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Use of dehydrated carrot (*Daucus carota*) pomace and almond (*Prunus dulcis*) powder for partial replacement of wheat flour in cake: effect on product quality and acceptability

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Introduction: Carrot (*Daucus carota*) is a nutrient-dense root vegetable, and carrot pomace is a by-product of the juice extraction procedure, which is recognized a source of phytochemicals and functional components. Almonds (*Prunus dulcis*) are packed with a decent amount of nutrients and bioactives.

Methods: This study investigates the utilization of carrot pomace powder (CPP) and almond powder (AP) as partial substitutes for straight grade white flour (SGWF) in cakes to enhance their nutritional value and sensory appeal, while reducing waste from carrot processing. The aim is to assess the effects of incorporating CPP (at 5%, 10%, and 15%) and AP (at 5%) on the chemical composition and properties of cakes.

Results and discussion: Comparative analysis reveals that AP is rich in fat (13.8±0.6%) and protein (31±0.6%), while CPP excels in ash (5.0±0.5%) and fiber (43.3±3.3%) content. Furthermore, SGWF exhibits the highest moisture content. Water holding capacities for CPP and AP are 5.2±0.2% and 5.0±0.1%, respectively, and oil holding capacities are 1.3±0.1% and 1.8±0.2%, respectively. Additionally, CPP contains higher levels of sodium, potassium, and calcium, while AP contains higher levels of magnesium, iron, and zinc compared to SGWF. The addition of CPP and AP increases the ash, fat, fiber, and protein contents of the cakes. Notably, cakes containing 80% SGWF, 15% CPP, and 5% AP show significantly higher total phenolic content (TPC) (125.5±3.8 mg GAE/100 g), total flavonoid content (TFC) (58.4±1.4 mg QE/100 g), and DPPH activity (17.6±2.7%) compared to control cakes. Furthermore, a significant increment in mineral content is observed in cakes with high levels of CPP and AP. Sensory evaluations reveal high acceptance of cakes containing 15% CPP and 5% AP. In conclusion, this study suggests that the incorporation of CPP and AP into cakes can improve their nutritional profile, antioxidant activity, and sensory characteristics, offering a sustainable approach to bakery product development.

KEYWORDS

cake, carrot pomace powder, almond powder, sensory evaluation, mineral analysis, waste utilization

Highlights

- Carrot pomace powder (CPP) and almond powder (AP) possess high nutritional and bioactive contents
- Increment in ash, fiber and mineral contents of CPP and AP incorporated cakes was observed
- Significantly high TPC, TFC and antioxidant capacity CPP and AP incorporated cakes was found
- CPP and AP also significantly affected the functional properties of developed cakes
- CPP at 15% while AP at 5% level provided highly acceptable cakes with good sensory scores

1 Introduction

Fast-growing food processing companies produce a significant number of by-products in huge amounts, such as pomaces, which are less useful and significantly pollute the environment. These by-products may be employed straight or indirect form in the creation of novel food items. Valorisation of plant derived by-products in the development of food products is a sustainable strategy for reducing the ecological impact of the accumulation of plant-based by-products and enhancing commercial value for the food business (Badjona et al., 2019). Plant sourced foods have been found associated with rich quantities of nutritional elements especially dietary fiber, minerals and phytochemicals. Huge quantity of pomace streamed out from beverages processing industries have been proved a cheap source of these necessary elements in abundance. This pomace when converted into powder represents a novel and functional ingredient for enrichment of bakery items promoting their nutritional profiles (Sahni and Shere, 2018; Hussain et al., 2024). Vegetables improve and diversify human diet, as each part of vegetables has been found loaded with phytochemicals, especially phenolics, flavonoids, carotenoids and minerals (Hussain et al., 2022a).

Consumption and processing of vegetables results in production of waste streams, which can be transformed into powders and extracts to utilize in food products for enhancement of their nutritional profiles (Hussain et al., 2022c, 2023c). Vegetables are edible parts of plants, that may include flowers, stems, leaves, seeds, roots, etc. Vegetables can be consumed raw or cooked and play a significant part in the nutritional supplies of an individual. Vegetables contain very less fats and carbohydrates but decent source of dietary fiber, vitamins, and minerals. A diet rich in vegetables reduces the risk of heart attacks and strokes, prevents some types of cancer, reduces digestive problems, and helps in managing blood sugar levels (Kumar and Kumar, 2011). Carrot (*Daucus carota*) is a nutritious vegetable and provides numerous health benefits. Carrot pomace is obtained as a by-product after carrot juice extraction and contains around 60–80% of carotene. So far carrot pomace is not utilized properly and adds to pollution. Carrot pomace contains dietary fiber and can be a good addition to different products without affecting taste (Kohajdová et al., 2012). Commercial production of carrot juice from fresh carrots results in production of 30–50% of waste carrot pomace, which has been recognized as rich source of nutritional components including fiber, phenolics, flavonoids, carotenoids and minerals (Bellur Nagarajaiah and Prakash, 2015). Rich in fibre, carbs, and minerals, carrot pomace has the potential to enhance not only the nutritional content of food products that contain it, but also its functional aspects during the processes of product development (Luca et al., 2022). Almonds are the edible seeds of *prunus dulcis*. A 1-ounce (28 g) serving of almonds contains 3.5 g fiber, 14 g fat, 6 g protein, vitamin E almost 37% of the RDA, manganese nearly 32% of the RDA, magnesium just about 20% of the RDA (Esfahlan et al., 2010). Almonds can be added to weight loss diet plans, as they have low amounts of sugars. As almonds have a high number of antioxidants they can contribute to protection against aging, stress, and cancer. Bitter almonds contain amygdalin, which is great for treating skin tumors. Almond powder can be a good addition to shakes, drinks, and bakery products (Chen et al., 2006). Almond varieties from two different countries have been analyzed for their phenolic composition and sufficient quantities of polyphenols were found in them (Kahlaoui et al., 2019). Proteins, unsaturated fatty acids, vitamins, minerals, and other minor components including phenolics and tocols make up the nutritional and phytochemical makeup of almonds, which makes them a prospective source for a range of food, pharma, cosmetic and animal goods (Kara et al., 2022). In several past studies, almond powder was successfully incorporated in the wheat flour, to develop nutritional cakes with increased polyphenols (Etienne et al., 2017a), value added good quality cakes (Ekumankama, 2021), gluten free cakes for medicinal purpose, by adding almond powder along with rice and arrowroot flour (Martinescu et al., 2020). Just like almond powder, utilization of carrot pomace powder can be seen in different studies, used to develop food formulations. Some examples include, black carrot pomace incorporated cakes (Kamiloglu et al., 2017), good quality breads through incorporation of 5% carrot pomace flour in wheat flour (Tańska et al., 2007), carrot pomace powder along with millet,

Abbreviations: AACC, American Association for Cereal Chemists; AOAC, Association of Official Analytical Chemists; SGWF, Straight grade wheat flour; CPP, Carrot pomace powder; AP, Almond powder; TPC, Total phenolic compounds; TFC, Total flavonoid content; GAE, Gallic acid equivalent; QE, Quercetin equivalent; DPPH, 2,2-diphenyl-1-picryl-hydrazyl-hydrate.

