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Physicochemical and Sensory Characteristics of Breads Produced in Some Bakeries in the City of N'Djamena Chad

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Abstract: The physical measurements, proximate composition and sensory characteristics of bread are likely to vary from one bakery to another. The present study aims to determine some physico-chemical parameters and to evaluate the sensory quality of bread produced in bakeries in the city of N'Djamena. A total of twenty-one samples are collected from seven bakeries in N'Djamena. Physical measurements as well as physico-chemical and sensory analysis of these samples are carried out in the laboratory using standard methods. The means of the physico-chemical parameters of the breads from the different studied bakeries show significant differences ($p > 0.05$). The analysis of the sensory characteristics shows a significant difference between the means of the studied parameters, with the exception of taste. Indeed, our results show that the average moisture content of the samples, depending on the bakery, varies from 20.07% to 26.91% and the ash content varies from 1.44% to 2.58%. The protein and lipid content vary from 8.58% to 10% and from 0.83% to 1.80% respectively. The three Hybah bakeries had the highest scores for bread color, texture and overall acceptability compared to that from the other four bakeries. Nevertheless, the application of good hygienic and manufacturing practices must be rigorously followed to ensure consumers health.

Keywords: Bread, Hygiene, Physicochemical Characteristics, Sensory, N'Djamena

1. Introduction

Cereal intake plays a major role in the human diet [1]. Wheat is one of the most important cereals in the world, whose milled grains give a bread-making flour, indiscriminately used in bakery and pastry making. It is rich in gluten, and it allows for airy bread according to Madragule [2]. Bread consumption in many countries, especially in sub-Saharan Africa is increasing due to urbanization, but there is a challenge in meeting the supply and demand of bread to match the dietary habit of consumers [3]. The bakery industry is challenged to produce bread with improved nutritional, physicochemical and sensory characteristics due to the increased consumer demand for healthy and high-quality bakery products [4].

In Chad, a country whose population's diet is mainly based on cereals (Sorghum, millet) and roots and tubers (cassava, potato, taro), supplemented by legumes [5]. Bread is now the third most consumed food by Chadians in urban and semi-urban centers after boule (local meal) and meat. In the capital N'Djamena alone, an average of more than 2 million baguettes are consumed per day, or about 10 baguettes per family [6]. However, little or no information is available on the nutritional and sensory quality of the breads made and sold in N'Djamena, where there are about 100 operating bakeries. Yet, physicochemical properties such as color, volume and texture affect the quality of bread which could be influenced by other factors, such as the type of flour,

additives and other ingredients [7].

Indeed, the ingredients used and the types of processes could influence the quality of the bread. As a result, the physico-chemical and sensory characteristics could vary from one bakery to another. Hence the interest of this study whose general objective is to evaluate the nutritional quality of locally produced bread in the city of N'Djamena. More specifically, the physical characteristics, proximate composition and organoleptic properties of the breads are determined.

2. Materials and Methods

This is a prospective descriptive study that takes place in N'Djamena. The study focus on physicochemical and sensory analyses of bread. The analyses are carried out at Laboratoire de Recherche en Sciences des Aliments et Nutrition (LaRSAN) of the Faculty of Human Health Sciences of the University of N'Djamena.

2.1. Materials

2.1.1. Biological Materials

Baked breads from different bakeries in N'Djamena is subjected to various physicochemical and sensory analyses.

2.1.2. Sampling Equipment

It includes the following elements:

Sterile bags and boxes served as containers for the samples.

A cooler that allowed us to collect the samples from the bakeries to the Laboratoire de Recherche en Sciences des Aliments et Nutrition (LaRSAN) of the Faculty of Human Health Sciences (FSSH).

2.2. Methods

2.2.1. Sampling

The collection of the twenty-one samples (3 samples per bakery) is done under controlled conditions in order to avoid any physical loads that could influence the analyses to be performed. The samples are analysed at LaRSAN of the Faculty of Human Health Sciences of the University of N'Djamena.

2.2.2. Physical Measurements of Bread

Mass: The objective is to determine the mass of the bread. To do this, bread samples from each bakery are successively weighed. The measurement is made on a tared scale. The mass (m) in grams is displayed on the screen once the bread is placed on the scale.

