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Study of physicochemical, functional, particle size and fermentation properties of flours composed of wheat and young shoots of palmyra palm in the perspective of the preparation of compound bread

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Abstract

This study on wheat flour type 55, the flour of young shoots of Palmyra palm (*Borassus aethiopum* Mart.), the mixture of the two (2) flours containing 5%, 10%, 15%, 20%, 25% of flour of young shoots of the palmyra palm, is an enhancement of the young shoots of the palmyra palm, a tuber little transformed in Côte d'Ivoire. The study on the physicochemical properties of the different flours revealed that the incorporation of the flour of young shoots of palmyra palm in the compound flours increased the content of reducing sugars, total sugars and especially fibers, which is beneficial for the health of populations ; the lipid and ash contents of wheat flour and of compound flour are not significantly different at the 5% threshold; the bulk density contents of all the flours are not significantly different at the 5% threshold with a general average of 0.65g / ml. The study of the functional properties revealed that the percentage solubility and the water absorption capacity of wheat flours and compound flours are not significantly different at the 5% level; that the swelling power of all the flours is not significantly different at the 5% level with a general average of 0.057 g/g. This study also consisted in evaluating the fermentation activity of *Saccharomyces cerevisiae* during the fermentation at 30 °C of baking dough containing 0%, 5%, 10%, 15%, 20%, and 25% of flour of young shoots of palmyra palm. When the incorporation rate is equal to 5%, we observe an increase in the fermentation activity of *Saccharomyces cerevisiae* and a significant volume increase in the fermentation paste. However, when the flour content of young shoots is greater than 5%, a gradual decrease in the fermentation activity of the yeast is observed. The granulometric study revealed that the flour of young shoots of palmyra palm is the finest with a grain content of less than 63µm diameter higher.

Keywords: Wheat flour; Flour of young shoots; Palmyra palm; *Borassus aethiopum* Mart; Fermentation activity; *Saccharomyces cerevisiae*

1. Introduction

Bread is a staple, global food [1] consumed in different parts of the world. It is the traditional staple food of many cultures. It is made from the ingredients of wheat flour and water. It usually contains salt. Other ingredients are added depending on the type of bread and how it is culturally prepared. When the sourdough or yeast is added, the dough of the bread is subject to swelling g due to fermentation [2].

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The growing consumption of bread in urban areas of developing countries is forcing governments to spend more in foreign exchange on the import of wheat [3]. Indeed, in 2010, Sub-Saharan Africa imported 12.3 million tonnes of wheat [4] and Côte d'Ivoire imported 625,000 tonnes of wheat in 2019 for around 150 million euros [5].

Therefore, efforts towards the partial substitution of wheat flour by local flour are already very commendable. It is therefore preferable, to look at local sources of flour, so that the reduction in the importation of wheat can really contribute to the economy of foreign exchange, to be affected in other sectors of the national economy. , mainly in agriculture and to stimulate the transition from peasant agriculture to industrial agriculture [6].

Today, thanks to improved agricultural practices, millions of tonnes of underutilized crops are available [7, 8]. This is the case with young shoots of the Palmyra palm (*Borassus aethiopum* Mart). It is a tuber that is widely consumed in the center of Côte d'Ivoire [9].

The economic use of the young Palmyra shoot is limited because of its ignorance by most of the Ivorian population. The physico-chemical and nutritional characteristics were evaluated [10]. However, the behavior of this flour during cooking, as well as the rheological properties and the baking qualities of flours composed from a potential mixture of wheat flours and the flour of young shoots of palmyra palm, as well as the sensory analysis of the bread obtained were never analyzed. In order to establish a method of making bread made from young shoot flour and wheat, it would be important to determine the physicochemical and functional characteristics of these flours. Thus, the general objective of our study is to enhance the young shoots of the Palmyra by studying the impact of the incorporation of their flour on the fermentation activity of *Saccharomyces cerevisiae* in the process of making a compound bread. The specific objectives are:

- Determine the physico-chemical parameters of the different flours
- Determine the functional properties of the different flours
- The grain size of the different flours
- Measure the rise of the dough according to the flour incorporated

2. Material and methods

2.1. Materials

2.1.1. Young shoots of palmyra palm

The young shoots of palmyra palm studied come from Dimbokro in central Côte d'Ivoire. These young shoots are 8 weeks old.

