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Influence of the germination time of sesame seeds on the functional properties of derived flours

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Abstract

The objective of this study is to contribute to the food valorization of sesame seeds by improving the nutritional and functional quality of the flours. To achieve this, germination was applied to sesame seeds for 4 days. The flours obtained at different germination times were analyzed for their functional properties. The results showed an increase in water absorption capacity and flour porosity depending on the germination time. FSG1 (Sesame seed flours germinated for 1 day) recorded a higher solubility index (47.86%) and foaming capacity (15.75%) compared to 45.50% and 11.44% for the control flour (FSF). Most functional properties increased except for the oil absorption capacity of the flours. FSG0 and FSG1 flours showed higher swelling power and solubility (at 70°C) than those at other germination times. FSG1 flour would be suitable for the preparation of infant food porridges. Overall, flours made from sprouted sesame seeds could be useful in the production of cakes and bakery products due to their high water absorption.

Keywords: Flour; Functional property; Germination; Sesame; Valorization

1. Introduction

Food is the basic need of humanity that is met by agriculture. Food demand is therefore a problem for the world economy and more specifically for these agricultural systems. Indeed, countries in sub-Saharan Africa are experiencing food crises because they are subject to international trade based on the export of cash crops (cocoa, coffee, cotton, oil palm, rubber, etc.). These countries have not developed subsistence agriculture very much. In addition, there are economic difficulties that mean that animal proteins remain inaccessible to part of the population [1]. The cereals and tubers within their reach are relatively low in protein. As a result, nutrient needs are not always met, and these populations are exposed to undernutrition and very often malnutrition [2]. Thus, to meet the nutritional needs of ever-growing populations, it is necessary to exploit potential sources of protein [3]. This is why the contribution of underexploited crops to food security and the economic prosperity of populations in developing countries is widely recognized today [4].

Among the under-exploited food resources in Côte d'Ivoire is sesame (*Sesamum indicum* L.), an oilseed belonging to the Pedaliaceae family. Its grains are a good source of nutrients such as protein (19-25%), lipids (57-63%) including unsaturated fatty acids, ash (5%), minerals, vitamins B1 and E [5, 6, 7]. Furthermore, the nutritional and technological potential of these grains could be improved by using less expensive methods such as germination. Indeed, germination is a metabolic process that promotes the bioavailability and digestive utilization coefficient of the minerals contained in the seed [8, 9]. It leads to an increase in the protein, vitamins C and E content of bean (*Vigna unguiculata*) [9] and flax (*Linum usitatissimum* L) seeds [10]. Sprouting also improves the digestibility of proteins by hydrolysis into

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polypeptides, essential amino acids and free amino acids that are more easily assimilated [11]. So, the aim of this study was to investigate the effects of the germination time on the functional properties of sesame flours in order to contribute to the valorization of sesame grown in Côte d'Ivoire.

2. Material and methods

2.1. Plant material

The plant material used in this work consisted of sesame seeds (*Sesamum indicum*) (Figure 1). The seeds were purchased approximately one month after harvest from a producer in Méagui, a locality located in the department of Soubré (South-West, Côte d'Ivoire) 369 km from Abidjan. They were then transported to the Biocatalysis and Bioprocesses Laboratory of Nangui Abrogoua University (Abidjan, Côte d'Ivoire).

Figure 1 Photograph of sesame seeds *(Sesamum indicum)*

2.2. Sesame seed germination process

Germination was carried out according to the modified method of [12]. The sorted sesame seeds (2 kg) were washed and then soaked in 10 L of tap water (ratio 1/5; w/v) for 24 h. After soaking, 0.5 kg of seeds was taken and dried in the oven at 45 °C for 24 hours. This step made it possible to obtain the sample of seeds soaked for 24 hours in tap water and symbolized by G0. The rest of the seeds were spread on a white cotton cloth for germination in a room with humidity and temperature around 85 ± 5% and 28 ± 3 °C, respectively. After 1, 2, 3 and 4 days of germination, an aliquot of seeds was taken, dried in the oven at 45 °C for 24 h and degermed manually. This step made it possible to constitute the samples of sprouted seeds at time T1, T2, T3 and T4 respectively symbolized by G1, G2, G3 and G4.

