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PHYSIOCHEMICAL AND SENSORIAL ATTRIBUTES OF APRICOT FORTIFIED WHEAT BISCUITS

F. Benmeziane -Derradji[1,2] ✉, A. Taguida[1], L. Djermoune-Arkoub[2,3], R.K. Raigar [4], S. Bellagoune S[5]

[1]Department of Agronomic Sciences, Faculty of Natural and Life Sciences, Chadli Bendjedid University of El-Tarf.PB 73. El-Tarf 36000, Algeria.
[2]Laboratory of Biomathematics, Biophysics, Biochemistry, and Scientometry (L3BS), Faculty of Nature and Life Sciences, University of Bejaia, 06000 Bejaia, Algeria.
[3] Department of Process Engineering, Faculty of Technology, University of Bejaia, Bejaia, Algeria
[4]Department of Processing and Food Engineering, College of Agricultural Engineering and Post-Harvest Technology, Central Agricultural University, Ranipool, Sikkim, 737135, India.
[5]Department of Commerce, Quality Control Service, Annaba -Algeria-
✉benmezianefarida@yahoo.fr

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ABSTRACT

This study envisages the application of apricot kerned, a by-product of apricot fruits, in partial substitution of wheat flour (WF) by apricot kernel flour (AKF) in the proportion of 5, 10 and 15 % in making biscuit with three formulations F1, F2, F3, respectively and the fourth one was a control biscuit without AKF. Physicochemical and functional properties of WF, AKF and their blends were studied. The effect of AKF addition on the physical and sensory properties of composite biscuits was also investigated. Obtained results showed that the incorporation of AKF affect significantly the physicochemical characteristics and the functional properties of the flours comparing to the WF as control. A significant difference ($p < 0.05$) in physical characteristic between biscuits fortified with AKF and control was showed except for spread factor and percentage of spread factor. Furthermore, sensory evaluation revealed that the cookies containing AKF were acceptable by the panellists at all concentrations ($p < 0.05$) and based on the sensory evaluation, biscuits supplemented with 5 % of AKF got the highest scores compared to other samples. Thus, AKF can be incorporated at a rate of 5 % to prepare acceptable quality biscuits.

1.Introduction

Feeding differs from person to another depending on the religions and eating habits of each person, but all human beings eat to protect their health with the nutrients they find in food and especially in fruits and vegetables. Among the most famous fruits, the apricot, which is one of the most important fruits because of its constitution which gives it a considerable place in the human diet and its use in other non-food products. Scientific investigations state that apricot is a fruit of high nutritional density in terms of sugars (more than 60%), proteins (8%), crude fibers (11.50%), crude fat (2%), total minerals (4%), vitamins (vitamin A, C, K and B) and reasonable amounts of organic acids (malic and citric acids) (Tabasum *et al.*, 2018). Like the fruit, apricot kernel has remarkable nutritional value. In fact, apricot kernels, especially rich in lipid, protein and total dietary fiber, are potentially valuable in human nutrition. The chemical and nutritional properties of apricot kernels were widely studied by many research groups (Aziz *et al.*, 2020). Various pharmacological effects of apricot kernel have been reported, including antibacterial, antifungal, anti-tumor, anti-coagulant, anti-inflammatory, antidiabetic, anticancer, antiparasitic, antiaging, anti-atherosclerotic, anti-anginal, hepatoprotective, renoprotective, antioxidant (Gupta *et al.*, 2018; Ramadan *et al.*, 2020). Furthermore, apricot kernels can contribute considerably in the prevention and treatment of chronic health disorders (Chen *et al.*, 2020). Those benefit health effects are due to the presence of bioactive components including polyphenol, fatty acid, sterol derivatives, carotenoids, cynogenic glycosides and volatile component (Tabasum *et al.*, 2018). With a production of 209 204 tons in 2019, Algeria is considered a major apricot producer country (FAO, 2019) and the major apricot productions in Algeria is mainly consumed as fresh or dried fruit, or transformed into jam or juice. In all of these uses, apricot kernels have always been considered waste. Recently, more attention has focused on the use of agricultural wastes due to their availability, biodegradability and above all, their lower cost (Melini *et al.*, 2020). This is the reason why, man invested in the valorization of apricot fruits through the recovery and use of their seeds (Dilucia *et al.*, 2020). However, the use of apricot kernels in the food industry is very rare; they are used as a flavoring in food gums. The main use of apricot kernels lies in the extraction of its oil which is already commonly used in cosmetics (soaps, ointments, creams, shampoo) and in medicine for its beneficial effects on health proven in several scientific studies due, mainly to its antioxidant properties (Chen *et al.*, 2020). Nevertheless, the use of apricot kernel in human food is limited due to the presence of amygdalin (cyanogenic glycoside also known as laetrile or vitamin B17) considered a toxic compound when consumed in amounts exceeding the prescribed doses (Jaswal *et al.*, 2018). Despite this, several studies have raised the possibility of adding apricot kernel flour to certain food preparations, given their beneficial effects on health (Dhen *et al.*, 2018; Aziz *et al.*, 2020). Thus, the main objective of the current study is the contribution to the valorization of apricot kernel from the Algerian production as flour in the manufacture of a biscuit. To achieve this, flour blends were made by partially substituting wheat flour by AKF at substitution percentages of (5, 10 and 15) % which were analyzed for their physicochemical and functional properties. The prepared biscuits were characterized in terms of physical characteristics and sensory features.