rice bran and soy cake powders, to develop nutritional breakfast cereals (Akinyede et al., 2020), carrot pomace along with different hydrocolloids to develop good quality cake (Majzoobi et al., 2017), carrot pomace powder based cookies and cakes (Gölge et al., 2022), and functional yogurt added with carrot pomace powder (El-Dardiry, 2022). Currently, customers around the world are looking for food products that provide health aids beyond the nutritional worth, therefore demand for functional foods is increasing. There is absolutely no exception to this in the snack category. Customers are willing to purchase food with additional health benefits (Naseer et al., 2021). Functional foods developed through incorporation of fruits powders have been found to promote human health through provision of biologically active components (El-Dardiry, 2022; Can-Cauich et al., 2017). One of the most widely consumed baked goods is cake, which has a sweet flavor. It has ingredients including flour, sugar, oil, eggs, and powdered baking soda. You can add nuts, fruits, or dry fruits to increase the flavor and add nutrients. Cakes may also gain value via the addition of fruit and vegetable pomace, as these can be a useful addition to cakes to increase their nutritious content and decrease the amount of waste generated by processing industries (Mohtarami, 2019). Carrot pomace is a viable ingredient that may be employed in the composite formulation with the wheat flour for the manufacturing of cakes (Badjona et al., 2019). Carrot pomace has the potential to be used to produce food with additional value that is both inexpensive and highly beneficial to consumer health. Carrot pomace powders could be used in wheat bread, gluten-free bread made with pseudo-cereals, fitness bars, cakes, biscuits, pasta, and more. Depending on how much is used, carrot pomace could contribute a significant amount of nutrients, particularly fibre, to the finished product (Luca et al., 2022). Keeping in view the potential of CPP and AP, in raising the phytochemicals of the formulated foods, this novel research design was created to blend the powders from carrot pomace and almond in combination, for development of a unique recipe. Before cakes development, a comparison among chemical profiles of CPP, AP and SGWF was done, in order to create and define the differences of phytochemicals located in these three flours. Therefore, this research work was planned to evaluate the nutritional potential CPP, AP and SGWF, and the cakes prepared by different combinations of these flours. Furthermore, influence of incorporation on the functional properties and sensory quality of cakes were also evaluated.

2 Materials and methods

2.1 Procurement of raw materials and chemicals

Straight grade wheat flour (SGWF) of wheat (*Triticum aestivum* L.) variety ‘Nayab 2018’, fresh carrots (*Daucus carota*), red color variety ‘Pusa kesar’ and almonds (*Prunus dulcis*) variety ‘American soft shell’ were obtained from the native market and other ingredients for the development of cakes were acquired from Imtiaz supermarket located in the district Sargodha, Pakistan. All of the chemicals and reagents were bought from Aladdin Chemicals (Shanghai, China), Merck (Darmstadt, Germany), and Fluka Chemical Co. (Buch’s, Switzerland).

2.2 Preparation of carrot pomace and almond powders

After washing and peeling, juice was extracted from the carrots (40 kg initial weight) by using stainless steel helical presser (PK-500, Mughal Pvt. Ltd. Pakistan), and carrot pomace obtained, which was calculated 11 kg after extraction of juice form 40 kg carrots, was dried through hot air in a laboratory oven (TS-2266, Biobase, China) at 60°C. Similarly, 5 kg almonds, properly dried were directly grinded and powder obtained was found 4.550 kg. Powder of each of these fractions was obtained by following the guidelines used by Hussain et al. (2023a), after conventional drying, and then grinding of dried materials with common spice grinder (PS-110, Panasonic, Japan) until fine powder with 0.5 mm size was prepared. Both dried carrot pomace and almonds were powdered having a particle size of 300 mm and packed in an airtight bag. Figure 1 presents the flow diagram of the study, showing important steps.

2.3 Treatments plan for development of cakes

Blend cakes were prepared with the composition elaborated in Table 1, which also provides the different levels of CPP, AP and SGWF used to develop different treatments of cakes for further analysis. Briefly stating, treatments were names as, T0 (100% SGWF), T1 (90% SGWF, 5% AP, 5% CPP), T2 (85% SGWF, 5% AP, 10% CPP) and T3 (80% SGWF, 5% AP, 15% CPP).

2.4 Preparation of cakes

For cakes preparation, guidelines were taken from the method adopted by Mohtarami (2019), with slight modifications. Explaining in detail, all the ingredients including, carrot pomace powder, straight grade wheat flour, almond powder, oil, sugar, salt, baking powder, eggs were weighed. Dry ingredients were first placed in a stainless-steel bowl and wet ingredients in another bowl, then they were gently combined, and hand mixer was used for mixing and better development. Butter paper was positioned in cake mold and this batter was added and allowed to settle. Baking was done in oven at 250°C for about 35 min. A toothpick was inserted to check if cake is completely cooked from center as well. The cake was taken out and placed in desiccator for moisture stabilization. The cooled sample was packed in a polythene bag until further evaluation.

2.5 Proximate analysis of flours used and developed cakes

Moisture, fat, ash, protein, fat, and fibre contents of SGWF, AP, CPP and developed cakes were measured by their respective standard procedures given in AACC (2000), with required modifications. Nitrogen free extract (NFE) was assessed by deducting the sum of above-mentioned components form 100, as given below;