2.3. Preparation of raw or sprouted sesame seed flours

2.3.1. Preparation of raw sesame seed flours

The raw sesame seeds (0.5 Kg) were previously sorted, then washed and then left to dry on the bench at room temperature (25 °C) for 48 hours. They have been ground to obtain raw sesame seed flour (FSF). This flour was stored in hermetically sealed containers at room temperature for further analysis.

2.3.2. Preparation of sprouted sesame seed flours

Seeds of different germination times (G0, G1, G2, G3 and G4) were crushed using a Moulinex type shredder. The different flours obtained were coded as follows: FSG0 (sesame seed flour soaked for 24 hours in tap water), FSG1, FSG2, FSG3 and FSG4 (Sesame seed flours germinated for 1, 2, 3 and 4 days). They were kept in hermetically sealed containers at room temperature for later analysis.

2.4. Analyses of the functional properties of flours

2.4.1. Water Absorption Capacity and Water Solubility Index

The water absorption capacity (WAC) and water solubility index (WSI) of the flours were determined using the methods of [13] and [14], respectively. One (1) g of sesame seed flour (raw, sprouted) (m_0) was diluted in 10 mL of distilled water. This mixture was stirred for 30 min and then held in a water bath at 37 °C for 30 min. It was then centrifuged at 4200 rpm for 20 min. The pellet obtained (m2) was weighed and then dried at 105 °C in the oven until a constant mass (m_1) was obtained. The water absorption capacity was obtained according to the following formula

$$\text{WAC } (\%) = \frac{(m_2 - m_1)}{m_1} \times 100$$

The solubility index was calculated according to the following formula

$$\text{WSI } (\%) = \frac{(m_0 - m_1)}{m_0} \times 100$$

m_0: mass of the sample taken; m_1: dry mass of the sample after passage through the oven; m_2: mass of the raw pellet after centrifugation

2.4.2. Bulk density and porosity

The bulk density (BD) of the flours was determined using the method of [15].

Fifteen (15) g of sesame seed flour (raw or sprouted) (me) was placed in a graduated test tube. The volume (V_0) of this sample was noted after a good leveling with a spatula. Then, the specimen was gently tapped on the bench until a constant volume denoted V_t was obtained. BD and porosity were determined as follows:

$$\text{BD (g/mL)} = \frac{m_e}{V_t}$$

BD: bulk density; me: mass of the sample; V_t: constant volume obtained after tapping

The porosity (P) is calculated according to the following relationship

$$\text{P } (\%) = \frac{(V_0 - V_t)}{V_0} \times 100$$

P: porosity; V_0: volume of the sample noted after a good leveling; V_t: constant volume obtained after tapping

2.4.3. Foaming Capacity

The foaming capacity (FC) of the flours was determined using the modified technique of [16].

Three (3) g of sesame seed flour (raw or sprouted) were placed in a 50 mL graduated cylinder previously dried in the oven. Then, thirty (30) mL of distilled water was added to the sample to facilitate the dispersion of the flour in the test tube and the volume noted (volume before homogenization). Then, the test tube was vigorously shaken by hand and the new volume was read on the test piece (volume after homogenization). The volume of the foam obtained was calculated by differentiating between the volume after homogenization and the volume before homogenization. The foaming capacity was calculated from the following formula:

$$FC\ (\%) = \frac{(V_{after} - V_{before})}{V_{before}} \times 100$$

FC: foaming capacity; V_{before}: volume before homogenization (mL); V_{after}: volume after homogenization (mL)

2.4.4. Determination of Oil Absorption Capacity

The oil absorption capacity (OAC) of the flours was determined using the [17] technique.

One (1) g of sesame seed flour (raw or sprouted) (m_0) was dissolved in 10 mL of oil. The mixture was stirred for 30 min at room temperature using a mechanical stirrer and then centrifuged at 4200 rpm for 12 min. The recovered base was weighed (m1). The experiment was repeated with four (4) types of oil, namely refined palm oil (Dinor), unrefined palm oil (Red), Sunflower oil and Olive oil.

