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To Study the Effect of Apricot Kernel Flour (By-Product) on Physico-Chemical, Sensorial and Antioxidant Properties of Biscuits †

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Abstract: This study was carried out to indicate the potential application of apricot kernel flour (a residue generated in the food processing industry) as a dietary supplement. Apricot stones contain a seed with high content of protein, fat, mineral, and dietary fiber that is mostly underused and underutilized. Six biscuit formulations were prepared by replacing wheat flour with apricot kernel flour at different incorporation levels and the effect of apricot kernel flour (AKF) on physicochemical properties, sensorial attributes, and antioxidant potential of enriched biscuits was investigated. Control biscuits without the addition of AKF were produced for comparisons. The enriched biscuits showed an improvement in physical characteristics, color, texture, protein, fat, fiber, ash, phenolic content, and antioxidant property without significantly affecting the organoleptic quality of biscuits. Sensory evaluation results depicted that all the samples were sensorially acceptable and the highest score in most of the attributes was obtained for 15% incorporation of AKF. This study demonstrates that AKF has great potential feasibility of improving the quality of confectionery products, an opportunity to increase their applications, and decrease the environmental pollution by the residue products of the food industry.

Keywords: Biscuits; detoxified apricot kernel flour; antioxidant properties; organoleptic quality

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1. Introduction

Apricot *(Prunus armeniaca L.*) is one of the most popular stone fruit produced worldwide. It belongs to family Rosaceae and is a nutritionally important. It is a temperate fruit grown in climates with well-differentiated seasons which requires a fairly cold winter and moderately high temperature in the spring and early summer (1). In India, it is grown in Himachal Pradesh, Uttrakhand and in some regions of Jammu and Kashmir, particularly in the cold desert of Ladakh and is a very rich repository of apricot germplasm. This fruit crop is a major source of livelihood and is deeply associated with the tradition and culture of the region (Ladakh). The total area under apricot fruit is 54% (707 ha) in Leh district with the approximate annual yield of 2956 MT/year. Due to the highly perishable nature of apricot fruit, nearly 85% of the fruit is processed in industries to extend its availability and generates a number of apricot pits. After processing, the amount of stone/pits left is quite large and is thrown as waste or sent to landfills causing environmental disposal problems and huge loss of biomass. Food industries produce a large amount of waste whose percentage ranges from 5 to 90% depending on the processed raw material (2). Apricot kernels present inside the pit are considered to be unwanted parts of the fruit and there is no definite use of the kernel. They are potentially useful in human nutrition due to the high percentage of lipids, proteins, dietary fiber and bioactive compounds (3). According (4) the apricot kernel oil content is mainly composed of a high amount of unsaturated, polyunsaturated fatty acids (linoleic and linolenic acids) and tocopherols (630 μg/g) and can be used in many cosmetics, drugs and can represent valuable products with a large industrial potential. The Apricot Kernel Flour has been reported to be a good source of protein, mineral, fiber and bioactive compounds of vital importance and have been exploited in the bakery industry mainly for the fortification of products (5). Apricot kernel is a nutrient-dense food and promising raw material due to their low cost and might be a good substitute for human nutrition because of health-promoting benefits (6). This underused nutrient-dense seed (rich in protein fat, dietary fiber and minerals) could be used as an alternative cheap source of substances for food and pharmaceutical industries. Considering the growing interest in finding new nutrient-dense food and in exploring new sources of high-quality edible oils and dietary proteins, this work proposes to evaluate the potential of AKF in biscuit properties.

Biscuit is one of the most important snack terms used in an average. Biscuits are considered as prominent ready to eat snack in the average household and fastest growing area of the food sector. Biscuits are produced from unpalatable dough that is converted into an appetizing product by baking. Biscuits can be easily enriched with nutrient-dense edible materials to meet the needs of a growing population. Several biscuit products in the country are imported costly and their consumption is increasing. There is a need for sustainable development by increasing the use of our local agricultural products and reducing pressure on the nation's economy and saving scarce foreign resources spent on importation. Local Industries can be innovative by producing food products using apricot kernel flour, in order to meet nutritional requirements of a rapidly growing population. Therefore, biscuit can serve as a vehicle for delivery of important nutrients if made readily available to the population. The objective of this paper was to determine the feasibility of producing nutrient-dense biscuits enriched with apricot Kernel flour using qualitative and quantitative analysis techniques and study the effect on nutritional, sensory and antioxidant characteristics of enriched biscuits.