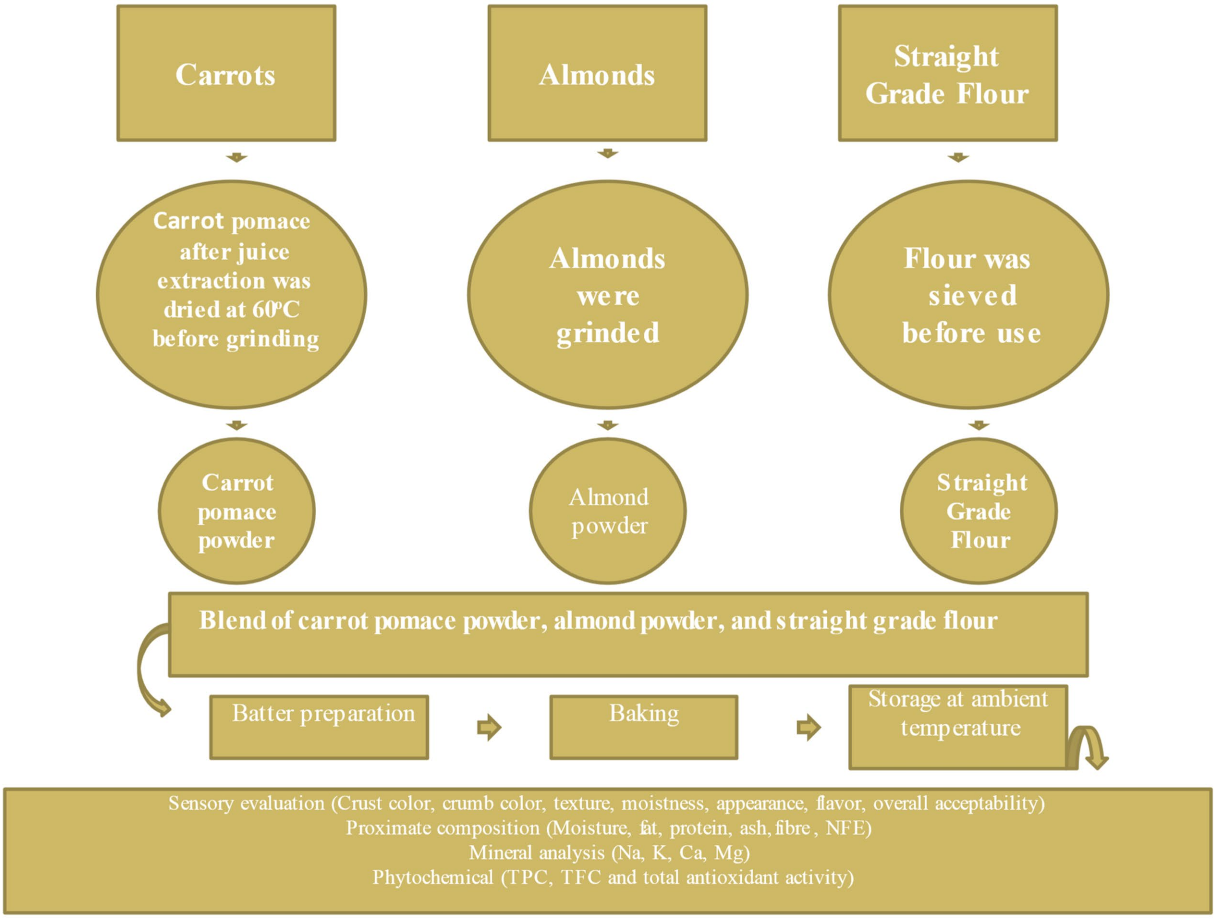

FIGURE 1
Flow diagram of study showing important steps.

TABLE 1 Treatment plan and recipe for development of cakes.

Treatments	SGWF (%)	CPP (%)	AP (%)	Sugar (g)	Fat (g)	Eggs (g)	Baking powder (g)	Salt (g)
T_0	100	0	0	18	18	18	2	2
T_1	90	5	5	18	18	18	2	2
T_2	85	10	5	18	18	18	2	2
T_3	80	15	5	18	18	18	2	2

SGWF; straight grade white flour, CPP; carrot pomace powder, AP; almond powder.

$$NFE\,(\%) = 100 - (moisture\% + ash\% + crude\ protein\% + crude\ fibre\% + Crude\ fat\%)$$

taken. For analysis, a sample weighing about 4–5 g was used (Figure 1).

2.6 Functional properties of CPP and AP

The process outlined by Lawal (2004) was used to calculate the water and oil holding capacities of CPP and AP. The number of grammes of water that 1 g of sample could contain was used to express the water holding capacity. The number of grammes of oil that 1 g of sample could contain was used to express the oil holding capacity. At 25°C, the water activity was measured directly using a water activity meter. There were three duplicate measurements

2.7 Preparation of extracts of flours used, and developed cakes

Asif et al. (2017) provided instructions on how to create developed cakes and extracts of three different powder types: CPP, AP, and SGWF. These instructions called for taking 20 g of powder from each sample and using 80% methanol as the solvent for each kind of extract. Each sample powder weighed 20 g. A 200 mL solvent was added, and the mixture was continuously stirred for 120 h at 25°C at 200 rpm in an orbital shaker made by Biosan ES-20 Japan. Whatman filter paper was used to assist separate this combination. The filter was concentrated using a rotary evaporator (BIOLAND RE-5000A China). Each fraction's 5 mL crude extract was kept in amber color vials at 4°C, for later examination.

2.8 Determination of total phenolic content (TPC)

Total phenolic content (TPC) of AP, CPP, SGWF, and formulated cakes were calculated using methanolic extracts using the method described by Li et al. (2015), with some modifications. Folin-Ciocalteau phenol reagent was combined with an aliquot of diluted extracts (0.25 mL) at a 10-fold dilution (1.25 mL), and the mixture was left to react for 6 min. After adding sodium carbonate solution (75 g/L, 1 mL), the mixture was shaken. At 765 nm, absorbance was measured after a 2 h. reaction period at room temperature and in the dark. The results were given as mg (GAE)/100 g powder.

2.9 Determination of total flavonoid content (TFC)

Total flavonoid content (TFC) of AP, CPP, SGWF, and formulated cakes extracts were calculated using the method described by Pasha et al. (2022c) with required changes. A 2.5 mL aliquot of the extracts was combined with 150 mL of a 5% $NaNO_2$ solution, and the mixture was left to react for 6 min. After adding 150 µL of 10% $AlCl_3$, the mixture was allowed to react for 5 min. Following this, 1.2 mL of distilled water and 1 mL of a 1 mol/L NaOH solution were added, and absorbance at 510 nm was measured. The outcomes were given as mg of quercetin equivalents per 100 grams of sample (mg QE/100 g).

2.10 Determination antioxidant activity by DPPH assay

The method described by Can-Cauich et al. (2017) was slightly modified in order to test the extracts' capacity to scavenge DPPH. An aliquot of the diluted sample (0.2 mL) was mixed with 2.8 mL of DPPH solution [mixture of 1.86×10^{-4} mol L^{-1} DPPH in ethanol and 0.1 M acetate buffer (pH = 4.3) in volume ratio 2:1(v/v)]. After 40 min of reaction at room temperature in the dark, the solution's absorbance at 525 nm was measured to estimate its free radical scavenging capacity.

2.11 Mineral analysis

Minerals present in SGWF, CPP, AP and developed cakes were analyzed through atomic absorption spectrophotometer after digestion of samples with the mixture of two acids using an air acetylene flame, by taking guides from the method described by Pasha et al. (2022a). In summary, 1 g of each powder sample was digested at 180–200°C using a 10 mL mixture of perchloric acid and nitric acid until it became translucent. Then, using double-distilled water, the digested matter was diluted to a volume of 100 mL. These diluted samples were passed through an atomic absorption spectrophotometer with an air acetylene flame to determine the concentration of the minerals. Three trials were carried out, and the mean results were computed.

2.12 Sensory evaluation of cakes

In a laboratory, hedonic rating scale was employed to judge the sensory quality of control and formulation cakes, during the first week of cake manufacturing, by following the protocols used by Zlatanović et al. (2019a). Using a score system (1–9), the representative sensory qualities of crust and crumb color, appearance, flavor, moistness, texture, and overall acceptability were evaluated in order to estimate the overall sensory quality. In brief, a set of sheets with ratings ranging from 1 to 9 where 1 represented severe dislike and 9 represented extreme like were given to a panel of 60 specialists, both male and female, and whose average age was 45. The panel members were given distilled water bottles along with sample cakes that had unique codes so they could rinse and neutralize their mouths after each test. The acquired data was gathered, computed, and examined. Annex 1, the proforma used for the sensory analysis, is provided at the end.

2.13 Statistical analysis of the results

Every measurement's data is shown as the means of three trials ± standard deviation. ANOVA was used to establish the significance of the treatments, and the HSD Tukey test ($p \leq 0.05$) was used to rank the means. Statistical analysis was carried out on Statistix 8.1 (Analytical Software for Windows, Tallahassee, USA).

