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Improving the nutritional quality of cereals and legumes by germination

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Abstract: Cereal and legume grains are germinated to improve their nutritional and sensory qualities. This study investigated the effect of germination on the physicochemical properties of some grains and legumes grown in Türkiye. At the end of the germination for 48 h and 96 h at 24 ± 1 °C, carbohydrate, protein, lipid, dietary fibre, dry matter, ash, total phenolic content, antioxidant capacity and colour analyses of the germinated grains were determined. The results indicated that the germination process increased the phenolic content of all samples. The legume seeds' 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity significantly increased with germination. The germination process significantly decreased the total carbohydrate contents of the samples. A statistically significant decrease was found for the protein content of barley and corn, especially by 48 h of germination. The lipid content of cereal grains decreased as germination progressed. It might be recommended to improve the functional properties of cereals and legumes by germination and their use in the food industry.

Keywords: cereal; nutrient content; phenolic; antioxidant capacity

Cereals and legumes, located in two separate leaves of the food pyramid, determined as 4-leaf clover in Türkiye, are the cornerstone of a balanced diet regarding macro and micronutrients worldwide. Cereals and legumes provide essential nutrients for human metabolism and contain biologically active compounds that promote health and prevent social diseases (Özer et al. 2016).

Edible sprouts are obtained by germinating seeds, and they are important sources of various micronutrients, macronutrients and secondary metabolites (Miyahira et al. 2021). The germination process causes cellular division and cellular expansion that change the structure of protein and starch, thus increasing the digestibility of carbohydrates and proteins and the concentration of vitamins. Metabolic pathways are activated, increasing the amount of specific bioactive compounds, such as phenolic compounds, which have antioxidant, antimicrobial, anticancer, and anti-inflammatory properties.

In germinated grains, the enzyme amylase catalyses the hydrolysis of starch into simple sugars, increasing grains' digestibility. Enzymes produced or activated during the germination process in grains cause the reduction of proteins and carbohydrates to small molecular compounds and increase the amount of amino acids (Singkhornart and Ryu 2011). Some coordinated metabolic activities that begin with germination cause the hydrolysis of the ester bonds of triacylglycerols by the enzyme lipase and release free fatty acids (Pal et al. 2017).

However, when germination is used to produce novel food ingredients, a controlled process and stability of the products must be provided. Because germination conditions favour microbial growth, providing sufficient shelf life is an important success criterion for all germinated products. At the same time, the intake of raw cereal and legume sprouts might cause symptoms in some allergic patients (Jensen et al. 2008). All the employed strategies to reduce the health risks of germinated seeds include physical, biological and chemical applications (Kaukovirta-Norja et al. 2004; Benincasa et al. 2019). All studies in the literature contribute to optimising germination

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conditions to maximise the nutritive values of cereals and legumes. However, there is still a need to obtain sprouted products and characterise their properties to provide helpful information for consumers and producers.

To date, common cereals and legumes and their germinated counterparts have not been assessed in Türkiye; the main aim of this project was to establish the influence of the germination process on chemical composition, including carbohydrate, lipid, protein, dietary fibre, ash and dry matter contents of selected commercially important cereal and legume varieties. Besides these, total phenolic content, antioxidant activity and colour parameters were investigated. This study will provide much beneficial information for the food industry to use germinated cereals and legumes as nutritious, biologically functional, and tasty components. In addition to the positive effects of fresh consumption on human health (low-calorie value, high biological activity, enhanced digestibility), the possibility of using them as a natural additive in some processed foods will create a good opportunity to consume sprouted products worldwide.

MATERIAL AND METHODS

Germination process. Barley, wheat, corn, mung beans and green lentils were obtained from a local market in Fethiye, Muğla. The samples were kept in ethanol at a 1:5 ratio (70%, *v*/*v*) for 10 min to provide sterilisation. The sterilised samples were soaked in pure water (1:3) at room temperature (24 ± 1 °C) for 24 h in darkness. The water was drained, and the grains germinated at room temperature for 48 h and 96 h. Grains with sprout lengths of 1 mm or more were considered germinated. Before analysis, they were dried overnight at 50–55 °C in a drying oven (Nüve NF-1200R; Nüve Laboratory/Sterilization Technology, Türkiye) and then milled into powder using a laboratory-type grinder (Briz-BR721; Muson Global, China). The ground grains were stored at –20 °C in locked polyethene bags until analyses.