The oil absorption capacity was calculated from the following formula:

$$OAC\ (\%) = \frac{(m_1 - m_0)}{m_0} \times 100$$

m_0: mass (g) of the sample taken; m_1: mass (g) of the raw pellet of the sample after centrifugation

2.4.5. Hydrophilic-lipophilic ratio

The hydrophilic-lipophilic (HLR) ratio as defined by [18] was calculated by making the ratio of water absorption capacity (WAC) to oil absorption capacity (OAC). This report made it possible to evaluate the comparative affinity of flours for water and oil.

$$HLR = \frac{WAC}{OAC}$$

HLR: hydrophilic-lipophilic ratio; WAC: water absorption capacity; OAC: Oil Absorption Capacity

2.4.6. Swelling and Solubility

The flour swelling and solubility test was performed using the modified technique of [19].

Suspensions of 1% (w/v) sesame seed flour (raw or sprouted) (m) were placed in a water bath at temperatures ranging from 50 to 95 °C under maximum stirring for 1 h. The suspensions contained in the tubes were centrifuged at 4200 rpm for 15 min. The pellets (m_1) and supernatants were collected in different containers. They were placed in the oven at 105 °C for 24 h for the supernatants (m_s) and 48 h for the pellets (m_2). The supernatants were used to determine the solubility (S) and the pellets, the swelling power (PG) according to the following equations:

$$SP\ (\%) = \frac{(m_1 - m_2)}{m_2} \times 100$$

SP: swelling power (g of water / g of starch); m1: wet mass of the aliquot (g); m_2: dry mass of aliquot (g)

$$S\ (\%) = \frac{m_s}{m} \times 100$$

S: solubility expressed as a percentage (%); m_s: mass of the sample after steaming (g); m: mass taken from the sample (g) to prepare the 1% solution (w/v)

2.5. Statistical Analysis

All analyses were performed in triplicates. Results were expressed by means of ± standard deviation. The data were analyzed using STATISTICA version 7.1 Statistical Software. Comparisons between means were determined using the one factor ANOVA and the Duncan test. Statistical significance was defined at P <0.05.

3. Results

3.1. Water absorption capacity and water solubility index of flours

The functional properties of flours such as capacity Water Absorption Capacity (WAC) and Water Solubility Index (WSI) are illustrated in the Table 1.

During germination, a significant difference (p <0.05) between the functional properties of raw sesame flour (FSF) and sprouted sesame flour (FSG) was observed. The WAC for flours varied from 188.05 ± 1.05 % (FSF) to 245.47 ± 1.17 % (FSG4) while the WSI has ranged from 45.50 ± 0.45 % (FSF) to 47.86 ± 0.18 % (FSG1) and then to 46.25 ± 0.35 % (FSG2). The FSG0, FSG3 and FSG4 Flours recorded respectively values lower than that of FSF, either 38.80± 0.28%, 44.65±0.49% and 44.50±0.71%.

3.2. Bulk density and porosity of flours

The bulk density (BD) of sprouted seed flours varied significantly (p <0.05) of 0.81 ± 0.02 g/mL (FSF) to 1.01 ± 0.02 g/mL (FSG3) and 0.98 ± 0.05 g/mL (FSG4). FSG0 and FSG1 flours recorded the lowest BD (0.68 ± 0.05 and 0.76 ± 0.02 g/mL). Porosity increased from 58.45 ± 0.88% (FSF) to 62.92 ± 0.72% after 3 days of germination.

3.3. Foaming capacity of flours

The foaming capacity of the flours during sprouting has increased significantly (p <0.05) from 11.44 ± 0.56% (FSF) to 15.75 ± 0.18% after 1 day of germination and then decreased to 13.95 ± 0.15% (FSG4).

