Absent	Satisfactory
Millet *dègué*	E1	1.40 ±0.28x10^{3c}	< 10	< 10	4.50±1.06x10^{2d}	Absent	Satisfactory
	E2	1.60 ± 0.35x10^{3bc}	< 10	< 10	8.00 ± 2.1x10^{2cd}	Absent	Satisfactory
	E3	2.57±0.12x10^{3a}	< 10	< 10	1.00± 0.28x10^{3bc}	Absent	Satisfactory
	E4	2.50±0.38x10^{3a}	< 10	< 10	1.50 ± 0.14x10^{2a}	Absent	Non-satisfactory
	E5	2.20±0.24x10^{3ab}	< 10	< 10	7.00±0.14x10^{2cd}	Absent	Satisfactory
	E6	2.10±0.80x10^{3abc}	< 10	< 10	1.40 ±0.38x10^{2ab}	Absent	Non-satisfactory
Sorghum couscous	E1	2.35±0.50x10^{3ab}	< 10	< 10	1.60±0.15x10^{3b}	Absent	Satisfactory
	E2	2.20±0.40x10^{3ab}	< 10	< 10	2.200±0.2x10^{3a}	Absent	Non-Satisfactory
	E3	1.00±0.90x10^{3b}	< 10	< 10	8.0±1.5x10^{2d}	Absent	Satisfactory
	E4	2.25±0.75x10^{3ab}	< 10	< 10	2.00±0.1x10^{3a}	Absent	Satisfactory
	E5	6.15±5.85x10^{3a}	< 10	< 10	4.00 ±1.0x10^{2e}	Absent	Satisfactory
	E6	2.55±0.85x10^{3ab}	< 10	< 10	1.10±0.1x10^{3c}	Absent	Non-Satisfactory

Table 3. Microbiological characteristics of precooked foods

In the same column, for each type of food, the values which have the same superscript letter are not significantly different at the threshold of p=0.05

Overall appreciation of the microbiological quality of samples

Taking into account all the microorganisms studied during this work, 22.22% (2/9) of the maize couscous samples, 16.66% (1/6) of the millet *dègué* samples, and 33.33 % (2/6) of the sorghum *dègué* samples were of unsatisfactory quality. All rice couscous samples were of satisfactory quality. For the samples of the four foods studied, 18.51% (6/27) were of unsatisfactory quality (Table 3). Thus, 81.41% of the samples used in this study had satisfactory microbiological quality. This high level of quality is linked to the low loads of microorganisms generally observed in the samples. These low loads could be explained by the very low humidity level in the different food samples studied [20]. Likewise, according to other authors such as Tarhouni et al. [20], cooking/drying coupling during food production would allow a significant reduction in the load of aerobic mesophilic germs and fungi. This could also explain the low microbial loads in the studied foods.

Conclusion

This study showed that precooked foods such as rice and maize couscous and millet and sorghum *dègué* have similar physicochemical and technological characteristics, which are generally acceptable. It also shows that these foods have satisfactory microbiological quality in general, especially in the case of rice couscous. However, some samples had unsatisfactory quality for yeasts, molds, and coliforms. This means that we must raise awareness and train producers of these foods to further increase the quality of precooked foods produced in Ouagadougou.

References

[1] Ghennai A, Zérafa C, Benlaribi M. Study of the genetic diversity of some varieties of soft wheat (*Triticum aestivum* L.) and durum wheat (*Triticum durum* Desf.) according to the characteristics of the U.P.O.V. J Appl Biosci. 2017;113:11246-11256.
[2] Wani AA, Singh P, Shah MA, Schweiggert-Weisz U, Gul K, Wani IA. Rice Starch Diversity: Effects on Structural, Morphological, Thermal, and Physicochemical Properties—A Review. Compr Rev Food Sci Food Saf. 2012;11(5):417-436.