Chemical analyses. For ash determination, approximately 5 g of dried samples were carbonised in a muffle furnace (PLF 110/6; Protherm Furnaces, Türkiye) at 550 °C for 6 h until white ash was obtained. The percentage of ash content was calculated using Equation 1. Ash determination was repeated three times per sample.

$$\text{ash (\%)} = \frac{\text{ash weight}}{\text{wet weight}} \times 100 \quad (1)$$

The samples' dry matter (DM) content was determined gravimetrically by drying them to the constant weight at 105 °C in a drying oven. Dry matter content was calculated from Equation 2.

$$\text{DM (\%)} = \frac{\text{dry weight}}{\text{wet weight}} \times 100 \quad (2)$$

Dry matter determination was repeated three times per sample. The content of available carbohydrates was determined using a difference method after determining the samples' protein, lipid, moisture, ash, and fibre amounts (Kassegn et al. 2018). Calculation was performed by using Equation 3.

$$\text{carbohydrate (\%)} = [100 - (\text{protein} + \text{fat} + \text{moisture} + \text{ash} + \text{fibre}) \text{ (\%)}] \quad (3)$$

Protein content was determined by using the Kjeldahl procedure. About 2 g of germinated seeds, 3.5 g of K_2SO_4 and 0.4 g of $CuSO_4$ were mixed in the Kjeldahl flask and then treated with concentrated H_2SO_4. The temperature of the Kjeldahl apparatus (ILDAM ILD-TAP; Delta, Türkiye) was gradually increased, and the samples were mineralised at 400 °C for 120 min. Obtained solutions were distilled with NaOH (40% *w*/*v*) in the Kjeldahl distillation apparatus for 5 min. Later, solutions were hand titrated using an indicator solution and 0.1 N HCl. The nitrogen value obtained was multiplied by 6.25 to convert it to crude protein. Analyses were repeated three times per sample.

The maceration technique described by Altıntaş and Kuleaşan (2010) was used with some modifications to determine lipid content. Hexane was added to 10 g of sample with a sample/solvent ratio of 1:2 (*w*/*v*), and samples were kept at room temperature for 24 h in dark conditions. After the maceration process, the mixture was filtered through coarse filter paper and the total lipid content was calculated by removing the hexane at the appropriate temperature. The maceration process was repeated twice. Analyses were repeated three times per sample.

The total dietary fibre analysis was performed using the enzymatic-gravimetric method of AOAC 991.43 in the NanoLab Laboratory Group (Beylikdüzü, İstanbul, Türkiye).

Determination of total phenolic content and antioxidant activity. The extraction of polyphenols from raw and germinated samples according to the method described by Zhu et al. (2005) with some modifications. A sample amount of 500 mg was mixed with 5 mL of methanol solution (80% *v*/*v*) for 2 h, then centrifuged at 9 000 rpm for 10 min, and the supernatant was obtained. The total phenolic content (TPC) of samples was determined us-

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ing the Folin-Ciocalteu reagent as described in the study of Singleton and Rossi (1965). The absorbance was measured at 765 nm using a spectrophotometer (Agilent Cary 60 UV-Vis; Agilent Technology, Malaysia). Phenolic content was expressed as mg of gallic acid (GA) equivalents per g of the extract (mg GAE·g^{-1}).

The standard 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method modified by Ankolekar et al. (2012) determined the antioxidant activity. Firstly, 250 µL aliquot of the sample extract was mixed with 1 250 µL of DPPH (60 µM in ethanol). The reaction mixture was incubated in the dark for 30 min. Absorbance was measured at 517 nm using a spectrophotometer. The readings were compared with the controls, containing 95% ethanol instead of the sample extract. The percentage inhibition was calculated by using Equation 4.

$$\text{inhibition}(\%) = \frac{\text{absorbance}_{\text{control}} - \text{absorbance}_{\text{sample}}}{\text{absorbance}_{\text{control}}} \times 100 \quad (4)$$

Colour analysis. Colour analyses of samples were conducted at room temperature (25 °C) using a CR-10 Colour Analyser (HunterLab Co., USA). The colourimeter was calibrated with a white colour standard. The germinated seed was put in a sample cup and then kept in the sample platform for its colour identification as L^*, a^*, and b^* values. The L^* value specified whiteness to darkness. The chromatic portion was examined by a^* (+) redness and a^* (–) greenness, b^* (+) yellowness and b^* (–) blueness. Three measurements were performed, and the results were averaged.

Statistical analysis. Data from parallel measurements obtained from the chemical analyses of the studied samples were expressed as mean ± standard deviation (SD). All data were analysed by one-way analyses of variance using the Minitab Statistical Software (Minitab Version 21.0). The significant means were compared by the Tukey multiple comparison test. The differences were considered statistically significant if $P < 0.05$. Two-way ANOVA was also applied to the data to understand better if the grain type and germination time affect the studied properties.