2.1.2. Wheat flour

It is type 55 wheat baker's flour.

2.1.3. The ingredients

The ingredients used in this study are salt, the yeast *Saccharomyces cerevisiae*, the improver and water.

2.2. Methods

2.2.1. Young shoot flour production

The flour of young shoots of palmyra palm was obtained by different stages which are peeling the tubers of the young shoot, washing, cutting into small pieces, drying in an oven at 80 °C for 24 hours, grinding and finally sieving.

2.2.2. Preparation of compound flours

For a total mass of 300g, the compound flours contain in addition to wheat flour, 5% (F1); 10% (F2): 15% (F3); 20% (F4); 25% (F5) flour made from young shoots of palmyra palm.

2.3. Determination of physico-chemical parameters

2.3.1. Humidity level

The method used for determining the moisture was that suggested by Bainbridge Z et. al., [11]. The moisture was assessed by drying 3 g of flour sample into an oven at 105°C till constant weight resulted after 4 h.

2.3.2. pH determination

The pH was determined according to the method of Estelle Eriksson [12]. A 10g sample of flour was weighed in a 50ml Falcon tube; 90 ml of distilled water was added and mixed. The tube containing the mixture is left to stand for one hour at room temperature. After filtration, the pH of the filtrate was determined using a Eutech brand pH meter 700.

2.3.3. The Ash contents

The ash content was measured by incinerating five (5) g of oven-dried flour into a muffle furnace at 550 °C for 12 h [13].

2.3.4. Total soluble sugars and reducing sugars contents

Ethanosoluble sugars were extracted from 1 g of ground dried flour with 20 mL of 80% (v/v) ethanol, 2 mL of 10% (m/v) zinc acetate and 2 mL of 10% (m/v) oxalic acid, according to the method of Agbo NG et.al.,[14]. The extract was centrifuged at speed of 3,000 rpm for 10 min. The ethanol residue was evaporated from the extract upon a hot sand bath. Then, the extracted total sugars were measured out using the method of Dubois M et.al.,[15]. The operation consisted in adding 0.9 mL of distilled water, 1 mL of 5% (m/v) phenol, and 5 mL of 96% sulfuric acid into 100 µL of extract, then measuring the absorbance at 490 nm with a spectrophotometer (PG instruments). For the reducing sugars, 1 mL of extract was processed with 0.5 mL of distilled water and 0.5 mL of 3, 5- dinitrosalycilic acid [16]. Prior to the recording of the absorbance from the final solution at 540 nm with a spectrophotometer (PG instruments). Calibrations were performed with standard solutions of glucose and sucrose for recovering the final total sugars and reducing sugars contents in the studied samples.

2.3.5. Lipids content

Lipids were quantified from 10 g of ground dried flour sample by solvent extraction using 300 mL of n-hexane reagent and a Soxhlet device for 7 h [17]. The hexan-oil mixture resulted from the extraction was recovered and separated with a rotavapor apparatus (Heidolph). The difference between the sample weight before and after the experiment allowed the estimation of the lipids content.

2.3.6. Proteins content

Crude proteins content was determined as the total nitrogen using the Kjeldahl's method [13]. Thus, 1 g of flour mash was mineralized at 400°C for 2 h, with adding of concentrated sulfuric acid (H_2SO_4) and potassium sulfate (K_2SO_4) catalyst. The mineralisate was diluted and distilled for 10 min. Thereafter, the distillate collected into a flask containing boric acid and methylene bromocresol reagents ion, was titrated for the total nitrogen using ammonium sulfate ($(NH_4)_2SO_4$). The crude protein content of the flour was deduced from the nitrogen level using 6.25 as conversion coefficient.