2. Materials and methods

2.1. Preparation of apricot kernel flour (AKF)

The pits were recovered from the apricots (*Prunus armeniaca*) in the region of Oum Tboul (Algerian-Tunisian border) during the month of August 2020. The fruits were collected in a meticulous manner, by taking from all sides of the orchards (left, right, up, down, face exposed to the sun and not exposed to the sun). The recovered pits were washed with tap water before being dried in the sun for 12 hours. At the end of drying, the pits were shelled and the kernels were thus collected and crushed to obtain the apricot kernel flour (AKF) with 500 µm particle size. The resulting AKF was stored in plastic bags in a freezer to prevent oxidation of the product until the time of analysis.

2.2. Flour blends preparation

The AKF was mixed with wheat flour in different proportions (AKF-Wheat flour) of 00: 100, 05-95, 10-90, 15-85, respectively. The resulting flours, besides WF and AKF, were analysed for their physicochemical and functional properties.

2.2.1. Physicochemical characteristics of wheat flour, AKF and their blends

Physicochemical analyses were carried out on WF, AKF and their blends. Flours were analysed for their:

- Moisture content: was assessed by heating the samples at 105 ± 2 °C until constant weight;
- pH: measured with pH meter (*Crison*);
- Acidity: the principle of the measurement is based on the titration of the alcoholic extract of the flour, using an alkaline solution titrated in the presence of phenolphthalein. Results were expressed in grams of sulfuric acid (H_2SO_4) per 100 grams of dry matter;
- Conductivity: measured with conductivity meter;
- Total ash: was determined by calcinations at 550 °C and finally;
- Total sugar: was determined by extraction with an alcoholic solvent (ethanol) followed by measurement of the absorbance at 485 nm.

Analysis was performed in the quality laboratory and conformity, Annaba (Algeria) in four replications.

2.2.2. Functional properties of flour blends

Some functional properties of flours were determined in order to know their behaviour once incorporated in food matrices (biscuit in the current study). The most important of them are water absorption capacity (WAC) and oil absorption capacity (OAC) which were evaluated according to the method described previously by Diomande et al. (2017). The hydrophilic-lipophilic ratio (RHL) as defined by Marie et al. (2015) was calculated by making the ratio of the WAC to the OAC. It is a report which allow to evaluate the comparative affinity of flours for water and for oil.

2.3. Preparation of biscuits

The biscuits were prepared according to the recipe given by Sheikh et al. (2019). Briefly, for 100 g of flour, 30 g of fine sugar, 20 mL of milk, one egg, 25 g of margarine, 1 g of sodium bicarbonate, 1 g of vanilla and 1 g of salt have been added. The ingredients were mixed as with any cake. The dough was rolled out into a thin sheet of uniform thickness and was cut using a cookie cutter to obtain discs 30 mm in diameter and 5 mm in thickness. The pieces have been placed on a baking tray and are baked at 180 °C for 10 to 15 minutes in a baking oven. The well-baked cookies were removed from the oven, allowed to cool at room temperature for 30 minutes, wrapped and stored at room temperature in polypropylene bags for further studies. Four biscuits formulations were prepared in accordance with Table 1. Control biscuits were formulated without the addition of AKF (B100).

Table 1. Experimental design of biscuit formulations

Formulation	B100	B95	B90	B85
Wheat flour (g)	100	95	90	85
AKF (g)	-	5	10	15
Egg	1 egg	1 egg	1 egg	1 egg
Fat (margarine) (g)	25	25	25	25
sodium bicarbonate (g)	1	1	1	1
Vanilla (g)	1	1	1	1
Salt (g)	1	1	1	1