RESULTS AND DISCUSSION

Chemical analyses. The green lentil sprouts did not reach the desired length on the second day of germination. At the end of day 4, all samples had already germinated (Figures 1A–E). The effect of germination on the proximate composition of studied samples is presented in Table 1. According to Table 1, the ash content decreased in germinated barley and corn seed within 48 h of germination. Islam et al. (2021) determined that the ash amount of waxy barley germinated for 48 h decreased by 1.88%. The decrease in the amount of ash at the end of germination is attributed to the transfer of minerals to the soaking water during washing and soaking. Germination was observed to have different effects on the ash content of two studied legume samples. At the end of 96 h of germination, the loss of ash content in green lentils reached 32%, compared to ungerminated green lentil seeds. Xu et al. (2019) also reached similar results in their lentil research. They found that the ash content decreased by 7.78% at the end of 48 h of germination. In contrast to the green lentils' observation, mung bean seeds' ash content increased from 3.32 to 3.79 g·(100 g)$^{-1}$ with about a 12% increment.

Germination induced significant ($P < 0.05$) changes in the dry matter contents of cereals and legumes. Considering the grains, dry matter losses during the seed germination period depended on germination time. The highest loss was observed during the first 48 h of germination for studied grains (Table 1). In our study, the lowest dry matter loss (from 91.83% to 90.36%) with germination was observed in mung beans. The leading cause of dry matter losses during the first 48 h may be the intensive imbibing of water by seeds at the beginning of germination. As germination proceeds, grains take up water from the environment to start the metabolic process. Washing and soaking processes applied to the grains before the sprouting process cause the cells to absorb water and decrease their dry matter content (Malik et al. 2021).

According to Table 1, the germination process significantly ($P < 0.05$) decreased the total carbohydrate contents of samples. It was observed that the carbohydrate content of mung bean and green lentils decreased from 60.34% to 54.01% and from 43.3% to 35.24%, especially at the end of 96 h of germination, respectively. However, the carbohydrate content of barley, wheat and corn (61.13, 73.97, and 75.76%, respectively) decreased significantly at the end of 48 h of germination (54.99, 66.30, and 68.61%, respectively). Islam et al. (2021) reported similar results of reducing the carbohydrate content for sprouted barley and Mbithi-Mwikya et al. (2000) for ragi corn. The partial hydrolysis of starch into glucose, maltose, and maltotriose and a wide range of dextrins explain a reduction in the amount of carbohydrates and increased sugar content. However, variation in the sugar profile during the germination process mainly depends on the cereal and legume type due to their stronger or weaker hy-

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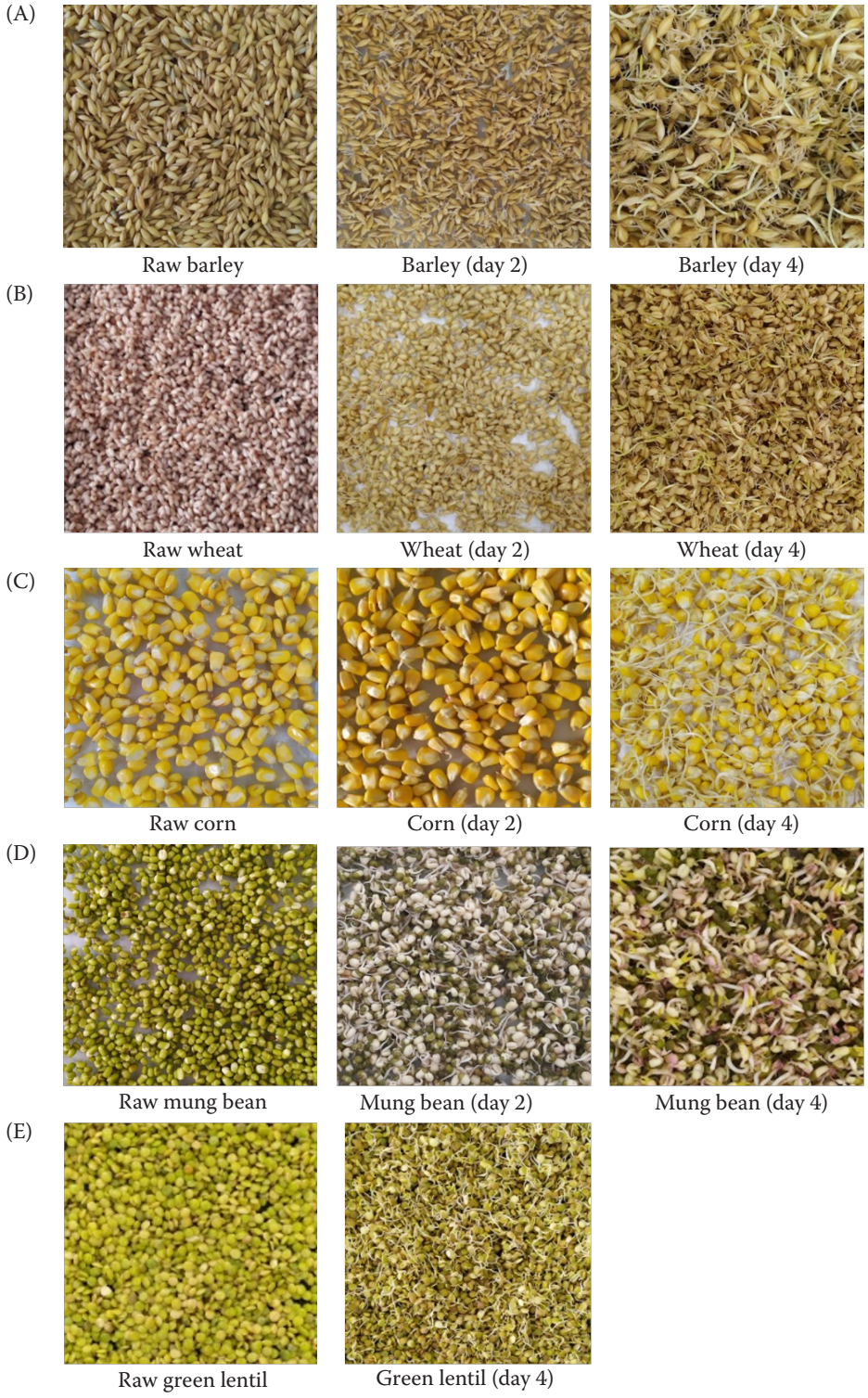