3 Results and discussion

3.1 Proximate composition of SGWF, AP, CPP and cakes

Results regarding the chemical composition of straight grade wheat flour (SGWF), carrot pomace powder (CPP), almond powder (AP), and cakes prepared by partial replacement of SGWF with CPP and AP has been revealed in Figure 2. Addition of CPP and AP in the cakes significantly ($p \leq 0.05$) increased the moisture, protein, fat, ash and fiber content. From the results analysis, significantly high ($p \leq 0.05$) protein and fat contents were observed in AP, whereas highest fiber contents were found in CPP, on the other hand, the ash contents were equally found high in both AP and CPP. Moisture was found highest in SGWF, as compared to the AP and CPP. As SGWF was good source of calories and NFE, replacement of SGWF with CPP, keeping constant level of AP, has resulted significant decrease in NFE and calories of the formulated cakes. High calories of SGWF were possibly due to high NFE contents, whereas highest calories of almond powder possibly were due to presence of high protein and fat contents, which have also resulted in high calories of formulated cakes as compared to control cake. Protein content of CPP were significantly lower than SGWF, however, AP was found to be comparatively high in protein content, which resulted in increment of protein contents of the cakes in which SGWF was replaced with CPP and AP. These results showed the similar trend as was previously reported during the

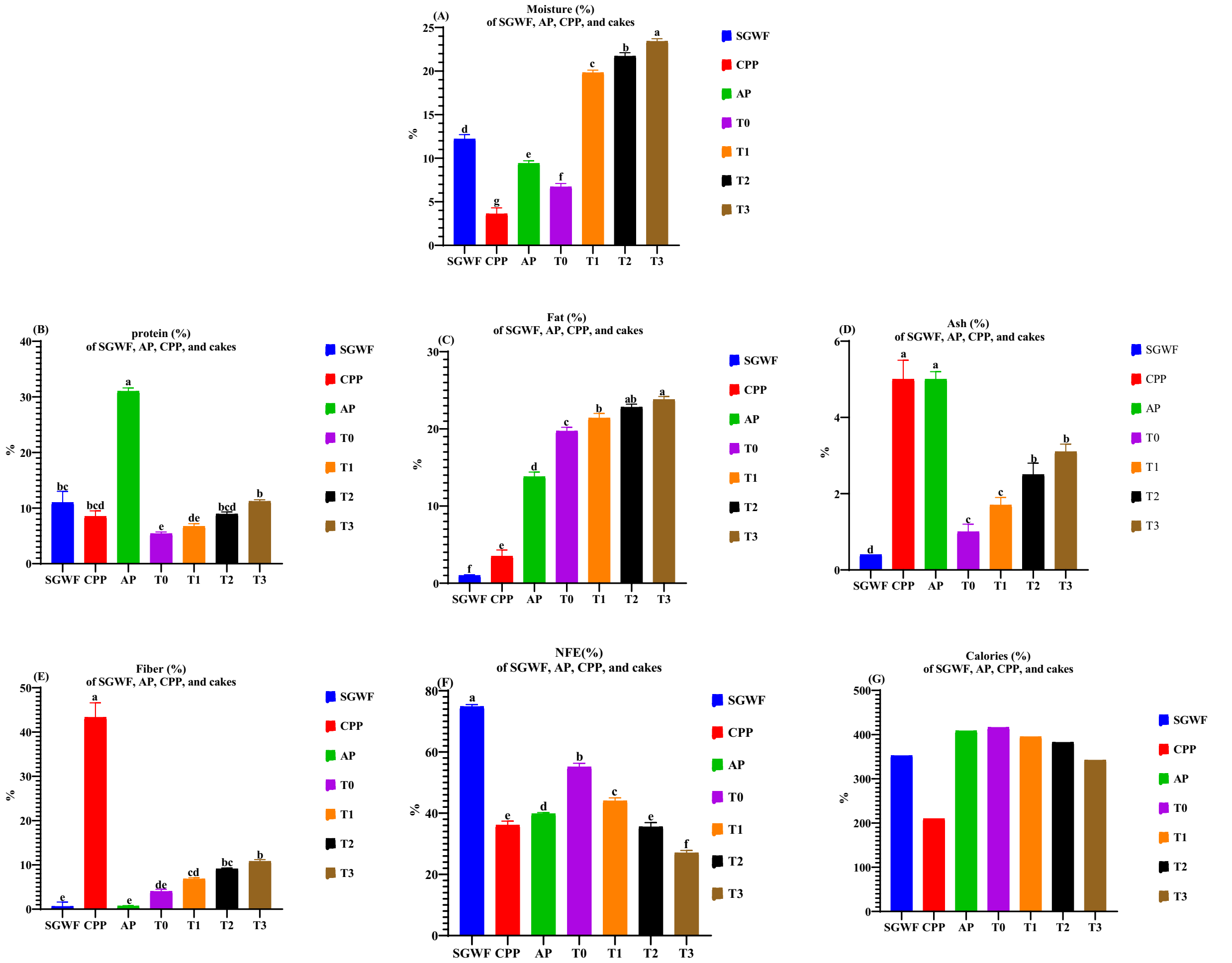

FIGURE 2
Chemical composition (%) of SGWF, AP, CPP and cakes. Based on the HSD-Tukey test, values represent the mean of triplicate ± SD with different characters on the bars indicating the significance ($p \leq 0.05$) difference among the variables, SGWF; straight grade white flour, CPP; carrot pomace powder, AP; almond powder, NFE; nitrogen free extract. T_0: 0% CPP + 0% AP + 100 SGWF, T_1: 5% CPP + 5% AP + 90% SGWF, T_2: 10% CPP + 5% AP + 85% SGWF, T_3: 15% CPP + 5% AP + 80% SGWF.

addition of carrot pomace and grape fruit juice in the cake (Mohtarami, 2019), during addition of carrot, apple and orange pomace powders in the cakes (Kırbaş et al., 2019), also during the addition of carrot pomace in sponge cakes, at 0, 5, 10, 20 and 30% replacement level, which caused increment in the moisture, ash and fiber contents, whereas, protein and carbohydrates contents showed reverse trend (Salehi et al., 2016). Addition of carrot pomace and chickpea flour in biscuits by Baljeet et al. (2014) showed significant increase in ash, fiber, moisture, and protein contents of biscuits, mentioning that increase in protein contents might be due the addition of chickpea flour. Before addition of carrot pomace powder in cereal-based snacks, Luca et al. (2022) determined proximate composition of carrot pomace powder of four different carrot varieties and values of moisture, ash, protein, fat and carbohydrates were found in range of 3.78–5.91, 5.29–5.89, 6.87–9.14, 0.70–1.13 and 48–58.95%, respectively, whereas energy value was calculated between 332 and 343.32 kcal/100 g pomace powder. High contents of ash and fiber in CPP were also witnessed by our findings.