2.3.7. Total carbohydrates content and energy value

Total carbohydrates and energy values were determined using calculation formulas [18] accounting the moisture, fat, protein, ash contents and the energetic coefficients for macromolecules.

$$TCC\ (\%) = 100 - [P\ (\%) + W\ (\%) + F\ (\%) + A\ (\%)]$$

$$CEV\ (kcal/100g) = [(4\times P) + (9\times F) + (4\times C)]$$

With: TCC, total carbohydrates content; CEV, caloric energy value; P, protein content; W, moisture content; F, fat content; A, ash content; C, total carbohydrates content

2.3.8. Fibers content

The determination of the crude fibers content consisted in the treatment of 2 g of flour sample with 50 mL of 0.25N sulfuric acid and 50 mL of 0.31 N sodium hydroxide and filtration of the resulting solution upon Whatman paper. The residue was dried for 8 h at 105°C then incinerated at 550°C for 3 h into ovens [19]. The final residue was weighed as crude fibers and expressed in percentage.

2.3.9. Determination of bulk density

Bulk density was determined by the method of Falade et. al., [20]. A 10-gram mass of a flour sample is placed in a graduated tube and weighed. The flour has been compressed and the volume is read directly. Knowing the mass of the sample, the density of the flour is calculated from the following formula:

$$\text{Bulk density (g/ml)} = \frac{Sample\ mass}{Sample\ volume}$$

2.4. Determination of functional properties

2.4.1. Swelling power and solubility of flour

The swelling power and the solubility are determined according to the method described by Estelle Eriksson [21]. In a 50 ml falcon tube, four grams of the flour sample as well as 40 ml of distilled water were added. The tube was shaken vigorously to allow the flour to completely absorb the water. The tube containing the mixture was heated at 90 °C for one hour in a water bath (memmert brand). While heating, the tube was stirred constantly (every 15 minutes) to avoid pellet formation. After cooling to room temperature, the tube was centrifuged in a centrifuge (SIGMA 3-16L Néo-Tech SA; BELGIUM) at 5000 rpm for 10 minutes.

The supernatant obtained was collected in a crucible of known weight and then dried in an oven (Memmert NEO-TECH SA) at 100 °C for 4 hours. After cooling, the weight of the dried supernatant was determined. The pellet volume was obtained by direct reading of the falcon tube. Swelling power and solubility were calculated as follows: Swelling power.

$$\text{g/g} = \frac{Pellet\ weight}{[sample\ weight\ x\ (1 - Moisture)] \times (100 - Solubility)}$$

$$\text{Solubility (\%)} = \frac{Weight\ of\ the\ dried\ supernatant}{Sample\ weight\ x\ (1 - Moisture)} \times 100$$

2.4.2. Water absorption capacity

The water uptake of flour samples was determined by the method of Yamazaki WT [22] modified by Medcalf, DJ et.al., [23]. A mass of 1 g of flour was weighed into a tube of known mass. The flour was dispersed in 10 ml of stirred distilled water and left to stand at room temperature for one hour, stirring every 10 min. After 1 h, the solution was centrifuged in a centrifuge (SIGMA 3-16L centrifuge of the Neo-Tech SA brand; BELGIUM) at 3000 rev / min for 15 minutes. The supernatant is poured in and the pellet is weighed. The water absorption capacity was determined by the following formula:

$$\text{Water absorption capacity (\%)} = \frac{pellet\ weight - sample\ weight}{sample\ weight} \text{x100}$$

2.4.3. Oil absorption capacity

The oil absorption capacity is determined by the method of Falade et. al., [20]. A hold of 1 g of flour, was dispersed in 10 ml of oil. Shake and let stand at room temperature overnight.

The solution is centrifuged in a centrifuge (SIGMA 3-16L centrifuge of the Neo-Tech SA brand; BELGIUM) at 3200 rev / min for 25 min. The supernatant is poured in and the pellet is weighed. The absorption capacity of the oil was determined by the formula below:

$$\text{Oil absorption capacity (\%)} = \frac{pellet\ weight - sample\ weight}{sample\ weight} \text{x100}$$

2.5. Dough leavening or fermentation activity of *Saccharomyces cerevisiae*

Dough rise was determined using the modified method from Aboaba OO et. al., [24]. This method consists of evaluating the fermentation activity of the yeast (*Saccharomyces cerevisiae*) in the dough. A 10g sample of dough was weighed on a balance (OHAUS brand) and placed in a graduated falcon tube and then placed in an oven (Memmert NEO-TECH SA) at a temperature of 30 °C. Lifting was measured every 10 min.