Table 1 Effects of sprouting on the functional properties of sesame seed flours

		Functional properties				
Germination time (day)	**Codes**	**WAC (%)**	**WSI (%)**	**BD (g/mL)**	**P (%)**	**FC (%)**
Raw (control)	FSF	188.05±1.05^{a}	45.50±0.45$^{b.c}$	0.81±0.02^{a}	58.45±0.88^{c}	11.44±0.56^{a}
0 (24h soaking)	FSG0	218.86±1.21^{c}	38.8±0.28^{a}	0.68±0.05^{a}	50.08±0.47^{a}	12.65±0.07^{b}
1	FSG1	213.04±0.6^{b}	47.86±0.18^{d}	0.76±0.02^{b}	57.28±0.67^{b}	15.75±0.18^{f}
2	FSG2	230.63±0.39^{d}	46.25±0.35^{c}	0.91±0.02^{c}	61.12±0.08^{d}	13.79±0.07$^{c.d}$
3	FSG3	232.50±1.44^{d}	44.65±0.49^{b}	1.01±0.02^{d}	62.92±0.72^{e}	13.04±0.49$^{b.c}$
4	FSG4	245.47±1.17^{e}	44.50±0.71^{b}	0.98±0.05^{d}	62.65±0.42^{e}	13.95±0.15^{e}

The means of the same superscript column are significantly different at p < 0.05 according to the statistical test. FSF: Raw sesame seed flour; FSG0: Sesame seed flour soaked for 24 hours; FSG1, FSG2, FSG3 and FSG4: Sesame seed flours germinated for 1, 2, 3 and 4 days respectively. Water Absorption Capacity (WAC), Water Solubility Index (WSI), Bulk Density (BD), Porosity (P), Foaming Capacity (FC).

3.4. Oil absorption capacity of flours

The oil absorption capacities (OAC) of four types of oil (sunflower, olive, refined palm or "Dinor" and unrefined or "Red") palm oil were studied (Figure 2).

The OACs of sesame seed flours decreased significantly (p <0.05) as a function of germination time and rates ranged from 91.63 ± 1.00 (FSF) to 70.62 ± 0.65% (FSG)3) from 95.20 ± 1.30 (FSF) to 65.97 ± 0.91% (FSG4), from 100.48 ± 0.98 (FSF) to 67.27 ± 1.26% (FSG4) and from 139.00 ± 0.67 (FSF) to 108.83 ± 0.58% (FSG4) respectively for Sunflower, Olive, Dinor and Red oils. FSF flour recorded the highest absorptions of "Dinor" oil and "Red" oil, while FSG0 flour absorbed more olive and sunflower oils than other flours. Overall, the flours absorbed more Red oil.

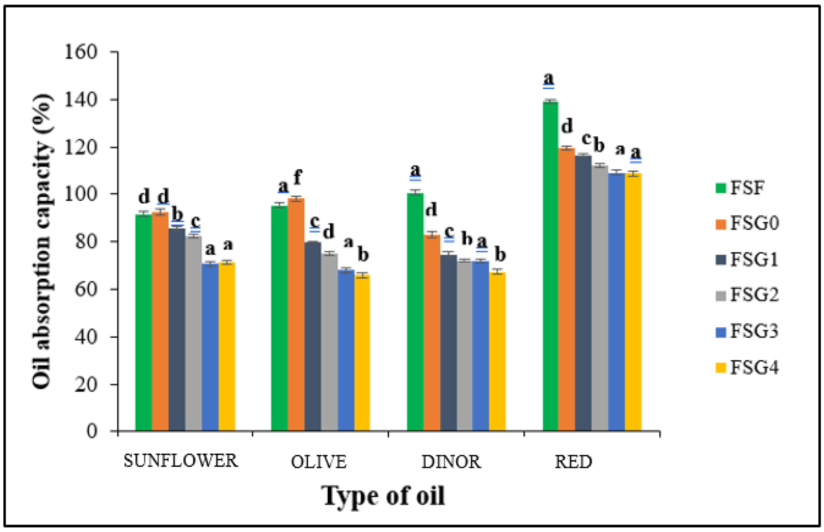


Figure 2 Influence of germination time on the oil absorption capacity of derived flours **(Figure was changed)**

The means of the histograms topped with different letters are significantly different at p <0.05 according to the statistical test. FSF: Raw sesame seed flour; FSG0: Sesame seed flour soaked for 24 hours; FSG1, FSG2, FSG3 and FSG4: Sesame seed flours sprouted for 1, 2, 3 and 4 days.