Majzoobi et al. (2017) provided values of moisture, fiber, protein, ash, and fat of CPP as 4.10, 11.54, 6.54, 5.99, and 1.05%, respectively, and these were very comparable with the present study findings, as CPP was found to be good source of ash and fiber. Similar results were also observed when Gölge et al. (2022) provided the values of moisture, ash, fat, fiber and protein contents of carrot pomace powder, before utilization in functional cookies and cakes. Badjona et al. (2019) also determined moisture, ash, and fiber contents as 9.33, 4.03 and 12.84%, respectively in CPP and found significant increase in nutrient composition of carrot-pineapple pomace incorporated rock buns. Bellur Nagarajaiah and Prakash (2015) provided values of moisture, protein, ash, and crude fiber contents as 6.54, 6.50, 5.12 and 30 g/100 g of CPP, respectively and found increasing trend of moisture, ash, fiber and carotenoids in cookies as the replacement level of CPP was increased from 0 to 12%. The current results were consistent with earlier research on bread enriched with carrot pomace by Tańska et al. (2007), which reported values of CPP's ash, fat, fibre, and carbohydrate contents that were greater than the SGWF. Our findings were somewhat dissimilar from the work of Trilokia et al. (2022), as they reported lesser amount (9.21%) in dried carrot pomace powder. These differences in the proximate composition might be due to the different variety of carrots used for experimental study, along with ripening stage, processing and pre-treatments adopted. The results of Zlatanović et al. (2019a), regarding the use of apple pomace powder in cookies, corroborated our findings as well. Carrot pomace along with millet, soy and rice bran was added in breakfast cereals by Akinyede et al. (2020) and higher values of moisture, ash, fiber, fat and protein contents were recorded in developed products. Another similar food application of AP was found when, Calutoiu and Misca (2018) used almond flour stuffed with plum jam to develop nutritional pastries. In order to create healthful cakes, Etienne et al. (2017b) substituted AP at varying degrees with wheat flour. They saw a considerable rise in the concentrations of ash, fat, fibre, and protein, but not in moisture or carbs. On the other hand, a significant increase in energy value of cake was noticed, which might be due to the high energy value of AP as compared to the CPP. In another study, formulation of rice flour, almond flour and arrowroot flour to develop gluten free cakes by Martinescu et al. (2020) was found successful experiment in increasing fiber, ash and moisture contents of cakes, which were specially designed for diabetic and patients and with celiac disease. Naseer et al. (2021) developed nutritional snack product using 20% almond press cake flour and 80% pearl millet flour and observed significant increase in ash and fiber contents. Utilization of almond and carrot flour with wheat flour for development of bakery products has also been witnessed from the studies of Guyih et al. (2020), when they used different combinations of these three flours and observed significant increase in moisture, ash, fiber, fat, protein and energy value of cookies, whereas there was slight decrease in carbohydrate contents of the cookies, which was due to the reason that wheat was good source of carbohydrates and replacing wheat flour with almond and carrots flours have increased protein and fat contents and decreased carbohydrates contents. Kausar et al. (2018) also compared proximate composition of plain wheat flour and carrot pomace powder before formulation development and reported high ash, fiber and fat contents in carrot pomace powder and incorporated biscuits. Higher levels of protein, ash and especially crude fiber contents, along with less calories, could prove very useful for development of a novel and demanding food formulation, which could meet the requirements of health-conscious consumers.

3.2 Functional properties of CPP and AP

Table 2 displays the water activity, and water and oil holding capacity of CPP and AP. While AP's oil holding capacity was significantly higher ($p \leq 0.05$) than CPP's, CPP's water holding capacity and water activity were significantly higher ($p \leq 0.05$) than AP's. Oil holding capacity refers to a powder's propensity to retain oil, which eventually affects the final product's sensory qualities. Water holding capacity, on the other hand, refers to a material's ability to bind and hold water with the matrix; it is dependent upon the amount and chemical makeup of dietary fibre. The tendency of a powder to dissolve in water determines how well it can be rehydrated. Solubility affects the functional qualities of powders in food systems (Aremo and Olaofe, 2007; Singh et al., 2000). Oil holding capacity is determined by factors such as lignin content, lignin structure, surface properties, total charge density, the thickness, hydrophobicity, and size of particles, while water holding capacity is a measure of the amount of dietary fibre available. As drying temperature increases, the oil holding capacity value decreases (Gorjanović et al., 2020). High water-holding capacity flour improves the viscosity and thickening of meat, custard, and soups; it also improves the handling and freshness of baked goods. The main factors affecting water retention capacity are the make-up of the powdered carrot and almonds as well as any possible pre-treatments such washing and drying. These powders have a good water-holding capacity because low drying temperatures do not break down cell wall polysaccharides (Zlatanović et al., 2019a). The produced flours exhibit great thermal stability and a prolonged shelf life due to the reduced water activity of the dried pomace from fruits (Zlatanović et al., 2019b). One key element in determining food safety is the water activity of a food sample. Reduced water activity prevents enzymatic reactions and oxidation (Trilokia et al., 2022). When Al-Janabi and Yasen (2022) measured the orange peel powder's water and oil binding capacities before incorporating it into wheat flour to create nutritious biscuits, they discovered results that were not all that unlike from the ones that are observed today. The physical and chemical makeup of the fibres as well as their processing determine how much water flour can contain. The higher the amount of soluble dietary fibre present in the flour, the higher its capacity to retain water. Fruit fibres therefore have a high water-holding capacity because of their high soluble dietary fibre concentration. Just in accordance with our findings Hussain et al. (2023a), reported high water holding capacity (5.8) and oil holding capacity (3.2) for lemon pomace powder, which was utilized to develop functional biscuits, aiming to improve technological properties. Rheological characteristics of food manufacturing process and physical properties of the developed foods are greatly influenced by the addition of powders from fruits and vegetables in the wheat flour (Hussain et al., 2023b).

TABLE 2 Functional properties of CPP and AP.

Flours used	Water holding capacity (WHC %)	Oil holding capacity (OHC %)	Water activity (a_w)
CPP	5.2 ± 0.2^a	1.3 ± 0.1^b	0.5 ± 0.02^a
AP	5.0 ± 0.1^a	1.8 ± 0.2^a	0.4 ± 0.01^b

^{a,b} are small superscript letters indicating significant differences among values. Based on the HSD-Tukey test, values represent the mean of triplicate ± SD with different characters in the same column indicating the significance ($p \leq 0.05$) difference among the variables, CPP; carrot pomace powder, AP; almond powder.

3.3 Total phenolic content (TPC), total flavonoids content (TFC) and antioxidant activity (DPPH assay) of SGWF, AP, CPP and developed cakes

Plants contain many chemical substances that can act as antioxidants and protect a body from damage in case of danger. TPC and TFC and DPPH radical scavenging activity of SGWF, CPP, AP and different treatments of cakes were analyzed and results obtained have been shown in Figure 3. Both CPP and AP contained ample amount of TPC and TFC, which were significantly higher ($p \leq 0.05$) than those of SGWF. Amount of TPC, TFC and DPPH radical scavenging activity of CPP was significantly high ($p \leq 0.05$) than of AP. Replacement of SGWF with CPP, keeping 5% constant level of AP, was proved helpful in significantly increasing ($p \leq 0.05$) the TPC, TFC and antioxidant capacity of the formulated cakes, as among all treatments T3 presented the highest amounts of TPC, TFC and DPPH