Volume: The volume of the bread is measured by the seed displacement method [8] with a slight modification, the millet grains are replaced by sand grains. The volume of the bread is calculated as the difference between V_1 and V_2, where V_1 is the volume of the grains without bread and V_2 is the volume of the sand grains and bread.

Density by volume: The density by volume is obtained by the ratio of mass to volume and is g/ml according to the method of Okezie and Bello [9].

2.2.3. Physicochemical Analysis of Bread

Proximate composition of bread samples are analyzed in triplicate for moisture (air oven method), fat (Soxhlet) and ash (incineration method) content following AACC standard methods [10]. Crude protein (Nx6.25) is analysed using approved methods of Kjeldahl in semi automatic machine (GEHARDT, Paris, France).

2.2.4. Sensory Evaluations of Breads

Breads are subjected to sensory evaluation at different sessions by panels of 15 untrained students drawn among the student population of the University of N'Djamena, Chad. Polystyrene sealed samples coded with three digit numbers are served randomly in two batches of 7 samples each at interval of 30 min. Panelists are instructed to rinse their mouth with water between samples. The assessors are asked to appreciate how much they liked the taste, the flavor, the texture and the overall acceptability of the breads on a hedonic scale varying from 1 (extremely dislike) to 9 (extremely like).

2.2.5. Statistical Analysis

The results of our different analysis performed in triplicates are calculated using the Microsoft Office Excel 2013 spreadsheet program and presented as means ± standard deviation. The one-way analysis of variance (ANOVA) and the correlation test are carried out using the statistical software R and SPSS respectively.

3. Results and Discussion

3.1. Physical Measurements of Bread

The physical parameters such as mass, volume and mass density of the samples are recorded in Table 1. From this table, it can be observed that the mass and volume of the breads vary respectively from 113.67 to 156.00 g and from 1196.67 to 1333.33 cm^3. As for the mass density, it varies from 0.09 to 0.12 g/cm^3. Also, the ANOVA analysis reveals that there is a significant difference at the 5% level between the means of the mass and density of the samples. The results obtained show that the breads from the different Hybah bakeries have high weights and low volumes compared to the breads from the other bakeries, which leads to breads of high density, fresher and wetter. The density, which is the ratio of the weight to the volume of the loaves, is low for the 3 Rotative bakeries plus Abeya and high for the three Hybah bakeries. The retention capacity of CO_2 is related to the amount of air incorporated during kneading [11]. The higher the air holding capacity of the dough, the greater the volume of the bread.

The density is strongly influenced by the amount of gas retained within the bread. Indeed, each air cell is characterised by a critical size beyond which the retention of CO_2 is random because it usually diffuses into the atmosphere [12, 13]. Indeed, a weak, inverse and significant correlation is observed between the water content and the volume of the breads. In other words, the higher the water content, the lower the volume. The variation in bread volume

can be attributed mainly to different levels of carbon dioxide production and the degree of starch gelatinisation. It should also be mentioned that the temperature and baking time affect the water holding capacity of bread [14].

Table 1. *Physical measurements of bread.*

Bakeries	Mass (g)	Volume (cm^3)	Density (g/cm^3)
Abeya Amriguebé	130.67±11.68b	1266.67±15.75a	0.10±0.021ac
Hybah Ambassatna	155.33±3.51c	1231.00±27.074a	0.12±0.000bc
Hybah Dembé	148.33±5.86c	1196.67±5.77a	0.12±0.006c
Hybah Gassi	156.00±1.00c	1241.00±0.00a	0.12±0.000bc
Rotative Amtoukouye	129.33±5.13ab	1333.33±57.74a	0.10±0.006b
Rotative champs de fil	113.67±2.08a	1300.00±.,00a	0.09±0.000a
Rotative Gredia	114.00±3.46a	1233.33±57.74a	0.09±0.000a
P Value	1.65e-07 ***	0.223	0.000361 ***

Means followed by different letters for each column are significantly different at the indicated probability.