3.5. Hydrophilic-lipophilic ratio of flours

The hydrophilic-lipophilic (HLR) ratios of sesame seed flours (non-sprouted and sprouted) are presented in the Figure 3.

Germination significantly influenced ($p<0.05$) the HLR. FSF flour has the lowest ratios regardless of the type of oil while FSG flours have the highest values, with variations of 2.06 ± 0,02 to 3.44 ± 0,06; 1,98 ± 0,03 to 3.72 ± 0,05; 1,88 ± 0,02 to 3.65 ± 0,06 and 1.58 ± 0,01 to 2.26 ± 0,01 respectively for Sunflower, Olive, Dinor and Red oils.

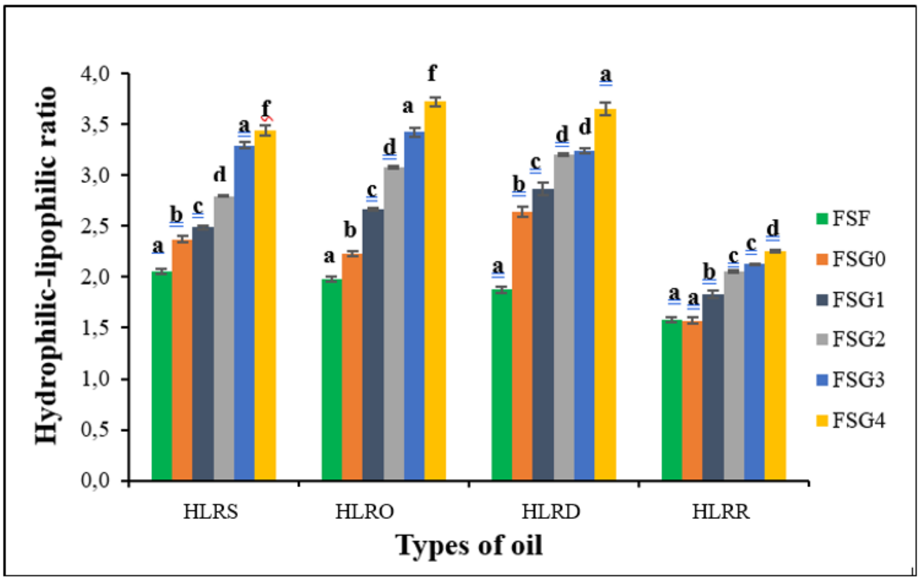


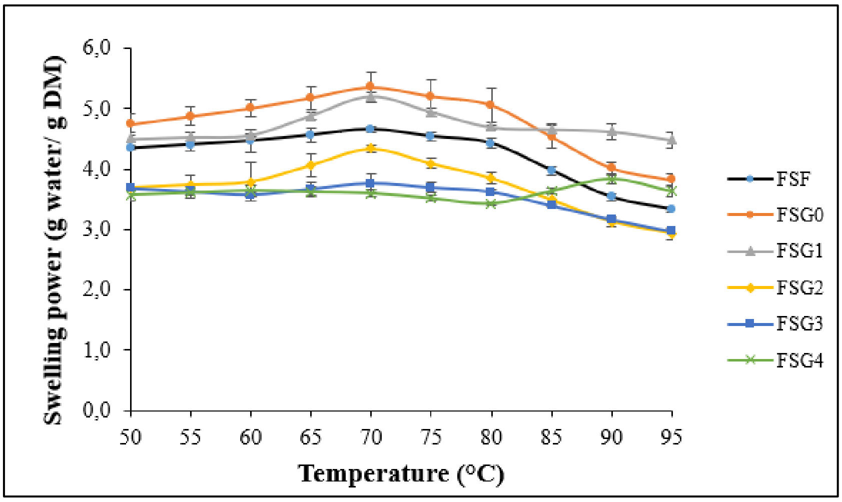
Figure 3 Hydrophilic-lipophilic ratios of sprouting sesame seed flours (Figure was changed)