Figure 1. Cereals and legumes at different germination stages (0, 48, and 96 h): (A) barley; (B) wheat; (C) corn; (D) mung bean; (E) green lentils

drolysis. Biomass remodelling during germination and seedling formation is affected by differences in the molecular structure of starch granules and amylase activity (Shaik et al. 2014).

While no significant difference was observed in raw and germinated wheat protein content, a statistically significant decrease ($P < 0.05$) was found for the protein content of barley and corn samples, especially

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Table 1. Results of chemical analyses of raw and germinated cereals and legumes [%, g·(100 g)$^{-1}$]

Samples		Ash	Dry matter	Carbohydrate	Protein	Lipid	Dietary fibre
Barley	raw	2.79 ± 0.05^{a}	91.07 ± 0.11^{a}	61.13 ± 0.29^{a}	11.64 ± 0.48^{a}	1.60 ± 0.02^{a}	13.82 ± 0.11^{a}
	germinated (day 2)	2.05 ± 0.11^{c}	82.34 ± 0.13^{c}	54.99 ± 0.36^{c}	10.21 ± 0.14^{b}	1.13 ± 0.04^{c}	13.95 ± 0.21^{a}
	germinated (day 4)	2.41 ± 0.11^{b}	87.31 ± 0.17^{b}	58.37 ± 0.15^{b}	11.28 ± 0.01^{ab}	1.30 ± 0.06^{b}	13.89 ± 0.18^{a}
Wheat	raw	1.47 ± 0.17^{a}	90.94 ± 0.09^{a}	73.97 ± 0.42^{a}	11.92 ± 0.11^{a}	1.20 ± 0.03^{a}	2.45 ± 0.04^{a}
	germinated (day 2)	1.34 ± 0.02^{a}	82.87 ± 0.03^{c}	66.30 ± 0.76^{b}	11.59 ± 0.66^{a}	1.07 ± 0.04^{b}	2.59 ± 0.10^{a}
	germinated (day 4)	1.32 ± 0.12^{a}	83.93 ± 0.26^{b}	66.97 ± 0.16^{b}	11.99 ± 0.09^{a}	0.99 ± 0.08^{b}	2.65 ± 0.10^{a}
Corn	raw	1.70 ± 0.04^{a}	91.40 ± 0.24^{a}	75.76 ± 0.15^{a}	6.22 ± 0.00^{a}	3.85 ± 0.14^{a}	3.78 ± 0.06^{a}
	germinated (day 2)	1.45 ± 0.04^{b}	82.60 ± 0.47^{c}	68.61 ± 0.88^{b}	5.65 ± 0.14^{b}	2.66 ± 0.13^{b}	4.01 ± 0.07^{a}
	germinated (day 4)	1.65 ± 0.07^{a}	87.67 ± 0.18^{b}	73.84 ± 0.03^{a}	5.75 ± 0.08^{b}	2.40 ± 0.08^{b}	4.02 ± 0.15^{a}
Mung bean	raw	3.32 ± 0.12^{b}	91.83 ± 0.13^{a}	60.34 ± 0.27^{a}	23.30 ± 0.28^{b}	0.45 ± 0.02^{b}	4.35 ± 0.04^{a}
	germinated (day 2)	3.60 ± 0.06^{ab}	90.21 ± 0.17^{b}	56.58 ± 0.24^{b}	24.81 ± 0.29^{b}	0.61 ± 0.01^{a}	4.47 ± 0.13^{a}
	germinated (day 4)	3.79 ± 0.16^{a}	90.36 ± 0.26^{b}	54.01 ± 0.13^{c}	27.57 ± 0.18^{a}	0.46 ± 0.03^{b}	4.35 ± 0.04^{a}
Green lentil*	raw	2.45 ± 0.07	92.52 ± 0.16	43.30 ± 0.50	22.74 ± 0.05	0.56 ± 0.01	23.41 ± 0.44
	germinated (day 4)	1.69 ± 0.08	85.47 ± 0.05	35.24 ± 0.42	23.49 ± 0.01	0.74 ± 0.01	24.31 ± 0.30