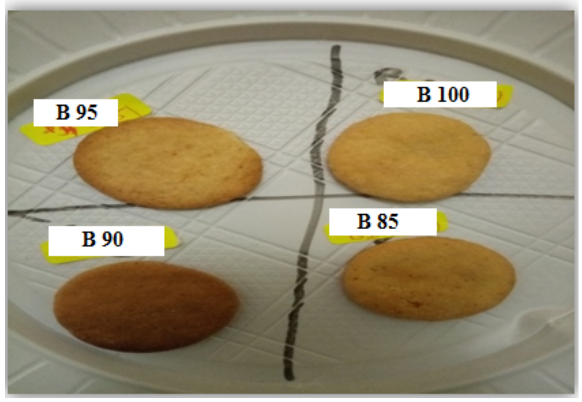

Figure 1. Produced Biscuit

2.4. Characterization of AKF fortified biscuits

2.4.1. Physical properties

The diameter (D) and the thickness (T) of biscuits were measured, using a caliper, on five pieces according to the protocol described by Sheikh et al. (2019), results were expressed in cm. The ration of the diameter to the thickness represents the spreading factor (SF). The percentage of the SF (%SF) was represented as the ration of the SF of the biscuits prepared with flour blends to the SF of the Control biscuits. As for the volume, this was determined according to the following equation: V (cm^3) = ($D^2\pi T$)/4, while the density was expressed by the ration between the weight and the volume of biscuit.

2.4.2. Sensory evaluation

The samples of biscuits were organoleptically scored by semi-trained subjects. For this purpose, judges were selected from the faculty staff (21 panellists, between teachers and students comprising male and female) of the department of agronomic sciences, faculty of natural and life sciences (University Chadli Bendjedid, El-Tarf, Algeria) were invited, according to their motivation and interest, to taste the control and fortified biscuits and to attribute a point based on a five-point hedonic scale (1: Don't like at all; 2: Don't like very much; 3: Indifferent; 4: Like a little and 5: Like a lot). The samples of cookies with different compositions were presented in plates divided into 4 parts, in each of them, a biscuit of each formulation is placed. The panelists were asked to evaluate the sensory attributes (General aspect, color, flavor, aroma, friability and overall acceptability).

2.5. Statistical analysis

The results are presented as a mean ± standard deviations calculated with Microsoft Office Excel 2007. Results obtained from different experiments were subjected to the analysis of variance (ANOVA). The significant difference between the means was tested against the critical difference at 5 % significance level (α = 0.05). The statistical analysis was performed using Minitab version 17 Software (Minitab Inc., State College, PA, United States). The means were compared and the differences were revealed using LSD test (Fisher's test).

3. Results and discussions

3.1. Effect of AKF addition on the physicochemical characteristics of flours

The physiochemical characteristics of the wheat and apricot kernel flours and their blends are summarized in Table 2. At 5% significance level, significant differences were recorded between all flour samples for all studied parameters. In fact, the AKF had the highest pH (6.38), acidity (0.035 g/L), dry matter (94.270 %), ash (3.50 %), conductivity (795.50 µS/cm) and total sugar (2.49 g/100g). Whereas, the same sample had shown a lower water content comparing to the WF (control) and flour blends (WF-AKF).

3.1.1. pH

The pH is a parameter which determines the aptitude of foods to be preserved. The addition of AKF had affected significantly ($p < 0.05$) the pH of wheat and composite flours. WF had the lowest pH (6.33) while AKF had the highest (6.38), wheat flours with the addition of 5, 10 and 15% AKF had intermediate pH of 6.35, 6.36 and 6.36, respectively. Indeed, the results revealed that pH of composite flours increased with decrease in proportions of WF from 100 % to 85 %. Our results were in accordance with those of Nabil et al. (2020) who indicated a decrease of pH in flour supplemented with cladode flour at different proportions 0, 25, 50, 75, and 10 0%. The same authors reported a pH of whole wheat flour of 6.05 which was slightly lower than that observed in the current study. Chandra et al. (2015a) have found that the pH of composite flours increased with increase in the level of composition of rice flour, green gram flour and potato flour and that the lowest pH value of 5.516 was noted, as in this study, in wheat flour.

3.1.2. Fat acidity

The result showed that mixing AKF with WF raised significantly ($p < 0.05$) the samples acidity with a percentage of 34.29, 34.29 and 31.43 % for samples C95, C90 and C85, respectively. AKF was clearly stood out by a higher acidity of 0.035 g/L compared to the other samples. The fat acidity developed in AKF was approximately 1.6 fold higher than that in WF, this makes AKF more sensitive to the oxidation phenomenon thus reducing its shelf life. Increasing the fatty acidity of composite flours is undesirable, since they will be more sensitive to oxidation, which will have repercussions on the shelf life just like AKF. The fat acidity of millet, wheat and corn flours, expressed as mg potassium hydroxide in 100 g of the product, was 47.5, 12 and 15 mg KOH/100 g dry matter, respectively (Goyal *et al.*, 2017). Goyal et al. (2017) observed an increase in fat acidity of these flours during storage and explained this by action of lipases, which causes bitterness and can make meal unacceptable. Authors also stated that the milling of grains leads to tissue damage, thus contact between enzymes and the fat substrate increases. Information on the fatty acidity of AKF is not available in the literature.