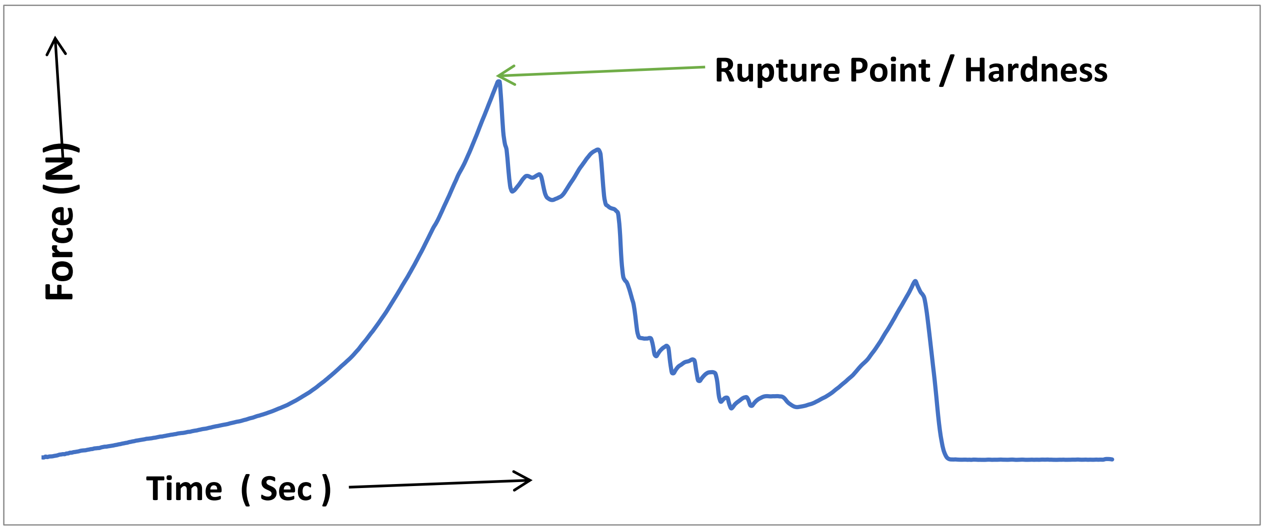

Figure 1. Graphical representation of textural properties of the biscuit samples.

2. Materials and Methods

2.1. Procurement of Raw Materials

All the ingredients like wheat flour, sugar, salt and hydrogenated vegetable shortening were procured from the local market of Allahabad while as, apricots were purchased from the certified fruit centre of SKUAST Kashmir. All chemicals and reagents of analytical grade were obtained from the departmental laboratory of SHUATS Allahabad.

2.2. Preparation of Apricot Kernel Flour (AKF)

The apricot pits were pitted manually and followed by washing and drying at 30 °C for about 2 weeks. The kernels were obtained from the pit using decorticator and stored at −10 °C in sealed plastic bags until use. The apricot kernels were detoxified according to method given by (7) with some modifications. To facilitate the reduction of toxic compounds cyanogenic glycosides (water soluble secondary metabolites), the apricot kernels were ground in a grinder (Bajaj-17172) and soaked in distilled water (1: 20 *w/v*) at 47 °C for 12 h. The whole slurry was filtered and washed twice with 70% ethyl alcohol before drying at 50 °C overnight in oven. The detoxified flour was sieved through the 10 mesh for efficient mixing during dough formation. To prevent the AKF from the possible deterioration that may occur during storage, the AKF was prepared fresh before the preparation of biscuits.