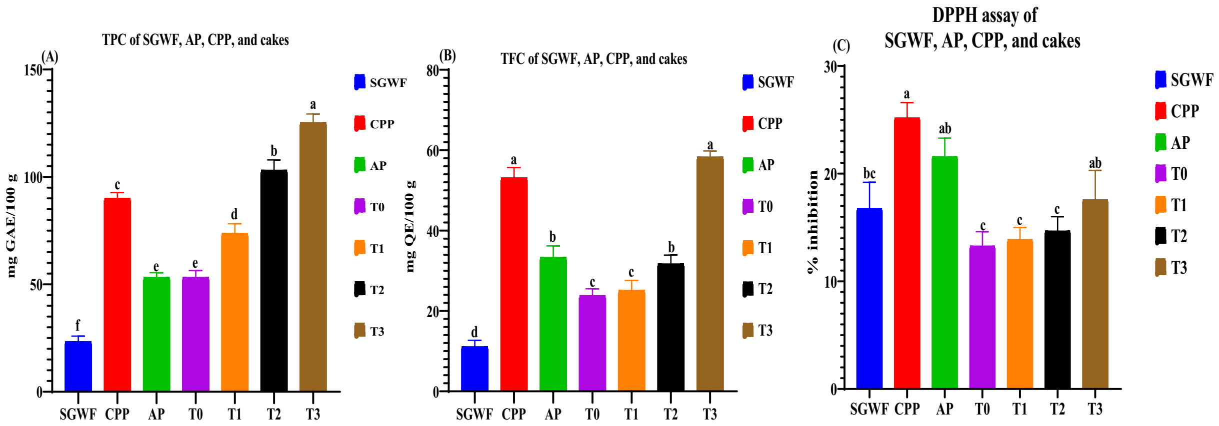

FIGURE 3
TPC, TFC and antioxidant activity (DPPH assay) of SGWF, AP, CPP and developed cakes. Based on the HSD-Tukey test, values represent the mean of triplicate ± SD with different characters on the bars indicating the significance ($p \leq 0.05$) difference among the variables, SGWF; straight grade white flour, CPP; carrot pomace powder, AP; almond powder, TPC; total phenolic contents, TFC; total flavonoid contents. T_0: 0% CPP + 0% AP + 100 SGWF, T_1: 5% CPP + 5% AP + 90% SGWF, T_2: 10% CPP + 5% AP + 85% SGWF, T_3: 15% CPP + 5% AP + 80% SGWF.

radical scavenging activity. Increased phenolic content in CPP and AP can contribute significantly to the number of antioxidants that help lower blood sugar and cholesterol, prevent cancer, and shield the heart. Flavonoids may prevent cellular deterioration and aid in DNA repair (Pasha et al., 2022b). Yet, including nuts in the diet from trusted sources has several health advantages. They also include a variety of vitamins, minerals, and bioactive substances (antioxidants, carotenoids, phytosterols, and phenols), dietary fibre, which has a positive impact on the intestines and their peristalsis (Markiewicz-Żukowska et al., 2022). When creating nutritious cakes, Kamiloglu et al. (2017) utilized pomace of black carrots as an important source of polyphenols and saw an increase in the quantity of polyphenols in the final product. Additionally, they used a standardized static model to conduct an *in vitro* study on cake digestion, and during the simulated stomach and intestinal digestion, they found a considerable rise in TPC and antioxidant activity. El-Dardiry (2022) observed that the addition of carrot pomace powder increased the phenolic and flavonoid content of the functional yoghurt. Similarly, during addition of almond powder in cakes prepared by Etienne et al. (2017a), a significant increase in phenolics and flavonoids was observed, witnessing the increase in phytochemical concentration of developed bakery items as a result of incorporation of almond powder. Our findings were also supported from those of Zlatanović et al. (2019a), as the inclusion of apple pomace powder was found to boost the TPC and TFC of the cookies. Addition of banana peel powder to wheat flour for development of salted noodles was also proved helpful in increasing the TPC, TFC and antioxidant activity of developed product. Comparing current findings with previous similar ones, it could be noticed that whenever flours from different plant sources or products were incorporated in wheat flour, rise in the phytochemicals of developed product was witnessed. Gölge et al. (2022) provided higher values of TPC as 2.30 mg/g of carrot pomace powder, which might be due to the difference in carrot variety selected, extraction solvent and techniques adopted in that study. Olawuyi and Lee (2019) incorporated carrot pomace and mushroom powder in muffins and recorded higher antioxidant activity of enriched muffins as compared to control sample prepared without addition of carrot pomace and mushroom powder, which was contributed by higher phenolic compounds present in carrot pomace, just as found in current study. Naseer et al. (2021) made a formulation using 20% almond press cake flour and 80% pearl millet flour and developed functional snacks, in which they found TPC and TFC as 56.91 and 18.29 mg/100 g, respectively, whereas DPPH free radical scavenging activity of developed nutritional cakes was calculated as 89.74%. These higher values would have been found due to presence of pearl millet flour added along with almond flour. In another study Nakov et al. (2020) incorporated grapes pomace powder at different levels to develop cakes and witnesses similar results as TPC, TFC and antioxidant capacity of developed cakes was high as compared to control. Enriched cakes were abundant in free gallic acid, catechin and quercetin. Hussain et al. (2022b) also found similar results, indicating that adding pumpkin peel, flesh, and seed flour significantly increased the biscuits' TPC, TFC, carotenoids, and DPPH activity in eliminating free radicals. The development, marketing, and marketing of this novel recipe, in which both APP and AP provided their polyphenols, giving the resulting cakes' total polyphenol content a notable boost, can satisfy consumer demand for food goods with the potential to promote health.

3.4 Mineral contents of SGWF, AP, CPP and developed cakes

Mineral analysis for SGWF, CPP, AP and different treatment of cakes, were performed and results are shown in Figure 4. Values of the essential minerals in CPP and AP were found higher than those found in SGWF. Whereas, addition of CPP and AP in SGWF, significantly increased ($p \leq 0.05$) these mineral contents in the formulated cakes, with the increasing level of replacement. Summarizing the results of Figure 4, contents of Na, K and Ca were highest in CPP, while, Mg, Fe and Zn were found highest in AP, whereas SGWF exhibited the lowest values of these important minerals. Minerals are necessary for human nutrition because they support the bones and control a number of metabolic functions in