The means of the histograms topped with different letters are significantly different at $p < 0.05$ according to the statistical test. FSF: Raw sesame seed flour; FSG0: Sesame seed flour soaked for 24 hours; FSG1, FSG2, FSG3 and FSG4: Sesame seed flours sprouted for 1, 2, 3 and 4 days; HLRS: Hydrophilic-Lipophilic Ratio in Sunflower Oil; HLRO: Hydrophilic-Lipophilic Ratio in Olive Oil; HLRD: Hydrophilic-Lipophilic ratio in Dinor oil; HLRR: Hydrophilic-Lipophilic Ratio in Red Oil.

3.6. Swelling power of flours

The study of the swelling power of the different flours as a function of the incubation temperature has shown that all flours have a swelling power that varies with the increase in temperature (Figure 4). However, overall, the swelling capacity was low between 50 and 60 °C and rapid from 65 °C with a peak at 70 °C.

FSG0 (5.35 ± 0.25 g water/g DM) and FSG1 (5.19 ± 0.09 g water/g DM) flours had a higher swelling power than FSF (4.65 ± 0.06 g water/g DM). The lowest swelling values were observed with sprouted seed flours for 2, 3 and 4 days, which recorded 4.34 ± 0.06 respectively; 3.76 ± 0.16 and 3.82 ± 0.07 g water/g DM. The swelling power of the flours decreased after 1 day of germination.



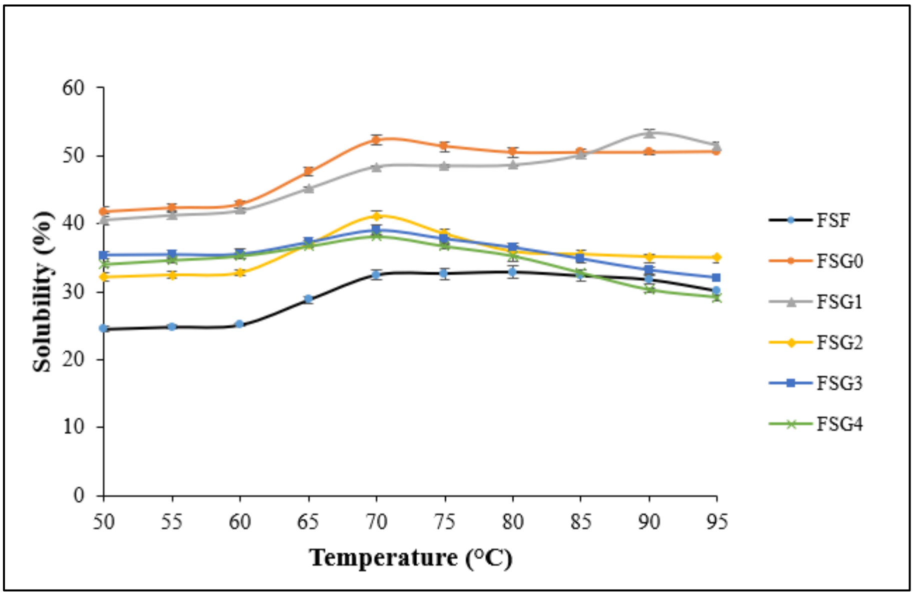
FSF: Raw sesame seed flour; FSG0: Sesame seed flour soaked for 24 hours; FSG1, FSG2, FSG3 and FSG4: Sesame seed flours sprouted for 1, 2, 3 and 4 days

Figure 4 Swelling powers of sesame seed flours in germination

3.7. Solubility of flours

The curves of the evolution of the solubility of flours of germinated sesame seeds presented on the whole, the same appearances; they grow with temperature (Figure 5).

Sprouting increased the solubility of sesame flours. Indeed, germination time significantly influenced ($p < 0.05$) solubility, which increased at 70 °C from 32.88 ± 0.88% for raw sesame flour to 52.30 ± 0.60% (FSG0) and 38.13 ± 0.18% at the end of germination. On the other hand, FSG1 flour recorded the highest solubility at 90 °C (53.25 ± 0.71%).