[3] MASA. 2013. Final results of the agricultural campaign and the food and nutritional situation 2012/2013. 0uagadougou. Burkina Faso, pp: 9-11.
[4] Chantereau J, Cruz JF, Ratnadass A, Trouche G, and Fliedel G. Sorghum, Quae editions, Gembloux agronomic presses. 2013;245 p.
[5] Reda N, Ketema B, Tsige K. Microbiological quality and safety of some-street-vendor foods in Jimma Town, Southwestern Ethiopia. Afr J Microbiol Res. 2015;11(14):574-585. DOI: 10.5897/AJMR2014.7326
[6] Komagbe GS, Sessou P, Dossa F, Sossa-Minou P, Taminiau B, Azokpota P. et al. Assessment of the microbiological quality of beverages sold in collective cafes on the campuses of the University of Abomey-Calavi, Benin Republic. J Food Safe & Hyg. 2019;5(2):99-111.
[7] Havelaar AH, Kirk MD, Torgerson PR, Gibb HJ, Hald T. Lake RJ, et al. World Health Organization Global Estimates and Regional Comparisons of the Burden of Foodborne Disease in 2010. PLoS Med. 2015;12(12):e1001923.
[8] Tabassum A, Saha ML, Islam MN. Prevalence of multi-drug resistant bacteria in selected street food and water samples. Bangladesh J Bot. 2018;44:621-627.
[9] Taylor JRN. 2016. Pearl Millet: Overview. Encyclopedia of Food Grains (Second Edition), 1, 190-198.
[10] AOAC, Official Methods of Analysis. (1990). 15th Editions, Washington DC, 808, 831-835, 1113.
[11] Rodriguez-Ambriz SL, Martinez AL, Millan F, Davila-Ortiz G. Composition and Functional Properties of Lupinus campestris protein isolates. Plant Food Hum Nutr. 2005;3:99-107.
[12] Lin CS, Zayas JF. Functionality of Deffated Com Germ Proteins in a Model System: Fat Binding Capacity and Water Retention. J Food Sci. 1987;52:1308-1312.
[13] ISO 4833, 2003. Food microbiology. Horizontal method for the enumeration of microorganisms; colony counting technique at 30°C.
[14] ISO 4832, 2006. Food microbiology, horizontal method for the enumeration of coliforms. Colony counting method. International Standardization Organization.
[15] NF V08-059, 2002. Microbiology of foods. Enumeration of yeasts and molds by colony counting at 25°C. Routine method.
[16] ISO 6579, 2002. Microbiology of foods. Horizontal method for the detection of Salmonella spp.
[17] ISO 4833-2, 2013. Horizontal method for the enumeration of microorganisms: Surface colony counting technique at 30°C.
[18] Angaman DM, Ehouman AAGS, Boko ACE. Physicochemical, functional and microbiological properties of germinated corn flour enriched with edible insect larvae *Rhynchophorus phoenicis* and *Oryctes owariensis*. J Appl Biosci. 2021;158, 16310-16320.
[19] Kone S, Soro D, Koffi EK. Formulation and physicochemical characterization of compound infant flour: Dehydrated Attiéké - Cashew kernel. Int J Innovation Appl Stud. 2019;25(2):700-708.
[20] Sika AE, Kadji BRL, Dje KM, Kone FTM, Dabonne S, Koffi-Nevry AR. Nutritional, microbiological and organoleptic quality of flours made from corn (Zea mays) and safou (*Dacryodes edulis*) produced in Ivory Coast. Int J Biol Chem Sci. 2019; 13(1):325-337.
[21] Houssou PAF, Ahoyo ANR, Metohoue R, Dansou V, Djivoh H, Hotegni AB. et al. Evaluation of the quality of *yêkè-yêkè* (corn couscous) and gambari-lifin (refined corn flour) during storage. Rev Ivoir Sci Technol. 2016;27:136-150.
[22] Yapi JC, Deffan ZAB, Koko AC, Diabagate JR, Kouame Kan KB, Kouame LP. Influence of particle size on the physicochemical and technofunctional characteristics of tiger nut flours (*Cyperus esculentus* l.). Agron. Afr. 2021;33(2):239-250.

[23] N'Goran-Aw EBZ, Coulibaly JK, Assidjo EN, N'Gatta C. Microbiological quality of corn flour marketed on the markets of the city of Abidjan. Rev Mar Sci Agron Vet. 2018;6(4):476-482.
[24] WHO/FAO. 2003. Complementary feeding of young children in developing countries. WHO: Geneva; 130-131.
[25] Kaur M, Singh N. Studies on functional, thermal and pasting properties of flours from different chickpea (*Cicer arietinum* L.) cultivars. Food Chem. 2005;91:403-411
[26] Ghavidel RA, Prakash J. Effect of germination and dehulling on functional properties of vegetable flowers. J Sci Food Agriculture. 2006;86:1189-1195.
[27] Gampoula RH, Dzondo MG, Moussounga JE, Diakabana P, Pambou-Tobi NPG, Sompila AWGT. et al. Development of a process for formulating an infant flour based on yam (*Discorea cayenensis*) enriched with proteins bycorporation d'additifs alimentaires d'origine agricole et de pêche J Biotechnol Biochem. 2020;6 (6):24-32.
[28] Nelson-Quartey FC, Amagloh FK, Oduro I, Ellis WO. Formulation of an infant food based on breadfruit and breadnut. Act Horticul. 2007;757:212 - 224.
[29] Assiélou B, Due EA, Koffi MD, Dabonné S, Kouamé PL. *Oryctes owariensis* Larvae as good alternative protein source : nutritional and functional properties. Annu Res Rev Biol. 2015;8(3):1-9.
[30] Aremu MO, Basu SK, Gyar SD, Goyal A, Bhowmik PK, Datta BS. Proximate composition and functional properties of mushroom flours from *Ganoderma* spp., *Omphalotus olearius* (DC.) Sing. and *Hebeloma mesophaeum* (Pers.) Quél. used in Nasarawa state, Nigeria. Malays J Nutr. 2009;15(2):233-241.
[31] Yadahally NS, Vadakkoot BS, Vishwas MP, Vasudeva S. Nutrients and antinutrients in cowpea and horse gram flours in comparison to chickpea flour : Evaluation of their flour functionality. Food Chem. 2012;13:462-468.
[32] Siddiq M, Ravi R, Harte JB, Dolan KD. Physical and functional cbaracteristics of selected dry bean (*Phaseolus vulgaricus* L.) flour. LWT- J Food Sci Technol. 2010;43:232-237.
[33] Codex Stan 74-1981, 1981. Standard for processed cereal based foods for infants and young children. 8p.
[34] Yao KM, Koffi KM, Kambire O, Dore GCE, Koffi-Nevry R, Boli ZBIA. Influence of Soaking Corn Kernels (*Zea mays* L.) with or without potash on the Fungal and Physico-chemical Quality of Their Flour. Am j food sci technol. 2021;9(1):8-15. doi: 10.12691/ajfst-9-1-2.
[35] Tarhouni A, Djendoubi N, Amri F, Elbour M, Sadok S, Mihoubi BN. Development of an integrated process for valorizing sardinella: effect of temperature and blanching on the nutritional value and microbiological quality of finished products. Bulletin of the National Institute of Marine Sciences and Technologies Salammbô. 2015;42:69-71.