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RESEARCH ARTICLE

Nutritional and physical properties of cookies enriched with whole wheat flour of ancient wheats

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Abstract

Background: The aim of the present study was to determine the increase in the nutrient and bioactive compounds of cookies obtained by using seven different ancient whole wheat flours (einkorn, emmer, spelt, old, and landrace) at the ratios of 0%, 25%, 50%, 75%, and 100%. Although ancient grains are notorious for their poor technological properties, improvements in rheological performance using refined flour might contribute to the production of new functional foods.

Findings: Cookies evaluated physical, functional, and nutritional properties were dramatically improved by increasing the whole wheat flour ratio. The cookies with %100 Köse (old wheat) had a higher breaking strength while those from %100 Kavlıca (Emmer *Triticum turgidum* ssp. *dicoccum)* had the lowest one. The cookies with %100 Kavlıca had the highest insoluble and total dietary fiber, total phenolics, antioxidant activities, Ca, K, and Zn, while the phytic acid content was the lowest among all genotypes.

Conclusions: Landrace and old cultivars are valuable raw materials that are gaining popularity due to their distinctive qualities and products.

Significance and Novelty: The use of ancient whole wheat flour-enriched cookies may present a novel cereal-based product with health benefits, in addition to being fit for production of foods made from whole grains.

KEYWORDS
ancient wheat, dietary fiber, functional cookies, mineral content, whole grain

1 | INTRODUCTION

Interest in functional foods has increased after it was demonstrated that functional compounds such as dietary fiber, phenolic compounds, and antioxidants in foods may prevent gastrointestinal diseases such as obesity, colon cancer, and diverticulosis in humans and also reduce the risk of developing atherosclerosis and coronary heart diseases by regulating the ratio of serum cholesterol and low-density lipoprotein cholesterol in the blood (Liu et al., 2020).

Accordingly, studies on enriching foods, especially foods consumed excessively, such as cookies and cereal products, in terms of functional compounds have accelerated. In this respect, ancient wheat, especially emmer, einkorn, spelt, landrace, and old, has received undoubted interest because its variety combines nutritional and functional attributes. Ancient wheat cultivars are valuable resources for increasing the genetic variety of genotypes of cultivated wheat. Einkorn (*Triticum monococcum* L. ssp. *monococcum*) is a diploid species (AA; $2n = 2x = 14$) cultivated in scarce areas worldwide (Arzani & Ashraf, 2017). Emmer (*Triticum turgidum* L. spp. *dicoccum Schrank*) is a tetraploid species (AABB; $2n = 4x = 28$), and Spelt (*Triticum aestivum* ssp. *spelta*), landrace, and old wheat (*T. aestivum* L. ssp. *aestivum*) are hexaploid species (AABBDD; $2n = 6x = 42$). Some ancient wheat such as einkorn, emmer, and spelt have glumes that must be separated from the grain at the mill, therefore known as hulled wheat (Longin et al., 2015). Several studies showed that emmer wheat is a good source of protein, unsaturated fat, soluble dietary fiber, resistant starch, and phosphorus, similar to modern wheat varieties (Righetti et al., 2016).

Likewise, spelt wheat is a good source of Fe, Zn, Cu, Mg, and P, while the phytic acid concentration of it is in lower level and the cookies produced from it have a unique flavor (Ruıbal-Mendıeta et al., 2005). Another study stated that spelt wheat has bioactive components and is hence suitable for producing food products with enhanced health benefits (Huertas-García et al., 2023).

Ancient wheat is gaining more and more attention since several studies suggest it may offer a healthier and better outstanding nutritional profile than modern wheat (Hidalgo & Brandolini, 2014). Therefore, ancient wheat is of interest in the production of healthy food products and can also be found as whole grain products. Wholemeal flour is obtained by grinding the kernels, without removing the germ and bran, which are the two fractions with the highest concentration of total phenolic content, antioxidants, and minerals. All these compounds have many benefits for human health, contributing to the prevention of diabetes, heart disease, cancer, and ischemic stroke (Liu et al., 2020). Despite their well-known health benefits, popular media, and consumer interest in ancient wheat grains, commercially available grain-based products are still highly rare due to the low technological quality of dough produced with ancient whole wheat flour such as strength, stability, development time, and extensibility (Cappelli et al., 2018). Nonetheless, further studies are needed to elucidate the full potential of this underutilized wheat (Arzani & Ashraf, 2017). Also, there is currently insufficient data available on the use of ancient whole wheat flour as a partial substitute for common wheat flour in making bread, cookies, pasta, and puffed seeds, and very little is known about the technological and nutritional parameters of ancient wheat sweet-baked goods.

To the best of our knowledge, the nutritional and technological quality of ancient whole flour cookies manufactured with varying ratios has not been explored so far. Therefore, the objective of the present study was to evaluate the suitability of different ancient wheat cultivars for cookie production in terms of various physical (width, thickness, and spread ratio) and textural characteristics (breaking strength) and determine the functional (phenolic content and antioxidant activity) and nutritional properties (dietary fiber and phytic acid) of cookies obtained from these ancient wheat cultivars.