2.6. Determination of grain size distribution

The grain size distribution of the flours is estimated by fractionating the total mass of the flours through a series of sieves of decreasing mesh size (2mm, 1mm, 500um, 250um, 125um and 63um). Under the 63um sieve is placed a recovery cover (the bottom). The sample is placed in a sieve of different mesh size and closed with a lid. The sieve is stirred (shaken) for 30minute. The grains are deposited one after the other according to the size of their diameter. The rejects and the passers-by of each sieve are weighed with a technical balance (Denver instrument SI-4002) of precision.

2.7. Statistic study

All analyzes were performed in triplicate, then data processed using Statistical Program for Social Sciences software (SPSS version 20.0, SPSS for Windows, USA). For each characteristic, the results were expressed as means followed by their standard deviations as parameters of data dispersion. A one-way analysis of variance (ANOVA 1) was also performed in order to test the effect of the flour on the characteristics evaluated, at the threshold of statistical significance of 5%. For statistically different means, classification was performed with the Student-Newman-Keuls test.

3. Results and discussion

3.1. Physico-chemical parameters (Table 1)

The results of the physicochemical analyzes of the various flours show that the humidity of wheat flour (11.22%) is higher than that of the flour of the young shoot (3.89%). Moisture levels in compound flours range from 09.55% to 10.78%. These humidity levels are below the maximum rate of 15.5% defined by the Codex Alimentarius Commission [25]. Indeed, when the moisture content is high, an aggregation of flour particles occurs, reducing its quality and functionality [26].

The young shoots of palmyra palm has a pH of 5.22. It is more acidic than wheat with a pH of 5.77. With regard to compound flours, we see that there is a slight variation in pH between the different substitutions, however their pH is close to that of wheat. The pH varies very little and remains below 7 despite the increase in the rate of substitution in young shoots flour. This result is comparable to that of Yetunde Ezinwanyi Alozie et.al., [27] and Alozie Ye et.al., [28]. The pH is a sign of the acidity or alkalinity of the flour and greatly affects its performance during use in the food system. When a flour has a pH <4, this flour is said to be very acidic, which indicates significant fermentation and therefore great degradation of the starch present. This type of flour would therefore not be suitable for breadmaking [29].

The presence of flour from young shoots in compound flours improves their total sugars and reducing sugars content. The presence of flour from young shoots in compound flours also improves their fiber content. Bread prepared from these flours could be a significant source of dietary fiber, which is eliminated more slowly from the stomach and thus improves intestinal transit.

These dietary fibers are essential for the balance of the digestive tract and that of the body. They represent a factor of good health. Studies have shown an inverse correlation between the consumption of dietary fiber and colon cancer. In fact, fibers can complex with carcinogenic molecules, thus preventing their contact with the colon and facilitating their excretion [30, 31]. The consumption of breads prepared from these flours could therefore increase the gastric volume and constitute a post-ingestive state allowing to reach a state of satiety more quickly [31 32]. Fiber generally lowers blood glucose, HDL-cholesterol, LDL-cholesterol levels and thus helps reduce coronary heart disease [33].

Statistically, there is no significant difference between the bulk densities of all flours at the 5% level. Density is a very important parameter in that it determines the packaging and transport conditions of the food product.