2.3. Preparation of Biscuits

Both control and AKF-enriched biscuits were prepared as per (AACC 2000) guidelines following the formulation described by (8) with some modifications. Wheat flour and apricot kernel flour blends were prepared in the ratio of 100:00, 95:05, 90:10, 85:15, 80:20 and 75:25 respectively. Control biscuits were formulated without the addition of AKF. The ingredients in the standard formulation of biscuits were blended flour (100 g), fine sugar (30 g), milk (20 mL), egg (1), shortening (25 g), sodium bicarbonate (1 g), Vanilla (1 g) and salt (1 g). The ingredients were thoroughly mixed and the dough was sheeted out to disks with the 21 mm diameter and 4 mm thickness and then baked at 190 °C for 20 min in a baking oven. Biscuits were allowed to cool at room temperature for 30 min and packed in polypropylene bags for physicochemical and sensory analysis.

2.4. Characterization of Biscuits

2.4.1. Physical Characteristics

Diameter (W) of biscuits was estimated by placing five biscuit samples edge to edge on a horizontal surface and measured with the help of a vernier calliper. An average of five values in millimeters was taken by rotating the same set of biscuits at an angle of 90° (9).

Thickness (T) of biscuits was determined by stacking five biscuits on top of one another and the average thickness of five biscuits was measured in millimeters. Samples were restocked and the average of five values was recorded.

The spread ratio was estimated by the ratio of diameter (W) to the thickness (T) of the biscuit sample as presented by Equation (1) (21).

$$Spread\ ratio = \frac{Diameter\ (mm)}{Thickness\ (mm)} \tag{1}$$

The volume of biscuit expressed as the area of the biscuit multiplied by the thickness was calculated by the equation given by Equation (2) (Agu et al., 2007)

$$Volume(\ cm^3) = \frac{d^2 \pi T}{4} \tag{2}$$

where,

d = diameter of biscuit in (mm)

T = average thickness of biscuit (mm)

The per cent spread factor of the biscuits samples was calculated by the equation presented by Equation (3)

$$\% \, Spread \, Factor = \frac{\begin{array}{c} spread \, ratio \\ of \, biscuits \, prepared \, from \, blend \end{array}}{\begin{array}{c} spread \, ratio \\ of \, biscuit \, prepared \, from \, control \end{array}} * 100 \quad (3)$$

The density of biscuit expressed as the ratio between weight measured by analytical weighing balance and the volume of the biscuit sample. An average of six biscuits at a time were weighed from which, the weight of single biscuit was estimated as shown by Equation (4)

$$Density = \frac{Mass \, of \, sample}{volume \, of \, sample} \quad (4)$$

2.4.2. Determination of Color Characteristics of Fortified Biscuits

The surface color of the biscuits was measured by using a Hunter Lab spectrophotometer- (B12TL). The surface color parameters *L* lightness* (0 = *black* and 100 = *white*), *a* redness* (*-a** = *greenness* and + *a** = *redness*) and *b* yellowness* (*-b** = *blueness* and *+b** = *yellowness*) of biscuit samples were calculated after calibrating the equipment with white tile. The experiment was repeated many times and an average of five readings was expressed in accordance with the CIELAB system (12); (9).

2.4.3. Determination of Hardness (N)

The textural parameter (Hardness) of the biscuit samples were evaluated by using Textural Analyzer (Exponent lite "TEE32"). The experiment was carried out in the following settings. Test type = compression, pre-test speed = 1.5 mm/s, test speed = 2.0 mm/s, post-test speed = 5.0 mm/s, target value = 3 mm, and trigger force = 5.0 g. The ratio of the minimum force required to break the sample and deformation at the failure point was recorded as hardness. The experiment was repeated many times and the average value of five was reported in Newton's (10)

2.4.4. General Chemical Composition of Fortified Biscuits

For nutritional analysis, the biscuits samples were crushed in mortar and pestle. Moisture content was determined by the gravimetric method, crude protein was determined by Kjeldahl method, crude oil was determined by Soxhlet method and ash content was determined by incineration of the biscuit samples (11). Total carbohydrate content was determined by the difference method described by (12). Experiments were carried in triplicates and average mean standard deviation values were reported.