* post hoc tests could not be performed for green lentils because there is less than three groups; $^{a–c}$ different letters within columns of each individual cereal and legume indicate statistically significant differences ($P < 0.05$) by Tukey multiple range test; results as mean ± standard deviation (SD)

48 h after germination. The study of Malik et al. (2021) supports our findings as they determined that the protein content of germinated corn decreased by 24.26%. However, in our study, germination increased the protein content of mung bean and green lentil seeds from 23.30% to 27.57%, and 22.74% to 23.49%, respectively, on the fourth day (Table 1). A similar increase was previously reported for mung bean and lentils after germination (Ghavidel and Prakash 2007).

A statistically significant decrease in lipid content was observed for barley, wheat, and corn after 48 h of germination. Lipid contents of barley, wheat and corn ranged from 1.60% to 1.30%, from 1.20% to 0.99%, and from 3.85% to 2.40%, respectively. A similar decrease in the lipid content of pearl corn with germination was reported by Obadina et al. (2017). This decrease is attributed to lipid hydrolysis due to the increased activity of lipolytic enzymes during germination. Contrary to some studies, the lipid content of legumes in our study increased with germination (Ghavidel and Prakash 2007; Fouad and Rehab 2015). Germination increased the lipid content of green lentil seeds (about 32%). Kumar et al. (2022) reported similar results and stated that the lipid content of the bean sprouts increased by 7.69% compared to the raw bean. This increase in lipid content could be explained as the proportional changes occurring with the loss of some soluble compounds during the sterilisation and soaking stages.

The total dietary fibre contents of cereals and legumes were not significantly ($P > 0.05$) affected by the germination process. It was observed that only green lentils had a slightly significant increase from 23.41% to 24.31% in the amount of dietary fibre. This result agrees with Fouad and Rehab (2019), who observed a significant increase in the dietary fibre content of germinated lentil seeds.

The interaction plots obtained from two-way ANOVA for ash, dry matter, carbohydrate, protein, lipid and dietary fibre are shown in Figure 2. As seen from the plots, all studied properties except for total dietary fibre were affected by grain type and germination time. The only influential factor for total dietary fibre was grain type.

Total phenolic content and antioxidant capacity. The results showed that the amount of TPC increased significantly after germination (Table 2). The highest increase in TPC of 96 h germinated samples was observed for mung bean (about 307%), and the lowest was for barley (about 28%). Gan et al. (2016) reported similar results of increasing TPC for germinated green and black mung bean, and Khang et al. (2016) for germinated white kidney bean, soybeans and peanuts. The activity of the enzyme phenylalanine ammonia-lyase (PAL) increases during sprouting, resulting in an increase in the total amount of phenolic substances.

The germination process changed the antioxidant activity of studied barley, wheat, corn, mung bean and