Table 1 Physicochemical properties

Parameters	WF	FYS	F1	F2	F3	F4	F5	P value
M (%)	11.22±0.19c	3.89±0.19a	10.78±0.19c	10.73±0.14c	10.11±0.19b	9.67b	9.65±0.69b	0.000
pH	5.77±0.02e	5.22±0.01a	5.76±0.006de	5.75±0.01cde	5.73±0.006bcd	5.72bc	5.70±0.01b	0.000
TS (%)	3.91±0.03a	7.52±0.36g	4.26±0.12b	4.61±0.05c	5±0.07d	5.35±0.08e	5.83±0.07f	0.000
RS (mg/100g)	58.70±0.43a	158.10±0.71g	62.76±0.37b	77.57±0.28c	80.73±0.69d	86.41±0.59e	90.60±0.3f	0.000
Lipids (%)	2b	1.06±0.42a	1.87±0.58b	2.2±0.2b	2.27±0.23b	2.4±0.2b	2.67±0.11b	0.001
Protein (%)	9.77±0.07c	9.15±0.22b	8.93a	9.81c	9.80±0.01c	9.81c	9.81±0.005c	0.000
TC (%)	76.14±0.25a	83.96±0.67c	77.62±0.39b	76.59±0.46ab	77.15±0.28ab	77.45±0.23b	77.24±0.67ab	0.000
EV (Kcal/100g)	361.64±0.88a	382.04±1.27d	363.01±3.65a	365.4±0.70ab	368.23±1.4bc	370.65±1.96c	372.19±3.3c	0.000
Ashes (%)	0.87±0.23a	1.93±0.3b	0.8a	0.67±0.3a	0.67±0.11a	0.67±0.3a	0.73±0.11a	0.000
Bulk Density (g/ml)	0.625a	0.66a	0.64±0.02a	0.64±0.02a	0.64a	0.67±0.04a	0.67±0.04a	0.148
Fibers (%)	6.53±0.2a	19.71±0.18g	7.16±0.05b	9.05±0.09c	10.26±0.16d	11.52±0.13e	12.57±0.21f	0.000

Per raw, values followed by different lower scripts are statistically different at 5% significance. P-value: statistical value of the probability test ; WF : Wheat flour type 55 ; FYS : flour of young shoots of palmyra palm ; F1 : 5% of flour of young shoots ; F2 : 10% of flour of young shoots ; F3 :15% of flour of young shoots ; F4 : 20% of flour of young shoots ; F5 : 25% of flour of young shoots ; M: Moisture; TS: Total Sugars ; RS : Reducing Sugars ; TC : Total Carbohydrates ; EV : Energétique Value

Table 2 Functional properties

Parameters	WF	FYS	F1	F2	F3	F4	F5	P value
Solubility (%)	14.38±0.94b	12.23±0.86b	13.83±0.14b	13.76±0.12b	13.57±0.14b	13.36±0.12b	13.16±0.1b	0.004
Swelling power (g/g)	0.054±0.001a	0.066±0.01a	0.053±0.0006a	0.054±0.0006a	0.057±0.0007a	0.058±0.001a	0.059±0.001a	0.080
Water absorption capacity (%)	85.04±11.22a	175.62±26.32b	90.71±9.49a	91.55±0.4a	92.54±1.73a	93.71±4.88a	94.26±0.84a	0.000
Oil absorption capacity (%)	118.47±1.8b	115.70±0.9a	117.63±1.09ab	117.56±0.17ab	116.72±0.13ab	116.54±0.17ab	115.39±0.22a	0.008

Per raw, values followed by different lower scripts are statistically different at 5% significance. P-value: statistical value of the probability test. WF : Wheat flour type 55 ; FYS : flour of young shoots of palmyra palm ; F1 : 5% of flour of young shoots ; F2 : 10% of flour of young shoots ; F3 :15% of flour of young shoots ; F4 : 20% of flour of young shoots ; F5 : 25% of flour of young shoots

3.2. Functional properties (Table 2)

There are no significant differences between the solubility content of wheat flour and that of compound flours. The solubility of wheat flour is higher than that of young shoots flour, whereas it decreases for the different compound flours. Solubility is the ability of the solid substances in flour to dissolve or disperse in an aqueous medium. Solubility is associated with the amylose content of the flour. Therefore, the higher the amylose content, the greater the solubility [34].

There are no significant differences between the swelling powers of any flour. Swelling power is a measure of the hydration and swelling capacity of starch granules and also reflects the extent of associative forces existing between the amorphous phase and crystalline phase of starch grains as well as between the grains of starch [20, 34]. A higher swelling index would indicate a weak intermolecular association between the starch granules.