2.4.5. In Vitro Measurement of Antioxidant Capacity

DPPH free radical scavenging activity assay

The antioxidant activity in the methanol extract of biscuit samples was determined by free radical scavenging activity using UV-Vis spectrophotometer as described by (13). 2 g of biscuit sample was blended in tubes with 20 mL of 95% methanol. The tubes covered with aluminum foil and were vortexed for 30 min and allowed to stand for 2–3 h. The sample was stirred for 1 h before centrifugation at 1000 *g* for 10 min at 4 °C. The supernatant recovered was dried under vacuum using a rotary evaporator (40 °C). The evaporated residue was re- dissolved at a concentration of 1 mg/mL. An amount of 120 µL of the extracted sample was added to 3.9 mL of 6*105 moles per liter of DPPH (2, 2-diphenyl-1-picrylhydrazyl). The resulting solution was held at room temperature in dark for an incubation period of 30 min. Absorbance was measured at a wavelength of 515 nm by UV-Vis-Spectrometer at 0 and 30 min using methanol as blank by Equation (5)

$$\text{DPPH Radical Scavenging Activity } (\%) = 1 - \left(\frac{\text{Absorbance of the sample at 30 min}}{Absorbance\ of\ control\ at\ 0\ min}\right) * 100 \quad (5)$$

Phosphomolybdinum Reduction Assay

Total antioxidant capacity of the biscuits was determined by phosphomolybdate method as described by (14). A 0.3 mL of methanol extract was mixed with 3 mL of reagent solution prepared by using sulphuric acid (0.6 M), sodium phosphate (28 mM) and ammonium molybdate (4 mM). The mixture was incubated at 95 °C in a water bath for 90 min. After cooling to room temperature, absorbance was recorded at 695 nm against the blank containing (0.3 mL) methanol in place of the extract. Total antioxidant capacity was calculated as ascorbic acid equivalents.

2.4.6. Sensory Evaluation of Biscuits

The quantitative descriptive sensory characteristics of biscuits enriched with AKF were conducted by a panel to determine the acceptability of the product. Biscuit samples with different compositions were presented in a sealed pouch coded with different codes to 15 panelists who were asked to evaluate each sensory attribute. Biscuits were evaluated for surface color, surface appearance, texture, taste, flavor and overall quality on a 9-point hedonic scale. Freshly made biscuits were served in white plates with randomly coded letters to prevent any bias. Water was provided to rinse the mouth between evaluations (15)

2.5. Statistical Analysis of Data

The data obtained from experiments were exposed to the analysis of variance (ANOVA). Duncan's multiple range tests at ($p < 0.05$) level was used to find the significant difference using statistical 7 (statistical-soft, TUSIA, USA) software packages. Correlations among means were determined using Pearson's correlation analysis (12).

3. Results and Discussion

3.1. Physical Analysis of Biscuits

Biscuits were characterized for the number of physical properties such as weight, diameter, thickness, volume, density, spread ratio, and per cent spread ratio as presented in Table 1. After analyzing the data obtained from the experiments, it was observed that incorporation of apricot kernel flour had a statistically significant effect ($p < 0.05$) on the physical characteristics of fortified biscuits. From the Table 1, it was found that with the increasing incorporation of AKF in the biscuit formation, weight, thickness, diameter, volume, density, spread ratio and percent spread ratio of the biscuit samples varied from (8.78 to 10.09 g), (1.10 to 1.31 cm), (4.85 to 4.59 cm), (20.31 to 21.66 cm^3), (0.43 to 0.47 g/cm^3), (4.40 to 3.50) and (100.00 to 79.54%) respectively. A variation of 14.92, 5.66, 19.09, 6.64, 9.30, 20.45 and 25.72% was observed in weight, thickness, diameter, volume, density, spread ratio, and per cent spread ratio of the biscuit samples with increasing AKF percentage in biscuit formulation. The increase in weight and thickness upon addition of AKF and decrease in diameter during baking of biscuits could be attributed to the increased protein network of the fortified biscuits by AKF which tends to decline the expansion of biscuit during baking. (16); (17); (18) reported similar results in diameter of biscuits upon addition of cereal bars, brewer's spent grain and sugar beet fiber respectively. Spread ratio (W/T) is one of the most important properties in evaluating the quality of biscuits. Greater spread ratio is desirable and indicates a better biscuit quality (19). A significant decrease of 20.45% was observed in the spread ratio of the biscuits with greater than 20% flour replacement with AKF. The reduction in spread ratio with increasing incorporation of AKF may be due to the increases protein binding capacity, which plays an important role in forming web-like structure during kneading and resists dough expansion during baking. Additionally, protein content influences the viscosity of the dough and higher hydrophilic and greater viscosity characters of AKF led to a decline in the spread ratio of the biscuit samples. (20) reported that spread ratio is determined by spread rate and the set time and these parameters are strongly dependants on dough viscosity. Therefore the competition for water between apricot kernel flour and the wheat flour for dough consistency leads to an increase in dough viscosity and reduced biscuit spread ratio. The results reported by (21) and (22) in flax seed and multigrain mixtures in the development of functional biscuits are in agreement with our results. (22) reported identical results in biscuits fortified with toasted flaxseed at 5–20% level, obtained lower spread ratio in biscuits with 20% flaxseed compared to the control.