3.1.3. Moisture content

Before preparation of biscuits, moisture content of wheat, apricot kernel flour and their blends at different levels were analyzed for their moisture content (Table 2). The moisture of AKF was significantly ($p < 0.05$) different from the wheat and blend flours. The AKF with 5.74 % moisture content makes it more stable and prevent the microorganism's proliferation. Depending upon the blending ratio, the water content ranged from 11.66 % to 12.16 % (dry basis). The respective moisture of composite flours was 12.16 %, 11.94 %, 11.78 % and 11.66 % for C100, C95, C90 and C80. Blending of AKF up to 15 % was found to decrease significantly ($p < 0.05$) the water content. Similar trends were reported previously by Chandra et al. (2015b). They used the blends of rice, green gram and potato flour which resulted in diminution of water content of composite flours. The water content of AKF in the current study was higher than the 2.18 – 2.47 % of moisture reported by Gezeret et al. (2011) in apricot kernels from five varieties collected from Malatya location of Turkey, whereas, that of wheat flour was close to the 13.01 % recorded by Legesse and Emire (2012).

3.1.4. Ash

The ash content of the AKF (3.5 %) differed significantly ($p < 0.05$) from that of WF and blend flours. However, the ash rate of WF and blends revealed non-significant differences ($p > 0.05$). From the results of table 2, it can be seen that incorporation of AKF at different levels in wheat flour significantly increased ($p < 0.05$) the ash content from 0.66 % in wheat flour to 0.70 % in C85 sample (wheat flour with 15% of AKF). The observed increase in ash contents of flour enriched with AKF can be explained by the intake of ash AKF which was very rich in minerals in comparison to wheat flour. Similarly, Sheikh et al. (2019) observed an increase in ash content of the AKF fortified biscuits. The authors explained this situation by the relatively higher ash content of AKF than wheat flour. This could justify the results obtained from the flour samples substituted with different rates of AKF. The same trend was found by Legesse and Emire (2012) who noted that blending of the mango kernel flour with wheat flour up to 30 % raised significantly the ash content from 0.85 for wheat flour to 1.13 g/100g for flour added with 30 % of mango kernel flour. It was established that in the mineral fraction, Ca, K, Mg, Na and P are as major minerals in apricot kernels (Gezer et al., 2011). Özcan et al. (2010) have stated the same situation.

Table 2. Proximate composition and functional properties of wheat flour composite flours (WF – AKF)

Combination	C_{100}	C_{95}	C_{90}	C_{85}	C_0
pH	6.33 ± 0.00^d	6.35 ± 0.01^c	6.36 ± 0.01^b	6.36 ± 0.00^b	6.38 ± 0.00^a
Fat acidity g/L of H_2SO_4	0.022 ± 0.00^c	$0.023\pm0.00^{b,c}$	$0.023\pm0.00^{b,c}$	0.024 ± 0.00^b	0.035 ± 0.00^a
Moisture content (%)	12.16 ± 0.01^a	11.94 ± 0.03^b	11.78 ± 0.02^c	11.66 ± 0.01^d	5.74 ± 0.03^e
Dry matter (%)	87.84 ± 0.01^e	88.06 ± 0.03^d	88.22 ± 0.02^c	88.34 ± 0.01^b	$94.270.03^a$
Ash (%)	0.66 ± 0.01^b	0.68 ± 0.01^b	0.69 ± 0.005^b	0.70 ± 0.01^b	3.50 ± 0.01^a
Conductivity (µS / cm)	730.25 ± 0.96^d	730.50 ± 0.58^d	737.00 ± 0.82^c	755.25 ± 0.96^b	795.50 ± 1.29^a
Total sugar (g / 100g)	1.45 ± 0.01^e	1.48 ± 0.01^d	1.52 ± 0.01^c	1.58 ± 0.01^b	2.49 ± 0.02^a

Each value in the table is the mean ± standard deviation (n = 4); Different letters in the same line indicate a significant difference (p < 0.05); Results are ranked in descending order: a>b>c>d;
***C_{100}**: Wheat Flour **(100%)** or control biscuit .*
***C_{95}**: Wheat Flour **(95%)** + AKF **(5%)** .*
***C_{90}**: Wheat Flour **(90%)** + AKF **(10%)**.*
***C_{85}** : Wheat Flour **(85%)** + AKF **(15%)**.*
***C_0**: Wheat Flour **(0%)** + AKF **(100%)**.*

3.1.5. Electrical Conductivity

From the Table 2, it appears that the AKF is the most mineralized (795.50 µS/cm) and its incorporation in WF had significantly ($p < 0.05$) increased the conductivity of the composite's flours with a percentage of 8.17, 7.35 and 5.06 % for wheat flour incorporated with 5, 10 and 15% of AKF, respectively. The conductivity of AKF which is reported for the first time in this research is much higher than the 2.86 µS/cm reported by Benmeziane-Derradji et al. (2020) in the lentils flour. The conductivity of the flour is proportional to the ash content recorded with correlation coefficient R^2 of 0.77.