2 | MATERIALS AND METHODS

2.1 | Materials

In the present study, three different old bread wheat cultivars, one landrace wheat cultivar, three different hulled wheat cultivars, and one soft bread wheat were used. The old bread wheat Köse 220/39, Sivas 111/33, and Ak 702 were registered in 1939, 1933, and 1931, respectively. The wheat cultivars used in this study were obtained from the gene pool of the wheat breeding program of the Ankara Field Crops Central Research Institute. Ata Siyez (*T. monococcum* L., einkorn) is diploid, Sünter (*T. aestivum* L.), spelta (*Triticum spelta* L.), and Bayraktar 2000 modern soft bread (*T. aestivum* L.) are hexaploid, and Kavlıca (*Triticum dicoccum* L., emmer,) is a tetraploid species. Bayraktar 2000, which is a soft white wheat with medium strong gluten properties, were used in all mixture as a standard wheat cultivar cookie production. The names of wheat samples Ak-702, Ata Siyez, Köse 220/39, Sivas 111/33, and Bayraktar 2000 were shortened as Ak, Siyez, Köse, Sivas, and Bayraktar, respectively, in the text for convenience. All of the wheat was grown by using the same agronomic applications in the Research and Production Farm, which belongs to the Central Research Institute for Field Crops (CRIFC) in Golbasi, Ankara (36° 61′N, 22° 67′E; 1.052 m above sea level), in 2020–2021 production season. The powdered sugar, salt, sodium bicarbonate, skimmed milk powder, ammonium bicarbonate, shortening, and high-fructose corn syrup were purchased from local suppliers.

2.2 | Methods

2.2.1 | Milling

Wheat samples were ground by using a laboratory type roller mill (Chopin, CD 1, Villeneuve-La-Garenne) to obtain whole wheat flour. Before milling, Siyez, spelta, and Kavlıca seeds were de-hulled with a thresher (Codema Inc). The coarse bran from the break system of the mill and the short from the reduction system were mixed and ground in a hammer mill (Perten 3100) using a 500 μm sieve for the other analyses. Whole wheat flour was obtained by mixing the thinned bran with the white flour obtained from the roller mill.

2.2.2 | Chemical and physicochemical analysis of whole wheat flour samples

The Zeleny sedimentation values of the whole wheat flour were obtained according to the International Association for Cereal Science and Technology (ICC) Method 116/1 (ICC, 2008). The protein and ash content values were determined by Approved Methods 46-30.01 and 08-01.01, respectively (AACC International, 2010). Wet gluten and gluten index values were determined according to Approved Method 38-12.02 (AACC International, 2010).

2.2.3 | Baking of cookies

The cookies were prepared using AACC International Approved Method No: 10–54.01 (AACC International, 2010). Five types of cookies were produced: control (100% cv Bayraktar, white wheat flour with a 63% extraction yield) and enriched with increasing percentages (25%, 50%, 75%, and 100%) of wholemeal flour. The formulation used in preparing cookies included 12.8 g of powdered sugar, 4 g of brown sugar, 0.4 g of skimmed milk powder, 0.5 g of salt, 0.4 g of sodium bicarbonate, 16 g of shortening, 0.6 g of high-fructose corn syrup, 0.2 g of ammonium bicarbonate, and 40 g of flour or whole wheat flour mixture (on 13% dry matter basis). Different whole wheat flours were used with our rate of 0%, 25%, 50%, 75%, and 100%, and water was calculated according to the following formula:

$$\text{Amount of water added (g)}: [(40 - \text{flour or whole wheat flour (g)}) + 8.8]$$

The cookies were baked in a rotary oven (Despatch) at 205°C for 11 min. The baked cookies were left to cool at room temperature and stored in bags until analysis.

2.2.4 | Quality analysis of cookies

The cookie's physical characteristics were calculated in terms of width, thickness, spread ratio, color, and texture (maximum force to break the cookie) values. The thickness and width of cookie samples were measured by placing Vernier callipers at five points on each cookie, according to AACC International Standard Method No. 10–54.01 (AACC International, 2010). The spread ratio was measured by dividing width by thickness. The breaking strength of samples was determined by using the three-point break test according to Gaines (1991) with a texture profile analyzer (TA-XT plus, Stable Microsystems) with a load cell of 50 kg, pretest speed of 1.0 mm/s, test speed of 3.0 mm/s, posttest speed of 10.0 mm/s, distance of 5 mm, and trigger force of 50 g.