FSF: Raw sesame seed flour; FSG0: Sesame seed flour soaked for 24 hours; FSG1, FSG2, FSG3 and FSG4: Sesame seed flours sprouted for 1, 2, 3 and 4 days

Figure 5 Solubility of sesame seed flours in germination

4. Discussion

Functional properties are defined as the set of physical and chemical properties affecting the behavior of proteins or carbohydrates in a formulation during the production, storage and consumption of food products [20]. They determine the application of food raw materials for various food products [21]. In view of the results obtained, germination has impacted the different functional properties of the flours. A significant difference (p <0.05) was observed between the water absorption capacities (WACs) of sesame seed flours (raw and sprouted). Indeed, the WAC of sprouted sesame seed flours increased with germination time and were higher than those of raw sesame seeds (unsprouted). This difference in absorption could be due to the lipid levels in these flours. In this regard, according to [22], the presence of lipids in large quantities in a flour reduces the ability of water to bind to particular substances, thus limiting the WAC. The decrease in the lipid level in sprouted sesame seed flours increased their ability to absorb more water. This result is similar to those of [23] and [24] which showed that the WAC of defatted breadfruit and sesame flours was higher than that of non-defatted flour. This increase could also be attributed synthesis of hydrophilic constituents (amino acid, amylose, amylopectin) during germination [25, 26], which has contributed to an increase in water interaction sites [27, 28]. Moreover, according to [3], the size of the flour and starch grains and the carbohydrate content are thought to be the cause of the differences observed.

The WAC, being an index of the maximum amount of water that a food product can absorb and retain [29], suggests that sprouted sesame seed flours, in view of the high values obtained, could be used in the formulation of certain foods such as sausages, pasta, processed cheese and bakery products [30] as well as certain cooked products [31]. Indeed, the higher the WAC of flour, the better the organoleptic characteristics [32].

FSG1 and FSG2 flours have higher solubility index (WSI) than FSF flour. This difference in solubility could be explained by the presence of soluble constituents that would be different from one flour to another [33]. In fact, the WSI reflects the extent of starch degradation and measures the amount of soluble substances released from the starch granules [34]. The high percentage observed for sprouted sesame seed flour (FSG1) could be due to starch degradation by amylolitic enzymes; which increased the solubility of the flour. However, such a result cannot be linked solely to starch, especially since, according to study of [35], sesame contains less than 1% starch. This increase could also be explained by the increase in soluble molecules resulting from the breakdown of lipids and fibers in flours [33, 26]. This index gives the affinity of a flour to disperse in water and to give a homogeneous solution [3]. Sprouting increases the solubility of sesame seed flours therefore, they can be used in the formulation of children's food and in the manufacture of beverages [36].

Bulk density (BD) determines the suitability of a flour to be easily packaged, which would facilitate the transport of a large quantity of it [37]. The BD depends on the intensity of the inter-particle forces and the size of the latter [38].

Sprouting increased significantly (p <0.05) the BD of flours compared to that of raw seeds. This difference in DA would be due to the size of the particles which would be inversely proportional to the bulk density [39, 40]. Sprouted sesame seed flours would therefore be made up of finer particles than raw seeds. This would probably be due to the degradation of complex macromolecules into simple molecules under the action of intrinsic enzymes of seeds or extracellular enzymes of microorganisms [27, 41]. The higher the BD of a product, the greater the amount that can be packed in a specified space. Thus, sprouted sesame seed flours (except FSG0 and FSG1) would be easily packaged; which would facilitate the transport of a large quantity [37]. FSG0 and FSG1 flours with low density values could be used in the preparation of weaning foods because, nutritionally, a low bulk density promotes the digestibility of food products, especially in children because of their immature digestive system [31].