Table 1. Influence of detoxified apricot kernel flour (DAKF) on the physical characteristics of biscuits.

Proportion of DAKF	Weight of biscuit (g)	Diameter (cm)	Thickness (cm)	Volume of Biscuits	Densi-tyg/cm^3	Spread Ratio	% Spread Factor	Hardness (N)
0%	8.78 ± 0.43 ^{bcd}	4.85 ± 0.44 ^{a}	1.10 ± 0.11 ^{a}	20.31 ± 0.22 ^{fg}	0.43 ± 0.002 ^{a}	4.40 ± 0.08 ^{a}	100.00 ± 0.00 ^{a}	15.20 ± 0.86 ^{f}
5%	8.90 ± 0.65 ^{ae}	4.70 ± 0.30 ^{a}	1.18 ± 0.09 ^{a}	20.46 ± 0.19 ^{bf}	0.43 ± 0.001 ^{b}	3.98 ± 0.08 ^{b}	90.45± 2.98 ^{b}	19.36 ± 0.18 ^{e}
10%	9.49 ± 0.78 ^{ad}	4.69 ± 0.24 ^{a}	1.20 ± 0.08 ^{a}	20.72 ± 0.33 ^{bceg}	0.45 ± 0.003 ^{c}	3.90 ± 0.06 ^{bc}	88.63 ± 1.02 ^{b}	21.03 ± 0.78 ^{d}
15%	9.52 ± 0.93 ^{ac}	4.65 ± 0.32 ^{a}	1.24 ± 0.10 ^{a}	21.04 ± 0.26 ^{cd}	0.45 ± 0.002 ^{c}	3.75 ± 0.13 ^{bcd}	85.22 ± 1.57 ^{c}	25.21 ± 0.27 ^{c}
20%	9.69 ± 0.59 ^{ab}	4.61 ± 0.43 ^{a}	1.27 ± 0.11 ^{a}	21.18 ± 0.18 ^{bd}	0.46 ± 0.012 ^{d}	3.62 ± 0.11 ^{de}	82.27 ± 0.87 ^{d}	27.14 ± 0.87 ^{b}
25%	10.09 ± 0.40 ^{a}	4.59 ± 0.54 ^{a}	1.31 ± 0.22 ^{a}	21.66 ± 0.29 ^{ae}	0.47 ± 0.003 ^{d}	3.50 ± 0.08 ^{e}	79.54 ± 0.97 ^{d}	33.04 ±.56 ^{a}

Values are means ± SD of triplicate determinations. Different letters in superscript within the same column indicate significant differences at $p \leq 0.05$.