The surface color parameters of cookies (L^*, a^*, b^*, and ΔE^* values) were determined by using the spectrophotometer Hunterlab MiniScan XE Plus (Hunter Associates Laboratory, Inc. Reston, VA, USA) and CIE Lab scale. The total color difference (ΔE^*) of cookies is calculated according to the following formula:

$$\Delta E = \sqrt{(L^* - L^*_0)^2 + (a^* - a^*_0)^2 + (b^* - b^*_0)^2}$$

2.3 | Functional analysis of cookies

The phytic acid content of the cookies was measured spectrophotometrically according to the method described by Haug and Lantzsch (1983). The total phenolic contents of the cookies were determined by the Folin–Ciocalteu spectrophotometrical method, whereas antioxidant activity was determined using DPPH according to Singleton and Rossi (1965). The soluble, insoluble, and total dietary fiber (SDF, IDF, and TDF) contents of cookies were determined by using Ankom TDF Dietary Analyzer (Ankom Technology), according to method AOAC 991.43 (Official Methods of Analysis of Association of Official Analytical Chemists, 2006). The concentrations of Ca, Fe, Mg, Mn, K, P, and Zn were determined by using Agilent 78500 ICP MS (Agilent Technologies, USA) according to the method specified by Fingerová and Koplík (1999).

2.4 | Statistical analysis

Test results are expressed as means from duplicate analysis and reported on a dry weight basis. One-way analysis of variance (ANOVA) was used to analyze the data, and statistical analysis was performed with software JMP (version 13.2.1, SAS Institute Inc.). Student's t-test was used to determine the differences in means when significant ($p < .05$) differences were found.

3 | RESULTS AND DISCUSSION

3.1 | Chemical and physicochemical properties of ancient whole wheat flours

Some chemical and physicochemical properties of whole wheat flour and refined modern wheat are shown in Table 1. The ash contents of whole flours obtained from ancient wheats ranged between 1.36% and 1.77%. The

TABLE 1 Some chemical and physicochemical properties of ancient whole wheat flours and refined modern wheat flour.

Cultivar	Ash[a] (%)	Protein[a] (%)	Sedimentation (mL)	Wet gluten (%)	Gluten index (%)
Whole wheat flour					
Ak	1.51 ± 0.02a	14.8 ± 0.2b	12.0 ± 0.5d	38.0 ± 0.4a	40.3 ± 2.1d
Kavlıca	1.50 ± 0.03b	12.3 ± 0.1e	11.0 ± 0.5e	31.0 ± 0.6d	1.6 ± 0.5e
Köse	1.77 ± 0.03c	14.3 ± 0.1c	16.0 ± 0.5c	33.0 ± 0.7c	54.8 ± 7.4c
Sivas	1.42 ± 0.02c	16.0 ± 0.3a	18.0 ± 0.5b	35.7 ± 0.7b	42.7 ± 2.8d
Siyez	1.43 ± 0.01c	14.3 ± 0.3c	12.0 ± 0.5d	4.0 ± 0.2e	68.1 ± 2.0b
Spelt	1.36 ± 0.04d	13.4 ± 0.4d	20.0 ± 0.5a	36.0 ± 0.5b	74.9 ± 1.8a
Sünter	1.56 ± 0.02a	14.7 ± 0.0b	15.0 ± 0.5c	31.6 ± 0.8a	43.7 ± 2.6d
Refined flour					
Bayraktar	0.50 ± 0.05	9.3 ± 0.0	20.0 ± 0.5	20.1 ± 0.5	96.9 ± 0.2

Note: Means followed by different small letters in the same column are significantly different at $p < .05$.
[a]On a dry basis.

whole flour obtained from cv spelt had the lowest ash content while that of cv. Köse had the highest one ($p < .05$). In a study, the ash content of spelt and emmer whole wheat flours were found to be 1.98% and 1.87% (Škrobot et al., 2022), which are higher than the ash content of spelt and emmer whole wheat flours used in the present study. When the protein content of whole wheat flours was compared, the protein content of cv Sivas (old wheat) was the highest (16.0%) (14.8%) while that of spelt was the lowest (13.4%). In addition, the protein content of refined flour of the cv Bayraktar, which is used as standard flour, was 9.3%. In a study conducted by Zielinski et al. (2008), the protein content of spelt grains originated from Polish breeding was determined to be 7.5%–10.8%. Likewise, in another study, the protein contents of spelt, einkorn, and emmer were found in the ranges of 10.8–16.1/100 g, 11.6–13.9/100 g, and 11.2–12.4/100 g, respectively (Geisslitz et al., 2018).