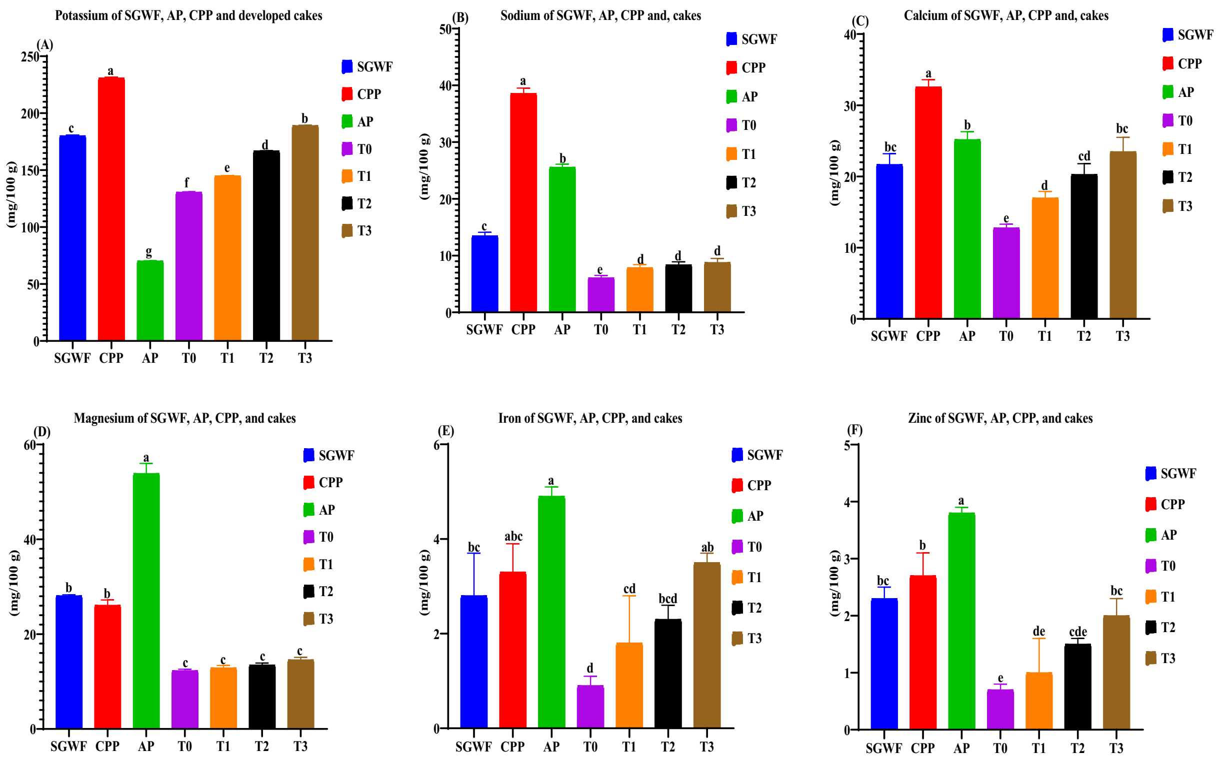

FIGURE 4
Mineral analysis of SGWF, AP, CPP and developed cakes (mg/100 g). Based on the HSD-Tukey test, values represent the mean of triplicate ± SD with different characters on the bars indicating the significance ($p \leq 0.05$) difference among the variables, SGWF; straight grade white flour, CPP; carrot pomace powder, AP; almond powder. T_0: 0% CPP + 0% AP + 100 SGWF, T_1: 5% CPP + 5% AP + 90% SGWF, T_2: 10% CPP + 5% AP + 85% SGWF, T_3: 15% CPP + 5% AP + 80% SGWF.

the body. Increased consumption of breads and pastries made from cereals has resulted in human deficits in essential minerals, which can only be addressed by combining non-wheat flours from fruits and vegetables with wheat flour to create nutrient-dense food products (Gupta and Gupta, 2014; Da Silva, 2014). The increase in calcium, iron, zinc, and other minerals can be attributed to the high mineral content of almonds and carrots. While iron and zinc are necessary for immunity and metabolism, calcium is necessary for the proper growth and development of infants and early children. Another mineral that carrots are rich in is magnesium. The human body needs magnesium for many different metabolic activities, including the production of bone, protein, and new cells as well as the activation of B vitamins, blood coagulation, muscle and nerve relaxation, and many more (Carlos et al., 2024). Nuts, especially almonds were tested for Ca, K, Mg, Se and Zn, and sufficient amounts of these essential minerals were found present in them (Markiewicz-Żukowska et al., 2022). Incorporation of almond and carrot flour in wheat flour for development of bakery products was witnessed from the studies of Guyih et al. (2020), where they formulated different formulations of cookies and analyzed their mineral contents. Contents of Ca, K, Na, Mg and Zn in 100% wheat flour cookies were found 185.77, 877.62, 47.03, 58.96 and 7.12 mg/100 g, respectively, which were altered to 230.16, 984.26, 56.12, 77.16 and 5.75 mg/100 g, respectively in cookies in which 70% wheat flour, 20% almond flour and 10% carrot flour was used. High values of minerals in T3 (cakes with 5% AP, 15% CPP and 80% SGWF), developed in current study, were attributed of CPP and AP, replacing SGWF in current study. These results were consistent with earlier research on bread that had carrot pomace added by Tańska et al. (2007), where they provided values of K, Na, Ca and Mg as 18.6, 3.3, 3.0 and 1.1 mg/g dried carrot pomace powder and reported that addition of carrot pomace powder can rise the mineral contents of developed bakery items. Carrot pomace along with millet, soy and rice bran was added in breakfast cereals by Akinyede et al. (2020) and significant increase in some important minerals was noticed, just in accordance with the current results. Baljeet et al. (2014) noted a noteworthy rise in the nutritious components of biscuits they made by including CPP and chickpea powder in varying ratios. This resulted in the development of another comparable pattern formulation. Hussain et al. (2023a) and Hussain et al. (2023b) discovered a noteworthy rise in mineral contents, particularly in biscuits containing fruit powder (zinc and iron) and biscuits containing orange seed powder (calcium), respectively. As in present product development minerals from two different plants powders were enriched in cakes, resulting the significant rise in trace and macro minerals. Previous studies also found that adding nuts, legumes, seeds, and cereals mildly improved micronutrient intake. Due to the disrupted distribution of nutrients, this nutrient density can help treat the many nutritional deficiencies that CD patients experience. It can also prevent the progression of certain NCDs and decrease the use of refined components. In a similar study gluten free cupcake were enriched with almond, flaxseed and chickpea flours and upon mineral analysis, the results depicted significant amounts of some important minerals (sodium, potassium, calcium, zinc, iron and magnesium) in formulated cakes (Jabeen et al., 2022). Results validating the current outcomes of mineral analysis were also present in almond powder added cakes developed by Etienne et al. (2017a). Eating biscuits made from a flour mixture of wheat, almonds, and carrots can therefore enhance the body's bioavailability of calcium, potassium, magnesium, and salt. These crucial minerals are needed by school-age children and infants who are still in the early stages of growth (Barber et al., 2017). From the comparison of existing literature, with current findings, it can be observed that combination of AP (5%), CPP (15%) and SGWF (80%), was proved a very successful trial for development of novel and nutritional cakes, with elevated minerals amounts coming from CPP and AP.

3.5 Sensory analysis of developed cakes

Cakes prepared by replacing SGWF, with CPP and AP were evaluated for sensory characteristics like crust color, crumb color, moistness, appearance, flavor and overall acceptability, and the results have been presented in Figure 5. Highest sensory scores for crust and crumb color, flavor and overall acceptability were exhibited by T3, whereas, texture score were found to be highest of T2. Increment in sensorial scores of formulated cakes, as a result of increasing CPP level up to 15%, with 5% AP, proved a positive indication of the study, because acceptance of product from the customers has always been the benchmark of the product sale. Crust and crumb color of cakes developed by different replacement levels of CPP and AP can be seen from Figure 6 also, which clearly explains the effect of addition of these powders on sensory parameters of the cakes. Fruits and vegetables pomaces in the form of powders are useful and effective functional ingredients to alter the physicochemical properties of developed food items, which have been found associated with balanced ratio of soluble/insoluble fiber and good hydration properties, ultimately resulting in acceptance of formulated products from consumers in good manners (Sahni and Shere, 2018). Tańska et al. (2007) reported that 5% replacement of carrot pomace powder with wheat flour was optimal for development of good quality bread, with acceptable rheological and sensory attributes. Akinyede et al. (2020) incorporated carrot pomace powder along with millet, rice bran and soy cake flours to develop breakfast cereals and consumers appreciated the developed products in terms of sensory evaluation, in which carrot pomace powder was incorporated at 5–10% level. A higher level (15%) used in current study was also acceptable, possibly due to the addition of 5% AP, because AP might have contributed with extra protein and fat contents, to mask the quality deterioration exhibited by high fiber of CPP. Majzoobi et al. (2017) used carrot pomace powder along with different hydrocolloids to develop good quality cakes and came on conclusion that 20% carrot pomace powder and hydrocolloids promoted the quality and sensory parameters of cakes. In this study hydrocolloids might have assisted the quality retention of the product. Olawuyi and Lee (2019) successfully incorporated carrot pomace and mushroom powder in muffins.