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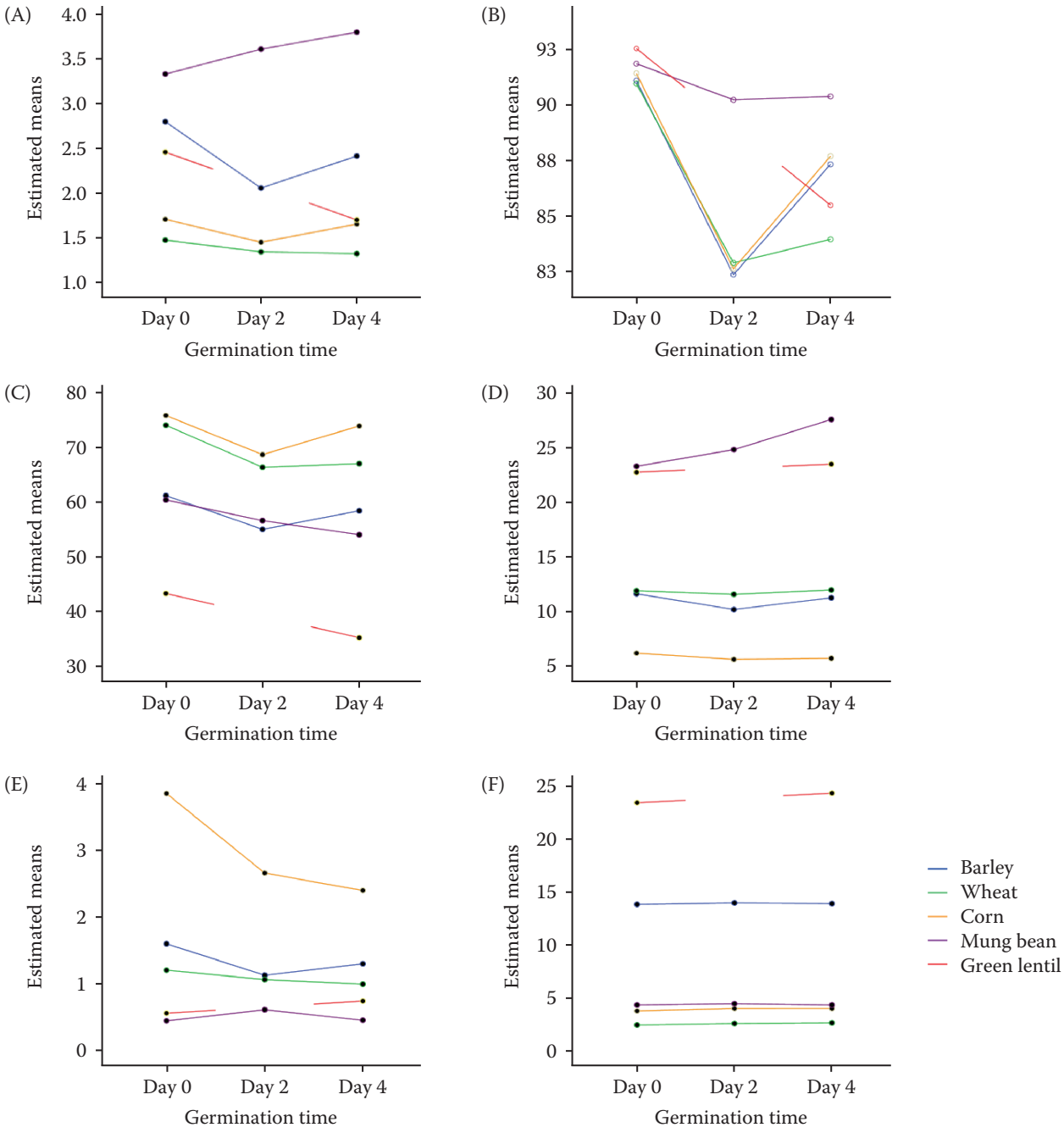

Figure 2. The interaction plots for (A) ash; (B) dry matter; (C) carbohydrate; (D) protein; (E) lipid; (F) dietary fibre

green lentils, but in a different manner in each of them. No statistically significant differences ($P > 0.05$) in the antioxidant activities of either barley or wheat were observed. However, the antioxidant activity decreased from 96.74% to 78.39% for corn after 48 h of germination. On the fourth day of germination, the antioxidant activity increased from 7.25% to 64.68% for mung bean, from 7.25% to 64.68% for mung bean, and from 49.99% to 82.04% for green lentils. Kaur and Gill (2021) stated a statistically insignificant increase in the DPPH-reducing capacity of grains as germination time increased. In another study, the DPPH radical scavenging activity of the barley sample showed a decrease of 20.7% at the end of four-day germination (Lu et al. 2007). It is known that the type and amount of phenolic acids are very effective parameters on the antioxidant capacity. During the sprouting process, individual phenolic acids can undergo polymerisation, significant structural changes, and other reactions that cause changes in the grain's antioxidant capacity (Pinelo et al. 2004).

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Table 2. Results of total phenolic content (TPC) and antioxidant activity of raw and germinated cereals and legumes

Samples		TPC (mg GAE·g^{-1} sample dry matter)	DPPH (inhibition %)
Barley	raw	106.44 ± 9.33^{b}	67.99 ± 1.04^{a}
	germinated (day 2)	116.62 ± 7.82^{ab}	63.94 ± 1.07^{a}
	germinated (day 4)	135.31 ± 24.67^{a}	68.29 ± 5.03^{a}
Wheat	raw	28.21 ± 1.40^{c}	54.79 ± 4.38^{a}
	germinated (day 2)	36.35 ± 1.16^{b}	47.65 ± 1.50^{a}
	germinated (day 4)	47.45 ± 2.80^{a}	49.49 ± 1.37^{a}
Corn	raw	53.52 ± 0.40^{c}	96.74 ± 0.30^{a}
	germinated (day 2)	58.62 ± 2.83^{b}	78.39 ± 0.74^{c}
	germinated (day 4)	96.35 ± 0.90^{a}	88.89 ± 0.54^{b}
Mung bean	raw	35.65 ± 0.17^{c}	7.25 ± 0.45^{b}
	germinated (day 2)	105.27 ± 0.70^{b}	61.60 ± 1.36^{a}
	germinated (day 4)	145.30 ± 5.11^{a}	64.68 ± 0.65^{a}
Green lentil*	raw	44.17 ± 0.35	49.99 ± 4.83
	germinated (day 4)	75.83 ± 1.57	82.04 ± 0.65