3.2. Physicochemical Analysis of Bread

The average results per bakery of the samples are given in Table 2. The parameters studied are the water, ash, total protein and lipid contents. The results show that the average water content of the samples, depending on the bakery, varies from 20.18% to 26.91%, and the ash content varies from 1.44% to 2.58%. As for the crude protein and lipid contents, they vary respectively from 8.58% to 10.01% and 0.84%to 1.80%. There are significant differences between the means of the different parameters studied ($p<0.05$). The water contents of the different bread samples are presented in Table 2. From this table, it appears that the water content of these breads varies considerably ($p<0.05$) between the samples. The observed differences in water content can be explained by the incorporation of different amounts of water in the formulations and the starting moisture of the flour [2]. Also, the water content of bread taken from the oven is generally higher than that of bread sold in the bakery's warehouse [15]. The water content observed in this study is much lower than that obtained by Mudau et al. [16] on breads. The low water content of our samples could be explained by a long baking time and high baking temperature. Furthermore, a weak and significant inverse relationship is observed between water content and bread volume.

Ash is the residue of mineral compounds that remains after the incineration of a sample containing organic substances of animal, vegetable or synthetic origin [17]. The average ash contents of our different breads are presented with only one sample that differs significantly from the others. The ash content obtained in this study (1.44% to 2.58%) is higher than that observed by Mudau et al. [16] on breads based on wheat on the one hand and on composite flours of wheat and millet on the other hand.

As for the lipid content, the means of different breads determined in this study vary significantly ($p<0.05$). The presence of lipids makes the crumb less dry but a high amount is not good for health [2]. The lipid contents observed in this study (0.84 to 1.80%) are slightly higher than those obtained by Bourre et al. [18] on ten types of bread (0.3 to 1.2%) except for cereal and seed bread (3.9%). The low lipid content of bread makes it exceptionally interesting nutritionally in our current diet. It contains less than 2g of fat per 100g of bread.

The protein content varies from 8.58% to 10.01%. These contents are almost homogeneous and are quite similar to the one obtained by Bourre et al. [18] which is 9.3%. As for the differences observed in the protein contents of our samples ($p<0.05$), these may be due to the starting composition of different types of wheat flours [2]. On the other hand, the protein content of the bread samples in this study is below the acceptable range of 10.5-14% protein content. This low protein content of the bread could potentially affect the gluten network and thus the volume and texture of the bread [19].

Table 2. *Nutritional composition of breads.*

Bakeries	Content of water (%)	Ash content (%)	Protein content (%)	Lipid content (%)
Abeya Amriguebé	26.91±1.36b	2.39±0.22b	9.79±0.11bc	1.20±0,02b
Hybah Ambasstna	24.41±1.29b	1.44±0.17a	9.97±0.10c	0.84±0,00a
Hybah Dembé	24.52±1.92b	2.55±0.10b	8.58±0.44a	1.80±0,12c
Hybah Gassi	24.00±0.90b	2.47±0.10b	9.58±0.14bc	1.20±0,04b
Rotative Amtoukouye	20.37±0.61a	2.52±0.19b	10.01±0.34c	1.72±0,06c
Rotative Champs de fil	20.18±0.944a	2.24±0.19b	9.89±0.04c	1.29±0,00b
Rotative Gredia	25.61±0.57b	2.58±0.05b	9.21±0.10ab	1.12±0,10b
P Value	3.18e-05 ***	4.22e-06 ***	1.8e-05 ***	3.34e-10 ***

Means followed by different letters for each column are significantly different at the indicated probability.

3.3. Sensory Analysis of Bread

The results of the sensory evaluation of the bread samples are presented in Figure 1. The scores for color, texture and overall acceptability of all samples are above average, implying that the breads are generally accepted by consumers. However, the results for color, texture and overall acceptability

show a significant difference between the different bread samples. On the other hand, taste is not affected by the origin of the breads. The results show that the colour scores of the breads range from 4.67 (Rotative Gredia) to 8.20 (Hybah Ambassatna). Similarly, the colour scores of three Hybah bakeries are higher than those of the other bakeries. Of course, since all bakeries use 100% wheat flour, there should not be any differences in the color of the breads. This is not the case. According to Zanoni, B. et al. [20], the color on the surface of breads depends both on the physico-chemical characteristics (water content, pH, reducing sugars and amino acids) and on the conditions during baking (temperature, air speed, relative humidity and heat transfer mode). During baking, a desiccation hardening (crust) and a non-enzymatic browning occurs on the surface of the bread, which gives the crust a golden yellow color with a slightly shiny, glazed appearance. Non-enzymatic browning, also known as the "Maillard reaction", refers to a very complex set of reactions leading to the formation of brown or black pigments, and to changes in odor and flavour [21].