3.1.6. Total sugar

The addition of AKF impacted significantly ($p < 0.05$) the total sugar of composite flours. In fact, the rate of total sugar increased as the substitution percentage from 5 to 15 % increased. The AKF had the highest rate of 2.49 %, which explain the elevation of the total sugar content of flour blends as the WF had the lowest content of 1.45 %. Alpaslan and Hayta (2006) have reported a mean total sugar content of 2.86 % in kernels from different cultivars in Turkey which is close to what was recorded in the current study. The same authors have partitioned the average sugar content into 0.77, 0.81 and 1.28 % for glucose, fructose and sucrose, respectively. Yarilgaç et al. (2008) have identified the sugar in some Turkish and Foreign Apricot (*Prunus armeniaca* L.) varieties. They found that the main sugar was sucrose in the majority of apricot varieties. Kernels of Turkish varieties contained 2.20-5.30 g/100 g sucrose, 0.40-3.40 g/100 g maltose, 0.90-3.64 g/100g glucose and 0.57-5.58 g/100 g fructose. Sugar contents of seeds belonging to foreign varieties were 3.30-4.67 g/100 g sucrose, 1.50-2.52 g/100 g maltose, 3.38-3.72 g/100 g glucose and 1.86-2.93 g/100 g fructose. The authors concluded that sugar contents significantly, differed by varieties. Differences in proximate composition with other results might be due to differences in varieties, soils, climatic environment, and physical conditions as stated by Nabil et al. (2020).

3.2. Effect of AKF on the functional properties of flours

Food proteins are the main constituent responsible for the functional properties of foods. Protein has both hydrophilic and hydrophobic properties therefore, can interact with water and oil in foods. Functional properties are of primary importance in food processing, including solubility, water and oil absorption capacities and many others. These properties are involved in food texture and organoleptic characteristics and are essential in the manufacture of products such as dairy and meat products, cookies, confectionery, drinks and salad dressings. These tests are carried out with the aim of simulating a possible incorporation into a food matrix.

Table 3. Functional properties of different flours

Combination	C_{100}	C_{95}	C_{90}	C_{85}	C_0
WAC (%)	107.92±0.33 ^{e}	109.18±0.06 ^{d}	110.26±0.10 ^{c}	111.76±0.47 ^{b}	147.66±0.27 ^{a}
OAC (%)	86.94±0.18 ^{e}	88.30±0.17 ^{c}	87.56±0.16 ^{d}	89.91±0.16 ^{b}	101.60±0.13 ^{a}
HLR	1.24±0.01 ^{b,c}	1.24±0.00 ^{b,c}	1.26±0.00 ^{b}	1.24±0.00 ^{c}	1.45±0.00 ^{a}

Each value in the table is the mean ± standard deviation (n = 4); Different letters in the same line indicate a significant difference (p < 0.05); Results are ranked in descending order: a>b; WAC: Water Absorption Capacity; OAC: Oil Absorption Capacity; HLR: Hydrophilic-Lipophilic Ratio