However, due to the higher gliadin/glutenin ratios of these proteins compared to modern wheat varieties, their gluten structure was also found to be weak (Hadnađev et al., 2022). The characteristics of flour are described by the sedimentation value. A higher value of this parameter shows a higher amount of gluten protein, especially glutenin, which is responsible for the baking quality of flour (Cappelli et al., 2018). The sedimentation content of flour obtained from cv spelt was the highest (20 mL) while that of cv Kavlıca was the lowest (11 mL) among all ancient wheats. As indicated that the sedimentation is related to the quantity and quality of protein and hence gluten, cv spelt has acceptable properties as compared with all the whole flours obtained from the other ancient wheats. Wet gluten is a binding agent that holds together wheat and other ingredients, forming the backbone of the dough in the process, making its presence crucial to the baking quality of the flour (Bojnanska & Francakova, 2002). As shown in Table 1, cv Ak and Sivas whole flour had the highest wet gluten (38.0%–35.7%), while cv Siyez (*T. monococcum*) whole flour had the lowest (4.0 ± 0.2%) wet gluten among all whole wheat flours. Bojnanska and Francakova (2002) determined 30.6%–51.8% wet gluten in cv Spelt wheat flour, which is in line with the present study. The whole flour of cv Kavlıca had the lowest gluten index value (1.6%) as compared to other samples ($p < .05$). Also, gluten index values of whole flours obtained from cvs Ak, Sivas, and Sünter were found to be 40.3, 42.7, and 43.7, respectively, while that of cv spelt was 74.9% (Table 1). So, according to these values, spelt had strong gluten properties as compared to other cultivars.

3.2 | Physical properties of cookies produced by using ancient whole wheat flours

The physical properties of cookies such as color, texture, and volume are important factors of priority for the consumer in the option of a product. The width, thickness, spread ratio, breaking strength, and color (L^*, a^*, b^*) of the cookies were evaluated 2 h after cooling at room temperature and the results are reported in Table 2. The width and thickness of the cookies varied between 66.39 and 74.27 mm and between 8.5 and 11.1 mm, respectively. In general, the ancient wheat variety had a notable effect on the width of the cookies ($p < .05$) (except cv Ak). The cookies' spread ratio is one of the significant parameters in

TABLE 2 Physical, textural, and color characteristics of cookies obtained by adding ancient whole wheat flours to refined modern wheat flour (Bayraktar) at different rates.

Cultivar	Ratio (%)	Width (mm)	Thickness (mm)	Spread ratio	Breaking strength (kg)	*L**	*a**	*b**	ΔE
Ak	0	74.27A	8.7cA	8.5aA	3.6eA	76.4aA	5.0dA	28.7dA	
	25	73.03	9.4bB	7.8bC	4.6dC	65.9cD	7.4cAB	30.7cB	10.7cA
	50	72.31	9.7abBC	7.5bcD	5.8cD	67.6bB	7.9b	31.4bB	9.5dB
	75	71.87A	9.8a	7.3c	6.2bE	65.2cB	8.2b	31.9abC	12.0bB
	100	70.63A	9.8aC	7.2cA	7.5aE	64.2dA	8.7a	32.1aB	13.0aC
Kavlıca	0	74.27aA	8.7cA	8.5aA	3.6eA	76.4aA	5.0cA	28.7A	
	25	73.94a	9.1cCD	8.1bB	3.9dDE	72.2bA	4.6cD	27.3C	4.5D
	50	73.92a	9.6bBCD	7.7cC	4.2cF	70.7bA	7.4b	28.6C	5.9C
	75	71.65bA	10.3a	7.0d	4.6bF	66.4cA	8.0ab	29.9D	10.0B
	100	69.99cA	10.5aB	6.7eB	4.9aF	65.1cA	8.9a	30.2C	12.6C
Köse	0	74.27aA	8.7dA	8.5aA	3.6dA	76.4aA	5.0dA	28.7dA	
	25	73.04a	9.4cBC	7.8bC	6.5cA	70.3aB	7.8cA	31.6cAB	7.1dD
	50	70.19b	10.2bA	6.9cF	9.2bA	68.1cB	8.0bc	32.9bA	9.5cB
	75	69.12bCD	10.3b	6.7c	9.5bA	66.1dAB	8.4b	33.9aA	11.8bB
	100	67.75cB	10.9aA	6.2dC	11.9aA	64.2eA	9.1a	34.0aA	13.7aC
Sivas	0	74.27aA	8.7d	8.5aA	3.6eA	76.4aA	5.0dA	28.7A	
	25	73.75a	9.3cBC	7.8bC	5.4dB	68.2bC	6.9cBC	28.0C	8.4aCD
	50	71.30b	9.5cCD	7.6cCD	6.1cC	62.9cC	7.8b	29.4C	13.7cA
	75	70.21cBC	9.8b	7.2d	7.3bC	60.8dD	8.2ab	30.0D	15.9bA
	100	69.97cA	10.4aB	6.7eB	8.2aC	58.9eB	8.5a	30.7C	17.9aA
Siyez	0	74.27aA	8.7dA	8.5aA	3.6eA	76.4aA	5.0cA	28.7cA	
	25	73.91a	9.0cD	8.2bAB	4.2dD	66.3bD	6.8bBC	28.4cC	10.2AB
	50	72.34b	9.2bD	8.1bB	6.2cBC	63.8cC	7.4ab	29.4bC	12.7A
	75	71.11cAB	9.8a	7.2c	8.2bB	63.0cC	7.6b	29.8bC	14.6A
	100	70.18cA	9.9aC	7.1cA	9.2aB	60.5dB	8.3a	30.5aC	16.2B
Spelt	0	74.27aA	8.7cA	8.5aA	3.6eA	76.4a	5.0cA	28.7dA	
	25	72.03b	9.8bA	7.3bD	4.3dCD	70.3bB	7.5bAB	32.2cA	7.4dCD
	50	70.80c	9.8bB	7.2bE	5.5cE	68.1cB	7.6b	32.9bcA	9.5cB
	75	68.36dD	10.2b	6.7c	6.8bD	66.1dAB	8.1ab	33.9abA	11.8bB
	100	66.39eCD	11.1aA	6.0dD	7.5aE	64.2eA	8.7a	34.0aA	13.2aC
Sünter	0	74.27aA	8.7bA	8.5aA	3.6dA	76.4aA	5.0eA	28.7dA	
	25	71.93b	8.5bE	8.4aA	3.6dE	68.8bC	6.7dC	31.3cAB	8.9dBC
	50	71.86b	8.6bE	8.4aA	6.5cB	63.6cC	7.7c	31.9cAB	13.3cA
	75	68.94cD	9.2a	7.5b	7.0bCD	61.5dD	8.1b	32.8bB	15.7bA
	100	67.09dBC	9.4aD	7.1cA	8.0aD	59.3eB	8.5a	33.7aA	18.0aA