The porosity of a flour is a measure of its weight [42]. The study of the porosity of the different flours showed a significant increase (p <0.05) depending on germination times. The increase in porosity is due to the reduction in the moisture content of the flours during this process. Indeed, the decrease in the humidity level in a food leads to a greater production of air space, thus increasing its porosity [43]. The high porosity of the flours suggests that they could be useful in the formulation of infant food because, according to [22], High porosity promotes the digestibility of food products.

The foaming capacity (FC) reflects the protein content of a flour, improving the texture, uniformity and appearance of the food [44]. A significant difference (p <0.05) was observed between FC of sesame seed flours (raw and sprouted). This variation can be attributed to a difference in the flour's composition [45]. Indeed, the FC of a flour depends on its protein, lipid and carbohydrate content [46]. Thus, the increase in the FC, especially on the 1st day of germination (FSG1), would be due to the increase in the protein content in these flour [47]. It should be remembered that the incorporation of sprouted sesame seed flours into wheat flour has given convincing results, particularly for the manufacture of biscuits [48] and breads [49]. Consequently, the sesame seed flours obtained from the various processes can be used in the same fields (biscuit and bakery).

The oil absorption capacity (OAC), which is the ability of a protein to absorb and retain oil in its structure, can be influenced by the lipophilic nature of proteins [50]. This is because the ability of a flour's protein to physically bind fat through capillary attraction is of great importance, as they act as a flavor retention agent and also increase the mouthfeel of food [33]. The OACs of sesame seeds flours varied significantly (p <0.05) from one flour to another and from one type of oil to another. In concrete terms, the OAC of sprouted sesame seed flours has decreased over time. The results obtained are contrary to those of [27] and [28] who have worked respectively on the tigernut (*Cyperus esculentus*) and sorghum (*Sorghum bicolour* L.) germinated. This difference may be due to the method used and the nature and biochemical composition of the seeds studied. The OAC of raw sesame seed flour is higher than that of sprouted sesame seed flours. This would be because raw sesame seed flour has more hydrophobic proteins than sprouted sesame seed flours [51].

The hydrophilic-lipophilic ratio values obtained ranged from 1.58 to 2.08 (raw sesame seed flour), 1.57 to 3.61 (sprouted sesame seed flours). All of these values are greater than 1 and have increased depending on the processing time and the type of oil used. These results show that raw, sprouted sesame seed flours have a greater affinity for water than oil. This difference in affinity is explained by a large number of polar groups present in the flours of germinated sesame seeds having the greatest ratios. Therefore, they should preferably be used for the formulation of (bakery) products requiring a high water absorption capacity [52].

Swelling power (PG) is an important factor used to determine the amount of water absorbed by the food and the degree of swelling over a given period of time [53]. The slight swelling of sesame seed flours between 50 and 60 °C is due to the presence of lipids and proteins which, by forming complexes with the starch granules in the flours, prevent the penetration of water into the flours, thus limiting their swelling power [54]. The increase in the swelling of flours at 70°C is due to changes in the physical state of the starch granules of the flours during hydrothermal treatments [55]. On the other hand, the decrease in the PG of flours beyond 1 day of germination would be attributed according to [56], to a reduction in the starch content in these flours.

The solubility of sprouted sesame seed flours is higher than that of raw seeds. This result is explained by their high swelling power. In fact, under the effect of heat, the starch granules weaken and facilitate the penetration of water into them. During swelling, amylose exits the granule and amylopectin is highly hydrated. As the temperature increases, the granules tend to fragment and break, releasing polymer molecules and aggregates that solubilize in the medium [55]. Flours with high solubility would be digestible and therefore may be suitable in infant food formulations. They could also be used in the manufacture of beverages [36].

5. Conclusion

The functional properties (water absorption capacity, bulk density, foaming capacity, swelling power and solubility) of sesame seed flours sprouted have been improved significantly over time. On the other hand, the oil absorption capacity has been reduced. The flour obtained after 1 day of germination has higher solubility, bulk density and foaming capacity than those from other times. This suggests that this flour (FSG1) would be suitable in the preparation of infant food porridges. Overall, flours made from sprouted sesame seeds could be useful in cake making and baked goods due to the high water absorption.

Compliance with ethical standards

Disclosure of conflict of interest

There are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

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