* post hoc tests could not be performed for green lentils because there is less than three groups; $^{a–c}$ different letters within columns of each individual cereal and legume indicate statistically significant differences ($P < 0.05$) by Tukey multiple range test; results as mean ± standard deviation (SD); TPC – total phenolic content; GAE – gallic acid equivalent; DPPH – 2,2-diphenyl-1-picrylhydrazyl

Colour coordinates. It was observed that the L^* value, i.e. the brightness of germinated samples, decreased except for corn grains as the germination period progressed (Table 3). As can be seen from Table 3, the a^* values of barley and wheat grains statistically increased by proceeding germination time. The a^* value of corn sprouts decreased significantly, while there was an increase in the a^* value of mung beans with-

Table 3. The colour coordinates of raw and germinated cereals and legumes

Samples		L^*	a^*	b^*
Barley	raw	71.97 ± 2.28^{a}	3.57 ± 0.35^{b}	18.07 ± 0.65^{b}
	germinated (day 2)	68.10 ± 0,96^{b}	4.27 ± 0.15^{a}	19.60 ± 0.66^{a}
	germinated (day 4)	66.20 ± 0,72^{b}	4.27 ± 0.23^{a}	19.77 ± 0.15^{a}
Wheat	raw	73.00 ± 0.89^{a}	2.7 ± 0.1^{b}	12.13 ± 0.60^{b}
	germinated (day 2)	71.23 ± 0.71^{a}	3.10 ± 0.53^{ab}	12.8 ± 0.7^{ab}
	germinated (day 4)	67.70 ± 0.53^{b}	3.60 ± 0.17^{a}	13.8 ± 0.2^{a}
Corn	raw	80.00 ± 0.53^{a}	2.23 ± 0.15^{a}	28.23 ± 0.55^{a}
	germinated (day 2)	78.77 ± 0.15^{b}	2.03 ± 0.12^{a}	28.67 ± 0.95^{a}
	germinated (day 4)	80.3 ± 0.6^{a}	1.0 ± 0.1^{b}	19.97 ± 0.59^{b}
Mung bean	raw	70.87 ± 0.51^{a}	0.43 ± 0.12^{b}	28.27 ± 0.42^{a}
	germinated (day 2)	68.00 ± 0.35^{b}	–0.07 ± 0.12^{b}	15.20 ± 0.53^{c}
	germinated (day 4)	54.03 ± 0.84^{c}	2.87 ± 0.32^{a}	19.87 ± 1.00^{b}
Green lentil*	raw	67.03 ± 0.55	–0.17 ± 0.12	23.77 ± 0.59
	germinated (day 4)	59.07 ± 0.45	2.27 ± 0.45	20.13 ± 0.40

* post hoc tests could not be performed for green lentils because there is less than three groups; $^{a–c}$ different letters within columns of each individual cereal and legume indicate statistically significant differences ($P < 0.05$) by Tukey multiple range test; results as mean ± standard deviation (SD); L^* – whiteness to darkness; a^* – redness/greenness; b^* – yellowness/blueness

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in 96 h of germination ($P < 0.05$). On the other hand, the negative a^* value (greenness) of green lentils at the beginning increased significantly with germination and showed positivity (redness). Table 3 shows no significant change in b^* values of barley and wheat with germination ($P > 0.05$). However, after 96 h of germination, the b^* value of corn, mung bean and green lentil grains was decreased appreciably. In the literature, the decrease in the L^* value of the grains has been explained as the degradation of starch into soluble sugars during germination and the Maillard reaction as a result. Degradation of green pigment substances and losses during wetting cause the colour of the grains to change (Li et al. 2020).

The interaction plots obtained from two-way ANOVA for total phenolic content, antioxidant activity and colour parameters are presented in Figure 3. It can be seen from Figure 3 that total phenolics, antioxidant activity and colour parameters were highly affected by grain type and germination time.