3.2. Color Measurement

The color appeared to be a vital criterion in the selection and purchasing of food products (23). Color can be used to judge the completion of the baking process as it develops during the later stages of baking (24). After analyzing the data obtained from experiments, it was observed that with an increasing percentage of apricot kernel flour in biscuit formulation, color development of biscuit samples showed a statistically significant effect ($p < 0.05$) when compared with the control sample as presented in Table 2. It was found that color parameters values of biscuit samples varied from (59.83–44.53) for lightness, (16.43–12.15) for redness and (32.60–33.37) for yellowness with an increasing percentage of AKF which indicates that enriched biscuit samples shift towards the darker side of the color scale. The possible reason for the improvement in color (darkened) could be attributed to the fact that apricot kernel flour is rich in protein, fiber, and polyphenolic compounds. The surface color of biscuit samples depends on physicochemical properties, raw dough and time, temperature combination during baking. (25) reported that the color of biscuits is mainly attributed to Maillard reaction occurs between reducing sugar and amino acids promoting with high temperature during baking as well as caramelization after 150 ºC has been reached. Moreover, (26) reported that development of the color could also be related to the non-enzymatic browning associated with an advanced stage of Mallard reaction and Caramelization. (8) reported similar results on chia flour seed fortified biscuits.

Table 2. Effect of detoxified apricot kernel flour (DAKF on the color of biscuits.

Treatments	Color Values		
	L*	a*	b*
T0	59.83 ± 0.23 ^{a}	+16.43 ± 0.32 ^{a}	+32.60 ± 0.22 ^{ac}
T1	52.41 ± 0.32 ^{b}	+15.22 ± 0.43 ^{b}	+32.72 ± 0.37 ^{ab}
T2	52.32 ± 0.12 ^{b}	+16.56 ± 0.13 ^{a}	+33.37 ± 0.69 ^{a}
T3	51.42 ± 0.43 ^{c}	+15.42 ± 0.34 ^{b}	+32.16 ± 0.58 ^{bc}

T4	50.83 ± 0.31 [c]	+16.43 ± 0.12 [a]	+32.60 ± 0.50 [ac]
T5	44.53 ± 0.60 [d]	+12.15 ± 0.44 [c]	+33.37 ± 0.47 [a]

Values are means ± SD of triplicate determinations. Different letters in superscript within the same column indicate significant differences at $p \leq 0.05$.

3.3. Texture Measurement

Breaking strength of biscuit samples is one the crucial parameter affecting consumer acceptance. The average initial rupturing force is the measure of strength (hardness) of biscuit sample. The influence of the increasing percentage of AKF in biscuit formulation on the textural properties is presented in fig 1. From the Table 1, it was observed that with the increase in the incorporation of AKF in the formulation, the force required to fracture the sample increased linearly from 15.20 to 33.04 N which indicates that more force is required to break the sample. The possible reason for the progressive increase in hardness of biscuits can be due to the higher protein content of apricot kernel flour which strengthened the gluten network structure of dough and results in restricted expansion during baking. (27) reported that the interaction of protein and starch by hydrogen bonding during dough development is mainly responsible for the textural properties. Additionally, (28) reported that hardness of biscuits is due to the formation of protein network (gluten) whereby increased network development attracts more water molecules and results in higher breaking strength. From the statistical analysis, it was found that hardness of fortified biscuits varied significantly ($p < 0.05$) when compared with the control sample. Our results are in good agreement with (16) and (29) who reported a similar trend in hardness with increasing the percentage of cereal brans and pigeon pea in biscuit formulations respectively. Moreover, (30) reported that the hardness increased with increasing fiber content in biscuit samples.

3.4. Proximate Composition

The influence of different levels of AKF on the proximate values is presented in Table 3. Primarily, the incorporation of AKF in the formulation, slack off the moisture content from (3.88 –3.18%) and carbohydrate content from (66.7–45.7%) of the enriched biscuits as correlated with the control sample. As expected from the composition of AKF, incorporation in the formulation significantly increased the proximate values for crude fat from (21.3–36.4%), crude protein (8.8–12.8%), crude fiber (1.41–3.06%) and total ash content (0.76–1.32%) at $p < 0.05$. The observed increase in the proximate composition values for fat, protein, fiber and ash content of the enriched biscuits can be due the higher nutritive value of AKF as reported by (31) that apricot kernels are rich in lipids (45.3–55.7%), proteins (18 -25.6), fiber content and ash content in comparison with control sample. Similarly, reports were observed by (32) by incorporation of pigeon pea flour with millet flour. (4) reported that the apricot kernels are having relatively higher crude fiber content than wheat flour. This could justify the results obtained from the biscuit samples enriched at different levels. This observation is supported by the findings of (33) on the baking properties of non-wheat flour breadfruit. (34) reported that the AKF fortification in bakery products could attract good acceptability by the people due to the health-promoting benefits of AKF. From the Table 3, it was observed that values obtained for the ash contents increased linearly with the incorporation of AKF and the highest value of 1.32% was found at 25% incorporation and the possible reason could be due to a relatively high content of minerals in AKF.