The water absorption capacity of the flour of young shoots of palmyra palm is higher (175.62%). On the other hand, there are no significant differences between the water absorption capacities of wheat flour and compound flours. In addition, the use of flours as food ingredients depends to a large extent on their interaction with water. The water absorbing capacity of flours plays an important role in the food preparation process because it predicts the ability of flour to absorb water under conditions where water is scarce. A high capacity allows more water to be added to the dough, improving its workability. In addition, the water absorption capacity is an essential property of dough and bakery products as it allows the thickening and increase of the viscosity of foods [20]. The high-water absorption capacity of young shoots flour may reflect the presence of high amount of hydrophilic substances capable of improving the viscosity of various food products [35]. It could also reflect a greater interaction between the proteins and water of the formed system. In addition, the type of protein such as polar proteins would also increase this capacity [29, 35]. It is important to note that the water absorption capacity of wheat flour is lower than that of young shoots despite its high protein content, this could mean a high presence of hydrophobic proteins in wheat flour.

The oil is more absorbed by the wheat than the young shoot with a higher oil absorption percentage (118.47%) than that of the young shoot flour (115.70%). For compound flours, the oil absorption capacity is between 115.39% and 117.63%. Oil absorption capacity is an important characteristic in fatty food formulations as it is believed to act as a flavor retainer and mouthfeel enhancer [36, 37]. This oil absorption capacity by flour is due to the interactions between the side chain of nonpolar amino acids and the hydrocarbon chains of lipids [38].

3.3. Granulometric classification of the different flours (Table 3)

The results of the particle size classification made it possible to separate seven characteristic fractions of the seven flours expressed as a percentage present in Table III. This table shows that all flours are composed of grains having a diameter of less than 250 µm. The flour of young shoots of palmyra palm is the finest flour with a percentage of grains with a diameter of less than 63 µm is the highest (67%), followed by flour composed of 20% and 25% (15%) (Table 3).

Table 3 Granulometry of the different flours

Class of flour according to diameter in (mm) and (µm)	**100% wheat in %**	**5% young shoot in %**	**10% young shoot in %**	**15% young shoot in %**	**20% young shoot in %**	**25% young shoot in %**	**100% young shoot in %**
< 2mm	100	100	100	100	100	100	100
< [2mm ,1mm]	100	100	100	100	100	100	100
< [1mm, 500µm]	100	100	100	100	100	100	99
<[500µm,250µm]	96	98	99	98	97	99	98
<[250µm,125µm]	43	38	38	43	51	52	78
< [125 µm, 63µm]	4	13	6	8	15	15	67
<63µm	4	13	6	8	15	15	67

The grain size distribution of flours is of major importance for their analysis and use. Indeed, it makes it possible to detect the presence of foreign particles and to comment on the problems of the grinding. It plays a fundamental role in hydration which is the operation of breadmaking and preparation of the dough. It also helps to predict its behaviour during hydration. In baking, the quantity of water absorbed during the fermentation of the dough, as well as the rate of water absorption increases with the fineness of the flour particles [39, 40} (Table 3)

3.4. Influence of flour of young shoot on the fermentation activity of *Saccharomyces cerevisiae* (figure 1)

The 100% wheat flour takes 110 minutes to reach a maximum volume of 35.41ml. On the other hand, flour composed of 5% young shoot takes a period of 100 minutes to reach a maximum volume of 35.38ml and its curve is above that of 100% wheat for up to 100 minutes. The 10% flour reaches its maximum of 29.82 ml in 80 min. The flour composed of 15% young shoot takes a duration of 110 minutes to reach 29.78ml and its curve overlaps with that of 100 wheat but at 50 minutes its curve is below that of 100% wheat and is similar to that of 10% but below the flour composed of 5% young shoot.

The 20% (27.21ml) and 25% (23.78ml) flours of the young shoot failed to reach the maximum volume of 35.41ml in 110 minutes. The 100% seedling flour takes 90 minutes to reach a constant volume of 12.56ml (see figure 1).