Note: The lowercase letters (a–e) in the same column indicate differences between the averages of the different ratios of the same varieties are statistically significant ($p < .05$). The capital letters (A–F) in the same column indicate differences between the averages of the same ratios of the different varieties are statistically significant ($p < .05$).

describing the cookie quality and influencing customer acceptability. The spread ratio of the control cookie (100% cv Bayraktar) was 8.5, and the value decreased as the ancient whole flour ratio increased, resulting in decreased width and increased thickness ($p < .05$) (Table 2). These results are similar to those of Sudha et al. (2007), who reported increased thickness and decreased width with the replacement of wheat bran with flour. Also, Saka et al. (2020) stated that the addition of wheat bran at increasing rates reduced the spread ratio of cookies. In the present study, the breaking strength of cookies increased as the whole flour ratio increased without exception ($p < .05$). This means that higher proportions of whole flour produced harder cookies. The cookies obtained by using 100% cv Köse flour had the hardest breaking strength (11.9 kg), while the 100% cv Kavlıca flour cookies were softest and had the lowest breaking strength (4.9 kg). This result stated that the whole flours with lower gluten strength resulted in 100% cv Kavlıca cookies with a softer texture. This may be related to the dilution of the gluten content available to bind water and the weak gluten structures of ancient wheat. Hidalgo et al. (2019) reported the reliance of cookie hardness on protein and gluten quality. Moreover, the cookie obtained using 100% whole flour had higher breaking strengths due to the bran's high water absorption capacity.

A significant physical characteristic of cookies is their color. The color values of cookies are given in Table 2. As the addition rates of whole wheat flour increased, the L^* (lightness) value of the cookies decreased while their b^* (yellowness) and a^* (redness) values increased (Table 2). Due to the use of 100% whole wheat flour, which contains the bran layer, the color pigments are intense in the final product. The dark and red color of the cookie may be the result of the Maillard reaction known as nonenzymatic browning, which takes place where reducing sugars and proteins are heated together (Asselman et al., 2007).

The b^* value of the whole flours (%100) of cvs Ak, Kavlıca, Köse, Sivas, Siyez, Spelt, and Sünter which were added to cookies changed in the range of 30.2–34.0, respectively. The b^* values of cookies obtained from the %100 cv Köse, Spelt, and Sünter were significantly higher than those of the other cultivars. The b^* values of the whole cv Siyez flour-added cookies changed between 28.4 and 30.5, respectively. According to Abdel-Aal et al. (2002), this may be related to the presence of lutein, which was the most common component of the carotenoid content in einkorn. Abdel-Aal and Rabalski (2008) indicated that the concentration of lutein (7.4–8.1 μg/g) was higher than those of emmer (3.7 μg/g) and hard wheat (1.1–1.5 μg/g). The b^* values of the %100 whole cv Kavlıca and cv Sivas flour-added cookies were lowest (30.2–30.7), respectively.

3.3 | Functional properties of cookies produced by using whole wheat flours

The increased use of whole wheat flour in the cookie formulation significantly ($p < .05$) increased the total phenolic compound content and antioxidant activity in the cookies. The amount of total phenolic compounds was lowest in the control (0% ancient wheat) and augmented linearly with increasing additions of whole wheat flours, reaching 923.93 mg GAE/kg DM in 100% cv Kavlıca cookies. The same increase in the total phenolic compound in the cookies occurred for all varieties (Table 3).