Table 3. Percent score of all chemical parameters (baking time & temperature, 15 min at 220 °C).

Treatments	Moisture Content (%)	Protein Content (%)	Fat Content (%)	Ash Content (%)	CARBOHYDRATE (%)	Crude Fiber (%)	Scavenging Activity (%)	Phosphomolybdenum Reduction Assay (mg AAE/g)

100:0 (T_0)	3.88 ± 0.12 ^{a}	8.8 ± 0.19 ^{f}	21.3 ± 0.64 ^{f}	0.76 ± 0.054 ^{e}	66.7 ± 1.2 ^{a}	1.41 ± 0.065 ^{a}	21.01 ± 1.87 ^{e}	0.651 ± 0.002 ^{f}
95:05 (T_1)	3.71 ± 0.10 ^{bf}	9.7 ± 0.45 ^{e}	26.09 ± 0.54 ^{e}	1.03 ± 0.086 ^{cd}	59.28 ± 2.28 ^{b}	1.83 ± 0.044 ^{b}	27.11 ± 2.54 ^{d}	O.792 ±0.004 ^{e}
90:10 (T_2)	3.69 ± 0.09 ^{cf}	10.8 ± 0.21 ^{dg}	29.75 ± 0.32 ^{d}	1.09 ± 0.034 ^{bd}	51.08 ± 0.92 ^{c}	2.48 ± 0.023 ^{cg}	32.23 ± 0.96 ^{c}	0.961 ± 0.003 ^{d}
85:15 (T_3)	3.44 ± 0.07 ^{d}	11.5 ± 0.60 ^{cfg}	31.49 ± 0.43 ^{c}	1.15 ± 0.085 ^{bc}	48.96 ± 1.08 ^{cd}	2.82 ± 0.046 ^{dg}	33.19 ± 0.65 ^{c}	1.152 ± 0.002 ^{c}
80:20 (T_4)	3.28 ± 0.19 ^{e}	12.2 ± 0.32 ^{bf}	34.54 ± 0.064 ^{b}	1.23 ± 0.046 ^{ab}	46.96 ± 0.96 ^{de}	2.92 ± 0.066 ^{e}	36.67 ± 1.98 ^{b}	1.342 ± 0.005 ^{b}
75:25 (T_5)	3.18 ± 0.11 ^{f}	12.8 ± 0.15 ^{a}	36.40 ± 0.067 ^{a}	1.32 ± 0.087 ^{a}	45.66 ± 1.56 ^{e}	3.06 ± 0.077 ^{f}	41.91 ± 2.75 ^{a}	1.491 ± 0.002 ^{a}

Values are means ± SD of triplicate determinations. Different letters in superscript within the same column indicate significant differences at $p \leq 0.05$.

3.5. In Vitro Antioxidant Properties

3.5.1. DPPH Radical Scavenging Activity

The DPPH radical scavenging activity assay is based on the reduction of DPPH in methanol solution in presence of a hydrogen donating antioxidant, bringing a change in color from purple to yellow, which is measured at a wavelength of 517 nm. From the experimental results as presented in Table 3, a progressive (21.01 to 41.91%) and significant ($p < 0.05$) increase in DPPH radical scavenging activity of the enriched biscuit samples with an increasing proportion of AKF in the formulation was observed. The possible reason for the increase in radical scavenging activity could be due to the presence of bioactive compounds (Ellagic acid, proanthocyanidins, quercetin, catechins, etc.) present in AKF as reported by (4). Moreover, (35) reported that the formation of melnoidins during the baking process of biscuit samples contribute to antioxidant property. The presence of higher antioxidants compounds in enriched biscuits samples could be vital to enhance the shelf life of biscuits which contain high fat as these compounds retard the development of rancidity. (36) also reported a progressive increase in antioxidant activity with increasing levels of wheat-barley flour blends.