C100*: Wheat Flour* ***(100%)*** *or control biscuit.*

C95*: Wheat Flour* ***(95%)*** *+ AKF* ***(5%)****.*

C90*: Wheat Flour* ***(90%)*** *+ AKF* ***(10%)****.*

C85*: Wheat Flour* ***(85%)*** *+ AKF* ***(15%)****.*

C0*: Wheat Flour* ***(0%)*** *+ AKF* ***(100%)****.*

From Table 3, it can be seen that AKF is distinguished by significantly ($p < 0.05$) higher WAC and OAC of 147.66 % and 101.60 %, respectively compared to those of WF or composite flours. The high OAC which supposes the lipophilic nature of the constituents of the AKF is very useful in flours as fats act as trap for flavors and different smells. Indeed, Seena and Sridhar (2005) indicated that high OAC, as that recorded for the AKF in the current study, is desired in ground meat formulations, flavor retention, amelioration of palatability, extension of shelf life of bakery or meat products, meat replaces and extenders, doughnuts, pancake, baked goods and soups. Whereas, high WAC is desirable feature in food such as sausages, custards and dough because these are assumed to absorb water without dissolution of proteins thereby attaining body thickening and viscosity, according to the same authors. In addition, Okpala et al. (2013) indicated that flours with high WAC, as recorded in this study, would be useful in bakery products, as this could prevent staling by reducing moisture loss. The WF had respective lowest values of 107.92 and 86.94 % for WAC and OAC. The addition of AKF had a positive significant ($p < 0.05$) effect on the WAC of composite flours, which was increased by 1.15, 2.12 and 3.44 % for the replacement percentage of 5, 10 and 15 %, respectively, along with a positive significant ($p < 0.05$) impact on the OAC which increase by 1.50, 0.74 and 3.30 % for the composite flours at replacement level of 5, 10 and 15 %, respectively. The increase in WAC may be due to different types of hydrophilic carbohydrates and a varied protein structure provided by AKF, and that in OAC may be due to the presence of non-polar side chains provided by AKF which link the hydrocarbon side chain of the oil (Seena and Sridhar, 2005). Our observations were lower than the earlier findings of Thakur et al. (2019) in wild apricot protein isolate which had higher water absorption and oil absorption capacities (2.45 mL/g and 2.52 mL/g, respectively) and those of Benmeziane-Derradji et al. (2020) in raw lentil flour (136 % for WAC and 130.67 % for OAC). The HLR varied significantly ($p < 0.05$) between flours; However, all flours recorded ratios greater than 1 which assumes that all flours have much more affinities towards water than oil, the AKF had the highest ratio of 1.45. Benmeziane-Derradji et al. (2020) obtained the same results on raw and roasted lentil flours.

3.3. Physical characteristics of biscuits

Biscuits prepared with varying levels of replacement of WF by AKF were assessed for diameter, thickness, spread ratio, percentage of spread ration, volume and density (Table 4). In the statistical processing of the results with the Fisher's LSD test, significant differences ($p < 0.05$) in the diameter, thickness, volume, density and weight were recorded between fortified biscuits and the control. Indeed, the diameter and the density of the biscuits increased as the inclusion of AKF increased in the biscuit formulation. This increase may be due to the presence of AKF by providing fibers which led to the leavening of the dough during baking. Our results don't agree with those of Ashraf et al. (2018) who reported a decrease in the diameters of nut crackers when foam mat dried apricot powder was substituted in wheat flour; and those of Chen et al (2020), who stated when the effects of spray-dried apple fiber was compared to wheat and oat brans in cookies, that as the concentration of apple fiber increased, the diameter of cookies decreased, and their thickness increased, oppositely, the diameters of oat bran supplemented cookies did not vary significantly as the addition percentage increased. As for the weight, there was no significant differences ($p > 0.05$) in all samples except the biscuit B85 which presented the highest weight (5 g). The same sample had the highest volume and the density, this can be explained by the increased protein network due to the presence of 15% AKF as stated by Sheikh et al. (2019). Our results were in agreement with Awad and skokry (2018) who pointed out that the increasing levels of pumpkin powder in cake manufacture (0 - 15 %) significantly increased the weight of biscuits samples and they attributed this increment in weight to the pumpkin fiber content which increased the water absorption capacity. However, the addition of the AKF didn't affect ($p > 0.05$) the spread factor and the percentage of the spread factor of enriched biscuits comparing to the control. According to Masmoudi et al. (2021) and Adeola and Ohizua (2018), the spread ratio is considered as one of the most important parameters in determining the quality of cookies, also, the higher the spread ratio of biscuit the more desirable it is. Hence, based on spread ratio, biscuit prepared from the flour blend containing 5 % of AKF may be the most preferred. This assertion is confirmed in Table 4 where there were no significant ($p > 0.05$) differences in the sensory attributes of this biscuit sample (B95) and the one adjudged to be the most acceptable. The same sample had the highest overall acceptability. Our results corroborate with those of Adeola and Ohizua (2018) on the biscuit prepared from blending 45 % cooking banana, 10 % pigeon pea and 45 % sweet potato, which was the most preferred based on spread ratio and the sensory evaluation. The current findings for diameter are coherent with results of Aziz et al (2020) who reported that the diameter of the cookies increases in supplemented cookies with apricot powder (10

%) comparing to the control. Masmoudi et al. (2021) have noted similar results with an insignificant decrease of the spread factor of biscuits enriched with jujube (*Zizyphus lotus* L.) flour and fiber concentrate compared to the control, while Jothi et al (2014) have indicated a significant ($p < 0.05$) decrease in spread factor with the addition of various amounts of composite flour (Gluten-free wheat flour, rice flour, Bengal gram flour, potato flour and Italian millet flour). Authors explained this decrease by the fact that composite flours apparently formed aggregates with increase numbers of hydrophilic sites available that contributed for the limited free water in biscuit dough. Furthermore, Özboy-Özbaş et al. (2010) indicated that spread ratio values of the resistant starch supplemented cookies decreased significantly ($p < 0.01$) as the percentage of resistant starch increased, however, a slight increase in the spread ratios of resistant starch/apricot kernel flour supplemented cookies were observed up to 20 % level. The spread factor is correlates with texture, grain finesse, bite and overall mouth feel of the biscuits (Jothi et al. 2014).