These results can be attributed to the rich phenolic content of whole wheat flours. Also, this may suggest that whole wheat flours have a higher phenolic content than refined wheat flour because the outer layers of the wheat are responsible for the total phenolic content of whole wheat flour (Adom & Liu, 2002). According to the phenolic compound results, as expected, the lowest antioxidant activity was found in control (0%) wheat flour cookies (59.45 μmol TE/100 g); by increasing the amount of whole wheat flour in the cookies ratio, the antioxidant activity also increased, reaching 331.98 μmol TE/100 g in 100% cv Kavlıca cookies. In addition, as shown in Table 3, antioxidant activity values and total phenolic content of all ratios of cv Kavlıca cookies were higher than those of all ratios of cv Siyez and cv spelt cookies. Abdel-Aal and Rabalski (2008) reported that emmer (3.20 μmole/g), einkorn (3.06–3.20 μmole/g), and spelt (3.03–3.17 μmole/g) would be potential high antioxidant candidates. Shewry and Hey (2015) reported that the total phenolic content of emmer wheat (779 μg/g) was higher than those of einkorn (615 μg/g) and spelt (579 μg/g) wheat. Similarly, in another study, the total antioxidant and phenolic content of emmer wheat was found to be higher than that of einkorn wheat (Cankurtaran Kömürcü, 2021). Dinelli et al. (2011) indicated that the total phenolic content of 16 old wheat cultivars ranges from 885.5 (Andriolo, old) to 1715.9 (Verna, old) μmol GAE/100 g of grain.

As expected, increasing proportions of whole wheat flour increased the phytic acid of cookies for all varieties because phytic acid is mainly concentrated in the bran and germ layers of the wheat grain (Table 4). Although phytic acid is an antinutritional component that forms chelate with minerals like Ca, Fe, Zn, Mg, and Cu, some researchers have suggested that it can be an antioxidant activity (Ozkaya et al., 2018). Therefore, the consumption

TABLE 3 Phenolic compounds, antioxidant activity, soluble, insoluble, and total dietary fiber contents of cookies obtained by adding ancient whole wheat flours to refined modern wheat flour (Bayraktar) at different rates.

Cultivar	Ratio (%)	Phenolic compounds[a] (mg GAE/kg)	Antioxidant activity[a] (μmol TE/100 g)	SDF (%)	IDF (%)	TDF (%)
Ak	0	325.70eA	59.45eA	0.61eA	0.96eA	1.57eA
	25	368.20dDE	79.56dE	0.97dA	1.97dE	2.93dD
	50	475.00cC	101.26cE	1.51cA	4.74cBC	6.24cA
	75	541.18bD	125.97bD	1.66bA	6.14bD	7.80bD
	100	645.09aE	220.89aF	1.77aAB	9.12aC	10.88aC
Kavlıca	0	325.70eA	59.45eA	0.61dA	0.96eA	1.57eA
	25	499.18dA	153.40dA	0.97cA	2.63dB	3.59dB
	50	628.90cA	172.64A	1.22bBC	5.04cA	6.26cA
	75	806.18bA	196.91bA	1.56aB	6.51bC	8.06bC
	100	923.93aA	331.98aA	1.64aC	10.07aA	11.70aA
Köse	0	325.70eA	59.45eA	0.61eA	0.96eA	1.57eA
	25	419.91dC	88.55dCD	0.83dB	2.14dD	2.97dD
	50	571.31cB	113.05cD	1.08cD	4.85cB	5.93cB
	75	714.75bBC	159.04bBC	1.31bD	6.41bC	7.71bD
	100	818.76aC	253.54aD	1.42aE	9.15aC	10.57aD
Sivas	0	325.70eA	59.45eA	0.61dA	0.96eA	1.57eA
	25	386.12dD	83.40dDE	0.63dD	1.82dF	2.44dE
	50	560.48cB	106.87cDE	1.06cD	4.77cB	5.83cB
	75	689.27bBC	149.95bC	1.58bB	5.88bE	7.46bE
	100	760.50aD	249.64aD	1.71aB	8.46aD	10.17aE
Siyez	0	325.70eA	59.45eA	0.61dA	0.96eA	1.57eA
	25	458.23dB	92.46dC	0.75cC	1.15dG	1.89dF
	50	594.76cAB	120.40cC	1.10bD	1.84cD	2.93cC
	75	743.93bAB	162.98bB	1.18bE	3.71bF	4.88bF
	100	838.50aC	283.67aC	1.53aD	5.09aE	6.62aF
Spelt	0	325.70eA	59.45eA	0.61dA	0.96eA	1.57eA
	25	449.63dB	103.21dB	0.99cA	2.74dA	3.72dB
	50	624.20cA	133.25cB	1.31bB	4.62cC	5.92cA
	75	750.82bAB	163.44bB	1.40bC	8.31bA	9.70bA
	100	874.41aB	317.72aB	1.83aA	9.85aB	11.68aA
Sünter	0	325.70eA	59.45eA	0.61eA	0.96eA	1.57eA
	25	360.63dE	80.83dE	0.93dA	2.36dC	3.29dC
	50	496.62cC	103.50cE	1.14cCD	4.73cBC	5.87cB
	75	668.00bC	136.06bD	1.34bCD	6.92bB	8.26bB
	100	751.84aD	238.11aE	1.51aD	9.87aB	11.38aB

Note: The lowercase letters (a–e) in the same column indicate differences between the averages of the different ratios of the same varieties are statistically significant ($p < .05$). The capital letters (A–F) in the same column indicate differences between the averages of the same ratios of the different varieties are statistically significant ($p < .05$).