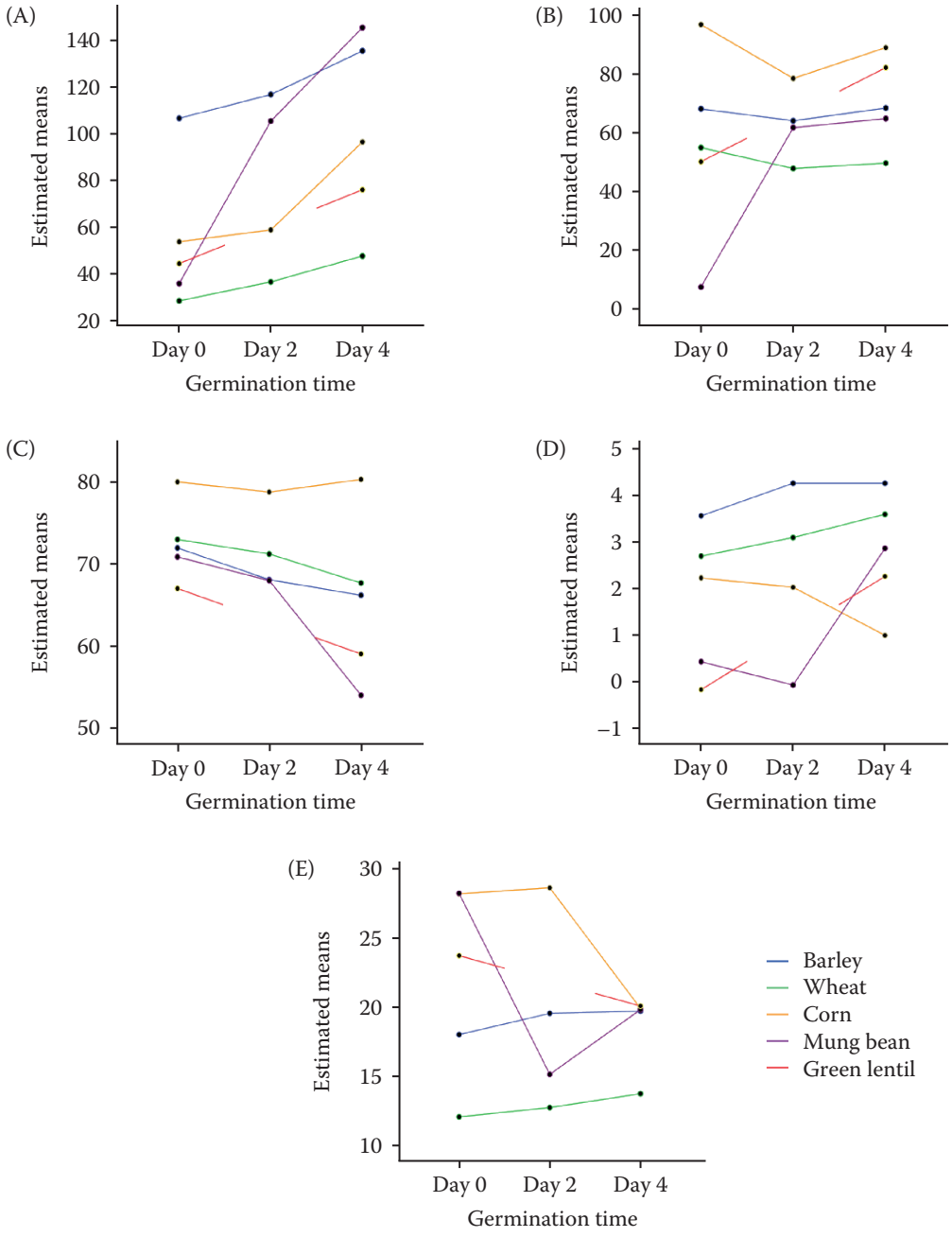

Figure 3. The interaction plots for (A) total phenolic content; (B) antioxidant activity; (C) L^* value; (D) a^* value; (E) b^* value

L^* – whiteness to darkness; a^* – redness/greenness; b^* – yellowness/blueness

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CONCLUSION

Results showed that the germination process significantly decreased the contents of carbohydrates and lipids in cereals and legumes. The germination significantly improved the total phenolic contents of all samples and the antioxidant properties of mung bean and green lentils. The most promising seed was found to be mung bean thanks to its increased level of ash, protein and total phenolic contents, antioxidant activity and decreased level of carbohydrate content during germination. The use of germinated products as alternative foods in calorie-restricted diet lists is increasing because of their low amount of carbohydrates and lipids. Considering the health benefits of antioxidants and phenolic compounds in preventing or delaying the prognosis of some chronic and degenerative diseases, germinated cereal and legume seeds could be offered to consumers in chain markets. Germinated seed supplementation into some food products will provide a great potential in developing functional products. Using low-cost and high-efficiency germinated cereal and legume seeds as food ingredients in baby foods, low-calorie beverages, and bread flour will significantly contribute to the economy.

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