Table 4. Influence of AKF on the physical characteristics of biscuits

Formulation	B100	B95	B90	B85
Diameter(cm)	3.200 ± 0.274^{b}	$3.300 \pm 0.274^{a,b}$	$3.300 \pm 0.274^{a,b}$	3.700 ± 0.447^{a}
Thickness (cm)	$0.800 \pm 0.274^{a,b}$	0.600 ± 0.274^{b}	$0.900 \pm 0.224^{a,b}$	1.000 ± 0.354^{a}
Spread Factor	4.400 ± 1.475^{a}	5.43 ± 2.44^{a}	3.900 ± 1.194^{a}	4.132 ± 1.711^{a}
Percentage of Spread Factor	100 ± 0.00^{a}	130.96 ± 75.58^{a}	99.30 ± 49.02^{a}	94.4 ± 21.01^{a}
Volume (cm^3)	$6.67 \pm 3.05^{a,b}$	5.25 ± 2.52^{b}	$7.88 \pm 2.67^{a,b}$	11.16 ± 5.48^{a}
Density	8.081 ± 1.396^{b}	$8.586 \pm 1.393^{a,b}$	$8.591 \pm 1.395^{a,b}$	10.87 ± 2.48^{a}
Weight (g)	3.60 ± 0.55^{b}	3.60 ± 0.55^{b}	3.60 ± 0.55^{b}	5.00 ± 1.00^{a}

Each value in the table is the mean ± standard deviation (n = 5); Different letters in the same line indicate a significant difference (p < 0.05); Results are ranked in descending order: a>b;
***B100:** Control biscuit (without AKF)*
***B 95:** 5% AKF fortified biscuit*
***B90:** 10% AKF fortified biscuit*
***B85:** 15% AKF fortified biscuit*

3.4. Sensory assessment

For each new food product developed, a sensory evaluation is necessary to determine its acceptability by consumers for whom the product is intended. The effect of AKF incorporation on the organoleptic characteristics of biscuits is presented in Table 5 and figure 2 (spider plot according to the sensory hedonic test). As it can be seen, the AKF addition had no statistically significant ($p > 0.05$) effect on the color and smell of biscuits, whereas a significant impact ($p < 0.05$) on the general aspect, flavor, friability and overall acceptability of the biscuits was noted. The current outcomes were contradictory to those of Ashraf et al. (2019) who recorded a significant difference between all sensory attributes (color, texture, taste and overall acceptability) of nut crackers fortified with apricot flour. The authors noted that the overall organoleptic assessment showed that up to 18 % of apricot powder did not influence the consumer acceptance and that this treatment scored more in terms of color, texture, taste and overall acceptability when compared with control. Overall, the study found that scores for the different sensory attributes were elevated with increasing incorporation of AKF. These results were in line with what was found by Chandra et al. (2015b) and Sheikh et al. (2019) where the authors reported that the scores attributed to the biscuits made from composite flour were higher compared to the scores of the control biscuit (made from wheat flour only). Our results showed that after control biscuit, which got a minimum score for all studied attributes and samples B90 and B85, which got an intermediate scores for all sensory attributes, the biscuit B95 got a maximum score for all the assessed sensory parameters. The overall acceptability on a five-point hedonic scale was 4.048 for biscuits at 5 % addition level which differ significantly ($p < 0.05$) from the control rated as poor (2.857) and B90 and B85 with intermediate overall acceptability of 3.190 and 3.333, respectively. Based on this and on the other attributes scores, the samples can be classified in the following decreasing order: B95 > B90 - B85 > B100.

Table 5. Effect of Apricot Kernel Flour (AKF) Addition on Sensory Properties of biscuits

Biscuit	General aspect	Color	Flavor	Aroma	Friability	Overall acceptability
B_{100}	3.048 ± 1.071^{b}	3.333 ± 1.238^{a}	2.714 ± 1.384^{b}	3.143 ± 1.153^{a}	2.810 ± 1.250^{b}	2.857 ± 1.315^{b}
B_{95}	4.048 ± 1.024^{a}	3.810 ± 1.209^{a}	3.952 ± 0.669^{a}	3.905 ± 0.768^{a}	4.143 ± 0.793^{a}	4.048 ± 0.805^{a}
B_{90}	3.048 ± 1.203^{b}	3.095 ± 1.375^{a}	$3.476 \pm 1.167^{a,b}$	3.667 ± 0.856^{a}	$3.667 \pm 1.065^{a,b}$	$3.190 \pm 1.209^{a,b}$
B_{85}	$3.190 \pm 1.250^{a,b}$	3.3667 ± 1.317^{a}	2.905 ± 1.221^{b}	3.381 ± 1.117^{a}	$3.524 \pm 1.123^{a,b}$	$3.333 \pm 0.913^{a,b}$