Abbreviations: GAE, gallic acid equivalent; IDF, ınsoluble dietary fiber; SDF, soluble dietary fiber; TDF, total dietary fiber; TE, trolox equivalent.

[a]On a dry basis.

TABLE 4 The mineral and phytic acid contents of cookies obtained by adding ancient whole wheat flours to refined wheat flour (Bayraktar) at different rates.

Cultivar	Ratio (%)	Ca (mg/kg)	Fe (mg/kg)	K (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	P (mg/kg)	Phytic Acid (mg/100 g)
Ak	0	248.2dA	7.9eA	837.7dA	144.5eA	4.4dA	2.3dA	53.4dA	81.7eA
	25	344.3cA	18.9dA	1475.4cB	558.2dA	19.6cA	6.1cA	134.3dA	181.3dB
	50	358.4bA	24.0cA	1749.5bA	720.9cA	25.2bA	8.1bC	150.2cA	296.7cB
	75	400.3aA	25.9bB	1765.4bE	738.7bA	25.3bA	8.3bD	170.3bA	367.0bB
	100	405.7aB	30.1aB	2171.0aB	962.0aA	33.8aA	12.3aD	218.4aA	482.6aB
Kavlıca	0	248.2eA	7.9eA	837.7eA	144.5eA	4.4eA	2.3eA	53.4eA	81.7eA
	25	271.3dG	13.3dE	1203.8dCD	334.0dD	9.5dF	5.2dC	91.7dE	124.6dE
	50	316.7cD	18.2cB	1575.1cB	483.8cE	13.9cF	9.0cB	122.8cE	191.6cE
	75	336.6bD	21.7bD	1883.6bC	645.1bB	18.1bG	12.2bB	158.7bC	262.0bE
	100	477.1aA	26.9aC	2365.8aA	842.3aC	23.6EF	16.4aA	206.3aB	331.3aE
Köse	0	248.2dA	7.9eA	837.7eA	144.5eA	4.4eA	2.3eA	53.4eA	81.7eA
	25	305.1cC	16.9dC	1232.8dC	343.2dC	11.4dC	3.9dE	91.6dE	153.4dD
	50	306.2cE	19.2cC	1593.5cB	509.2cD	17.1cB	5.5cE	125.7cD	205.2cD
	75	350.5bC	26.7bA	2020.4bA	718.7bA	24.2bB	7.8bE	169.7bB	327.2bD
	100	358.8aD	27.9aC	2362.0aA	872.8aB	29.6aB	8.9aF	197.3aD	418.5aD
Sivas	0	248.2eA	7.9eA	837.7eA	144.5dA	4.4eA	2.3eA	53.4eA	81.7eA
	25	279.8dE	17.4dB	1547.3dA	494.5cB	14.6dB	6.0dA	129.1dB	212.1dA
	50	287.5cG	18.4cD	1589.1cB	516.8cC	15.0cD	6.5cD	136.6cC	326.6cA
	75	302.1bE	21.1bE	1925.3bB	619.3bB	19.2bF	8.1DE	171.6bB	376.0bA
	100	318.7aE	25.1aF	2117.2aB	839.7aC	24.0aDE	9.5aE	203.7aC	511.8aA
Siyez	0	248.2eA	7.9eA	837.7eA	144.5eA	4.4eA	2.3eA	53.4eA	81.7eA
	25	277.0dF	13.0dF	1122.9dE	289.1dF	9.8dE	5.2dC	96.0dD	155.2dD
	50	298.9cF	17.3cF	1330.5cE	412.0cG	14.2cE	7.9cC	127.7cD	211.7cD
	75	332.9bD	21.8bD	1663.0bF	571.0bC	19.6bE	12.0bB	171.7bA	253.1bF
	100	356.4aD	25.7aE	1841.4aD	672.4aF	23.3aF	14.3aC	192.4aE	310.2aG
Spelt	0	248.2eA	7.9eA	837.7eA	144.5eA	4.4eA	2.3eA	53.4eA	81.7eA
	25	324.0dB	16.3dD	1204.3dCD	328.3dE	11.3dC	5.8dB	87.9dF	123.1dE
	50	339.3cB	19.5cB	1518.3cC	459.2cF	16.3cC	9.3cA	119.1cF	182.6cF
	75	394.6bA	24.8bC	1837.1bD	654.5bB	23.4bC	12.8bA	151.3bD	251.7bF
	100	401.4aB	32.5aA	2044.5aC	759.4aE	27.2aC	15.4aB	172.5aF	319.5aF
Sünter	0	248.2eA	7.9eA	837.7eA	144.5eA	4.4eA	2.3eA	53.4dA	81.7eA
	25	282.9dD	12.5dG	1182.3dD	340.5dC	10.5dD	4.3dD	98.4cC	170.1dC
	50	330.8cC	17.3cF	1468.2cD	523.7cB	16.5cC	6.6cD	138.9bB	239.3cC
	75	362.8bB	21.3bE	1789.8bE	727.7bA	22.7bD	8.8bC	189.8aA	350.3bC
	100	376.6aC	23.4aG	1843.8aD	772.3aD	24.2aD	9.1aF	194.5aE	436.6aC