The ability of the baker's yeast, *Saccharomyces cerevisiae*, to ferment wheat flour and compound flour (wheat and young shoots) was investigated in this study. Here, the time required for the fermented dough to reach maximum volume was analyzed. During fermentation, the yeast consumes the fermentable sugars in the flour and produces carbon dioxide and ethanol. The carbon dioxide produced is responsible for raising the dough. Indeed, the gas produced is trapped by the gluten network formed during kneading by the proteins of the wheat flour (gliadin and glutamine). This retention capacity of the carbon dioxide produced depends on the structure of the network formed [41].

The incorporation of more than 10% of flour of young shoot of palmyra into wheat flour negatively influences the fermentation activity of *Saccharomyces cerevisiae* and probably the formation and stability of the gluten network hence the elasticity of the dough.

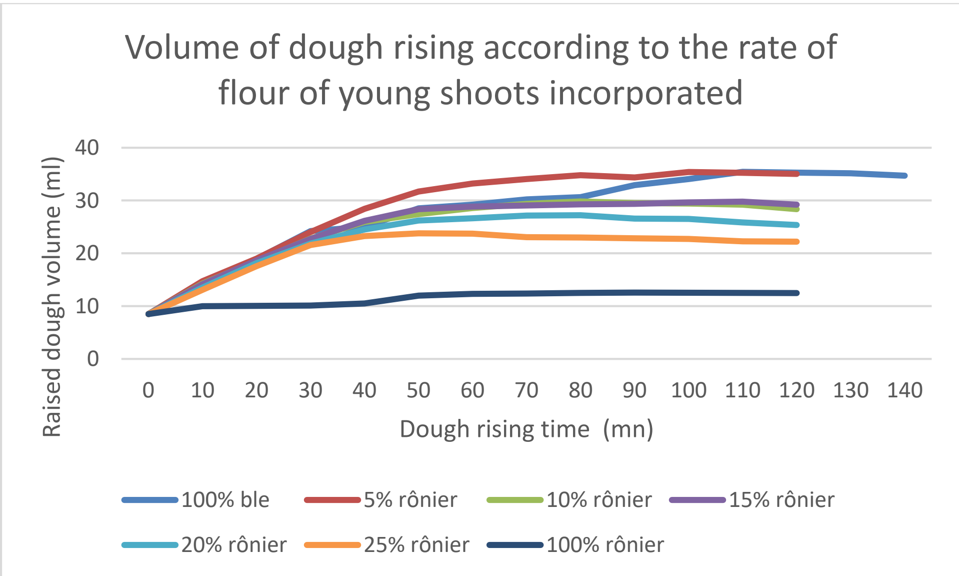

Figure 1 Summary graph of the fermentation dough growth

In this study, it was observed that the incorporation of flour of young shoots with that of wheat in the production of composite bread leads to a change in the dough leavening profile compared to that of 100% wheat. Indeed, the inclusion of young flour at a rate of 5% results in a rise of the dough significantly greater than that of 100% wheat for up to 100 minutes. A comparable result was also obtained by Ade-Omowaye Bio et.al., [42] using 5% tigernuts and 95% wheat. On the other hand, an incorporation at a rate ranging from 10 to 25% results in a leavening of the dough markedly lower than that of 100% wheat, This can be explained by the fact that, as the concentration of wheat flour in each successive sample was reduced, the concentration of wheat gluten was also reduced and therefore a corresponding decrease in the volume of the dough. Gluten is responsible for the imprisonment of carbon dioxide produced by the respiration of yeasts and ultimately for the elasticity of the dough.

4. Conclusion

These various studies have enabled us to know that in the process of making bread dough, flour of young shoots of palmyra palm could be incorporated up to a rate of 5% in wheat flour. This incorporation results in a volume of fermentation dough significantly greater than that of the 100% wheat reference for up to 100 minutes. Beyond 5% incorporation of the flour of young shoots of palmyra palm, the rise of the dough gradually decreases. In addition, the study of the physicochemical parameters of the different flours showed that the incorporation of the flour of young shoots of palmyra palm, improved the total sugar content, the reducing sugar content and the fiber content which would be beneficial for the health of consumers.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest

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