3.5.2. Phosphomolybdenum Reduction Assay

Total antioxidant capacity as determined by phosphomolybdenum reduction assay method is based on the reduction of phosphomolybdate ion in the presence of an antioxidant resulting in the formation of a green phosphate complex which is measured spectrophotometrically at 695 nm. The enriched biscuits samples had showed higher phosphomolybdenum reduction assay than control sample as presented in Table 3. The total antioxidant capacity of the biscuit sample changes from 0.651 to 1.491 mgAAE/g with increasing percentage of AKF respectively. The possible reasons for increased total antioxidant property of enriched biscuits could be either due to the Maillard reaction products formed during baking or due to the presence of important bioactive compounds (flavonoids, carotenoids, phenols, isoflavones and anthocyanins) certainly contributed by AKF with remarkable antioxidant ability. Similar results have been reported by (36) in chips enriched with chia.

3.6. Sensory Evaluation

The mean sensory scores for color, appearance, mouth feel, texture, taste and overall acceptability of fortified biscuit samples using descriptive analysis parameters is presented in Table 4 The biscuits samples with different levels of AKF showed a statistically significant difference in texture and appearance. The color, taste, and flavor of the fortified biscuits improved on the incorporation of AKF. With the increase in the incorporation level of Apricot kernel flour, biscuits became harder compared to the control. The increase in hardness of biscuits may be due to the higher protein content of the AKF. Biscuits prepared with 10% apricot kernel flour incorporation received the highest ratings for all sensory attributes. The highest score for overall acceptability of biscuits was observed by incorporation of AKF up to 10%.

Table 4. Sensory evaluation for detoxified apricot kernel flour (DAKF) Fortified Biscuits.

No. of treatment	Color	Taste	Flavor	Texture	O.A.A
(T_0)	8.0 ± 0.12 ^{c}	8.0 ± 0.21 ^{b}	7.33 ± 0.14 ^{b}	7.33 ± 0.12 ^{c}	7.66 ± 0.61 ^{ac}
(T_1)	8.66 ± 0.11 ^{a}	8.66 ± 0.17 ^{a}	7.0 ± 0.15 ^{bc}	7.0 ± 0.19 ^{c}	7.83 ± 0.62 ^{ab}
(T_2)	8.33 ± 0.21 ^{b}	8.66 ± 0.08 ^{a}	8.33 ± 0.18 ^{a}	8.66 ± 0.26 ^{a}	8.49 ± 0.13 ^{a}
(T_3)	7.66 ± 0.14 ^{d}	7.33 ± 0.11 ^{c}	6.66 ± 0.32 ^{cd}	8.33 ± 0.29 ^{ab}	7.49 ± 0.86 ^{ad}
(T_4)	6.33 ± 0.16 ^{e}	7.0 ± 0.15 ^{d}	6.55 ± 0.19 ^{d}	8.66 ± 0.26 ^{a}	7.13 ± 0.76 ^{bcd}
(T_5)	6.33 ± 0.15 ^{e}	7.33 ± 0.11 ^{c}	6.5 ± 0.23 ^{d}	8.0 ± 0.41 ^{b}	7.04 ± 0.90 ^{bcd}

Values are means ± SD of triplicate determinations. Different letters in superscript within the same column indicate significant differences at $p \leq 0.05$.

Hence the addition of apricot kernel flour (a byproduct) to the wheat flour affected the physicochemical, functional as well as the sensory properties of biscuits. Highly accepted fortified biscuits could be obtained when 10% of AKF was used in the formulation. The dietary composition of these fortified biscuits indicated that lipids, proteins as well as fiber, which play a very crucial role in human nutrition, could be enriched in biscuits made from AKF and wheat flour. These studies have shown the potential of developing fortified biscuits using by-products (AKF) in order to increase the nutritional and functional properties. However, the development and consumption of such products could be beneficial for those suffering from degenerative diseases associated with today`s changing lifestyles and could lead to increased utilization of indigenous food crops in the country.

Institutional Review Board Statement:

Informed Consent Statement:

Data Availability Statement:

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