Note: The lowercase letters (a–e) in the same column indicate differences between the averages of the different ratios of the same varieties are statistically significant ($p < .05$). The capital letters (A–G) in the same column indicate differences between the averages of the same ratios of the different varieties are statistically significant ($p < .05$).

of phytic acid needs to be well-balanced enough to provide beneficial health benefits without reducing mineral absorption. The phytic acid content obtained from the cookies produced using 100% whole wheat flour had the highest cv Sivas (511.8 mg/kg) and cv Ak (482.6 mg/100 g) while cv spelt (319.5 mg/100 g) and cv Siyez (310.2 mg/100 g) had the lowest value. Kohajdová and Karovicová (2008) indicated that the phytic acid content tends to be 40% lower in spelt than in wheat. In addition, Ruibal-Mendieta et al. (2002) reported that spelt is suitable for the biscuit-like product because it combines low phytic acid content with a little sweet taste.

As shown in Table 3, the cookies that did not contain whole wheat flour were obtained to have lower soluble, insoluble, and total dietary fiber content (0.61%, 0.96%, and 1.57%, respectively) than the cookies obtained by adding different ratios of (25%, 50%, 75%, or 100%) whole wheat flour. As expected, our findings reveal that the addition of whole wheat flour at different rates increased the amounts of dietary fiber. As expected, our findings reveal that the addition of whole wheat flour at different rates increased the amounts of dietary fiber. The amount of soluble and total dietary fiber in the cookies produced with cv Spelt whole flour was the highest (1.83%, 9.85%, 2.23%, and 11.68%, respectively). In contrast, the cv Siyez whole flour-based cookies had the lowest total dietary and insoluble fiber (6.62% and 5.09%, respectively). Also, our results showed that cv spelt had the highest dietary fiber, which may reduce the risk of heart diseases by lowering cholesterol (Rodríguez et al., 2006). Similar to the present study's findings, Gebruers et al. (2008) reported that einkorn wheat contained lower levels (7.2%–12.8%) of dietary fiber while common wheat contained total dietary fiber in the range of 11.5%–18.3%. In addition, Shewry and Hey (2015) stated that emmer and spelt wheats contain total dietary fiber in the range of 7.2%–12% and 10.7%–13.9%, respectively. They also found that einkorn wheat contains lower total dietary fiber (9.3%–12.8%).

The mineral content of cookies enhanced with ancient whole wheat flour is shown in Table 4. The differences in the amounts of calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), and zinc (Zn) between the variety were significant ($p < .05$). The highest proportion of ancient wheat (100%) increased the Ca, Fe, K, Mg, Mn, and Zn content of the cookies by approximately 1.63 (cv Kavlıca, Emmer), 4.09 (spelt), 2, 82 (Kavlıca, Emmer), 6.65 (cv Ak), 7.73 (cv Ak), and 7.11 (cv Kavlıca, Emmer) folds, respectively, compared to cookies without ancient whole wheat flour. Evidently, the cookie's mineral content is directly related to the rich mineral content of whole wheat flour. Boukid et al. (2018) found that spelt, emmer, and einkorn whole grain flour had many more minerals than common wheat, which is already regarded as a crucial source of minerals in human nutrition and diet.

4 | CONCLUSION

There is an absence of information on the composition and content of the functional components in ancient wheat and their products. Hence, the findings of the present study showed that the nutritional value of the cookies increased to the highest level when 100% whole wheat flour was used. According to the obtained data, cv Kavlıca resulted in good technological, functional, and nutritional properties as compared to other cookie samples by using the other ancient wheats.

In comparison to cookies made with refined modern wheat flour, ancient-enriched cookies demonstrated higher levels of ash, total phenol, antioxidants, soluble, insoluble, and total dietary fiber as well as Fe, Zn, Mg, Ca, K, and P minerals. Therefore, these cookies can be potential functional foods. Ancient wheat may still have a place in human consumption, particularly as a promising candidate for the development of functional foods like bread, cookies, cracker, pasta, baby food, or products with significant amounts of bioactive compounds (such as dietary fiber and antioxidant activity), which may also be a step toward harmless and environmentally friendly farming also suggest that ancient wheat may still have a place in human consumption. In general, the findings showed that it is possible to make technological cookies from ancient wheat varieties that also have genetic diversity. To select suitable bakery products that are enriched in nutritional components, further comprehensive studies with multiple genotypes of ancient cultivars of wheat are required.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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