Different letters in the same column indicate a significant differences ($p < 0.05$); Results are ranked in descending order : a>b
***B100:** Control biscuit (without AKF)*
***B 95:** 5% AKF fortified biscuit*
***B90:** 10% AKF fortified biscuit*
***B85:** 15% AKF fortified biscuit*

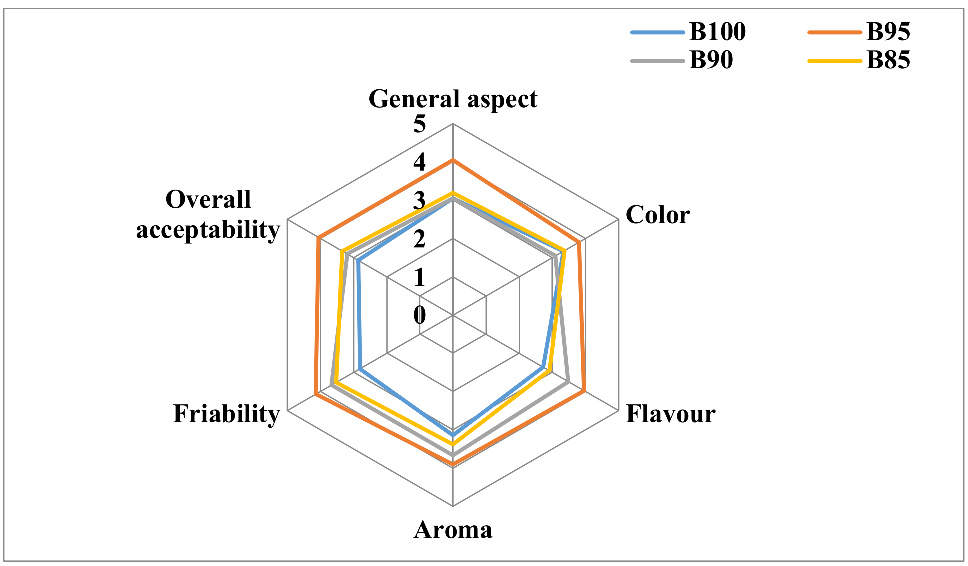

Figure 2. Sensory evaluation of apricot supplemented cookies.
***B100:** Control biscuit (without AKF)*
***B 95:** 5% AKF fortified biscuit*
***B90:** 10% AKF fortified biscuit*
***B85:** 15% AKF fortified biscuit*

As it can be seen in figure 2, the tasters liked more the biscuit B95 for all studied sensory attributes (general aspect, color, flavor, aroma, friability, overall acceptability). The samples B90 and B85 had the same or very close appreciation for their sensory attributes with a low appreciation for the general appearance of the B90 compared to B85. The flavor of the control and the enriched biscuit at 15 % was the least appreciated than the fortified biscuit at 5 % and 10 %. Color is a major sensory attribute which impacts consumer preference. Although, there was a significant difference ($p < 0.05$) between samples in term of color, the enriched biscuit at 5 % was the most preferred. This had a slight but a significant and positive influence on biscuit acceptability. Finally, the control (B100) had the lowest appreciation degree, so the least accepted by tasters, comparing to the fortified biscuits. In addition, the figure showed that there was no significant differences ($p > 0.05$) in terms of aroma and color of biscuits, but the enriched biscuits present distinctly different general aspect, flavor, friability and overall acceptability. Based on the results of the sensory analysis, fortification of biscuits with apricot flour clearly increased their level of appreciation by consumers, which encourages the making of biscuit from wheat flour enriched with AKF. Dhen et al. (2018) have found that a partial substitution of wheat flour in bread up to 12 % by AKF, yields in satisfactory overall consumer acceptability. However, bread containing 24 % of AKF was noted comparatively lower, which might be due to excessive amounts of AKF which negatively affected the aroma, taste, and texture of bread.

4. Conclusions

According to the results obtained from this study, it can be concluded that the AKF has been used advantageously in the preparation of biscuits, which constitutes a way of upgrading apricot kernels, considered until now as waste. The addition of apricot kernel flour into wheat flour up to 15 % (w/w) enabled acceptable biscuit in terms of physical and sensory properties. Referring to the sensory evaluation, the control biscuit had the lowest score while, biscuit with substitution rate at 5 % of AKF had the highest score when compared with other treatments. Therefore, AKF might be accepted when used up to 5 % to obtain an acceptable biscuit in view of sensory quality as well as to improve the nutritive value. Thus, give to producers an alternative way to diversify the production and healthy choice option to the consumers.

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