Texture is the bread quality determined by touching and feeling and involves the degree of roughness or smoothness, hardness or softness [22]. Bread texture scores ranged from 6.4 (Rotative Gredia, Abeya Amriguebé) to 7.53 (Hybah Ambassatna). The low texture value of the breads of Rotative and Abeya bakeries could be due to the high fibre and sugar content of these flours, which results in a harder bread, not acceptable to consumers [23].

The general acceptability expresses how consumers or panelists accept the product taking into account all other parameters of the sensory evaluation. The results show that the overall acceptability of the bread samples is significantly affected depending on the bakery. The bread from the Hybah Ambasstna bakery obtained the highest score (7.73), while the lowest score (6.8) is attributed to the bread from the Rotative Gredia bakery. Two fundamental properties, color and texture, determine acceptability of bread. These two properties are interrelated in the sense that the appreciation of one is generally reflected in the appreciation of the other. The aim of this explanatory sensory evaluation is to highlight the causes (bakeries) that explain the general acceptability effects. The analysis of the problematic raised by this research shows that the factors (bakeries) do not act directly on the responses (general acceptability, reference variable) but rather on other responses (color and texture, proximal variables) which, in turn, act on the reference variable.

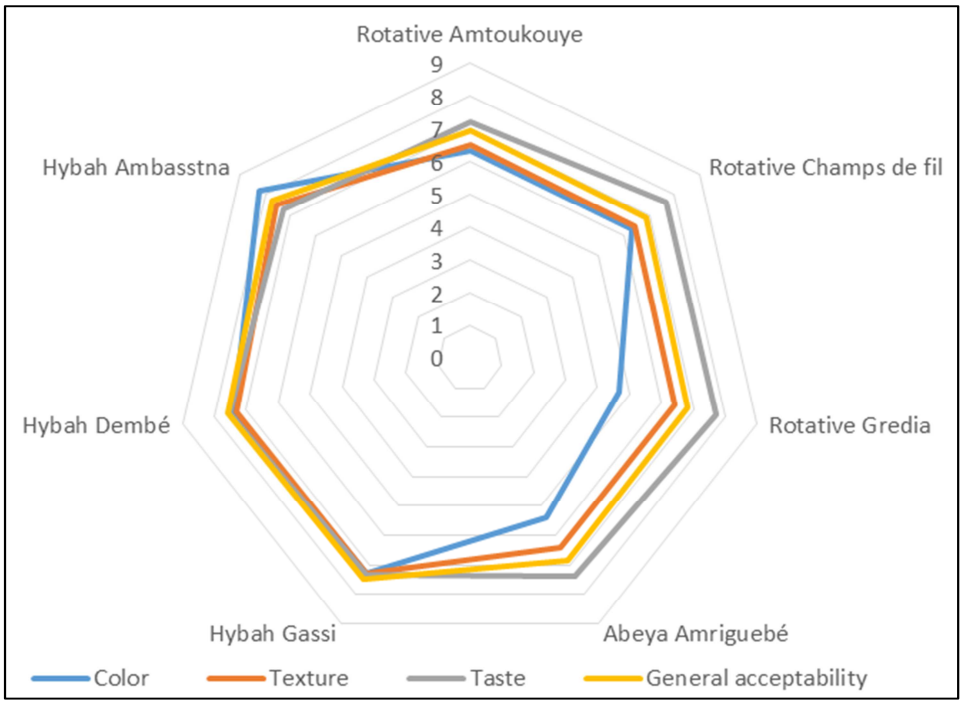

Figure 1. *Sensory analysis of the breads.*

4. Conclusion

The results obtained allow us to know the moisture, carbohydrate, protein, lipid and ash composition of the breads from the different bakeries, which are generally acceptable from a nutritional point of view. These breads are also generally produced under appropriate hygienic conditions since they are generally accepted by consumers. However, further studies, including microbiological analysis, need to be undertaken to assess the quality of the bread and the distribution and storage conditions of some bakeries. More specifically, the study should be deepened in other works especially on fermented doughs before freezing. Also, the study of the microbiological quality of bread and the preservation of the fermenting activity are research fields to be investigated on the subject.

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