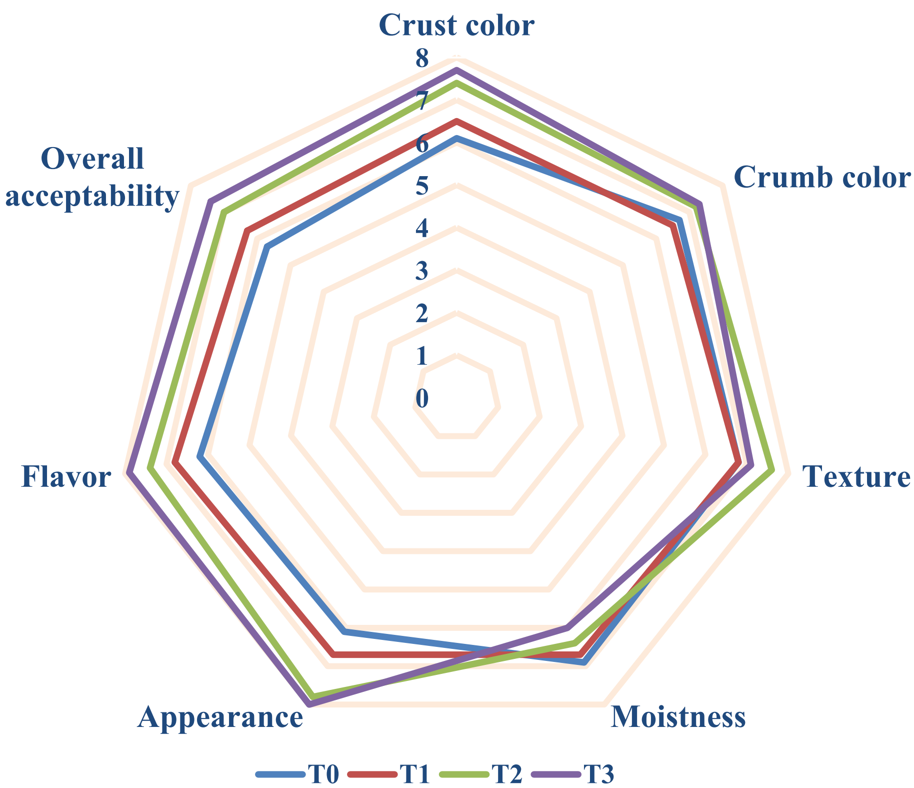

FIGURE 5
Sensory evaluation of cakes prepared by partial replacement of straight grade wheat flour with carrot pomace powder and almond powder. Based on the HSD-Tukey test, values represent the mean of triplicate ± SD T_0: 0% CPP + 0% AP + 100 SGWF, T_1: 5% CPP + 5% AP + 90% SGWF, T_2: 10% CPP + 5% AP + 85% SGWF, T_3: 15% CPP + 5% AP + 80% SGWF.

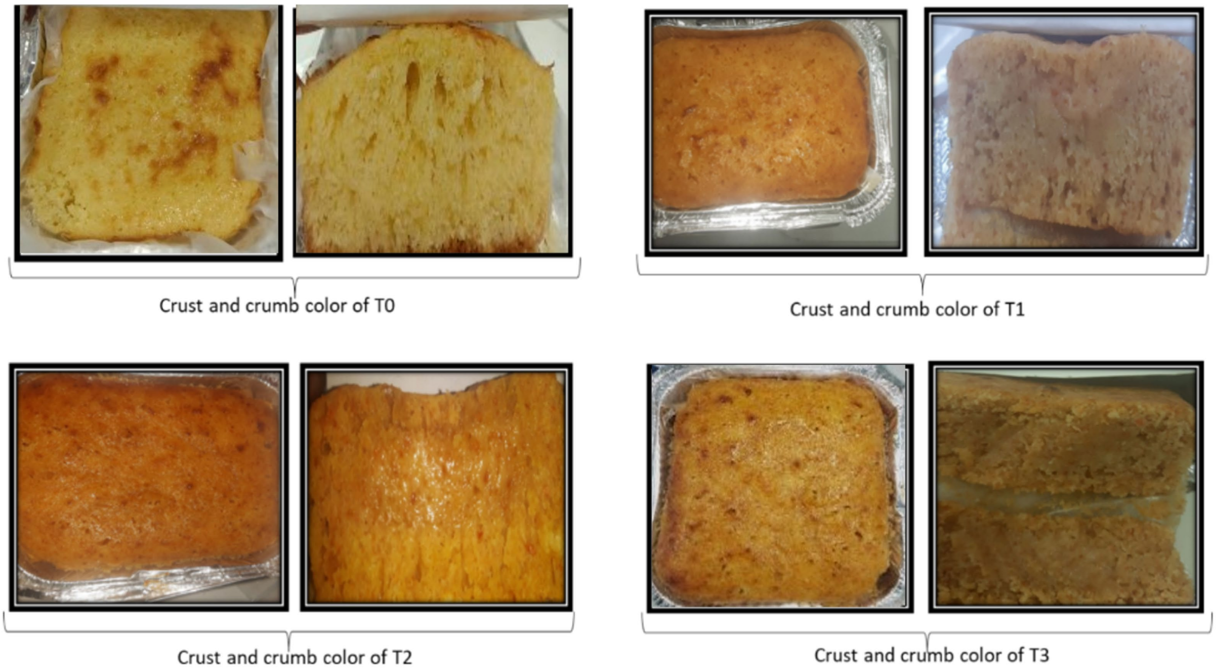

FIGURE 6
Crust and crumb color of different treatments of cakes developed by addition of carrot pomace and almond powder.

Similar results were also observed when Gölge et al. (2022) incorporated black carrot pomace in cakes and cookies and products developed with 5 to 7% incorporation of carrot pomace were found acceptable by sensory panelists, recommending the use of carrot pomace powder as a source of functional ingredients in bakery products. Ekumankama (2021) used almond seed powder at higher level than current study, and observed highest scores for control cakes, developed from 100% wheat flour as compared to cakes developed from combination of almond seed powder (30%) and wheat flour (70%). Decrement in sensory scores was probably due to elevated level of AP used, whereas 5% AP in current product development provided excellent results. Martinescu et al. (2020) added almond powder with rice and arrowroot flour and observed that 10% almond powder, 10% arrowroot flour and 80% rice flour produced good quality acceptable cakes for diabetic and celiac disease persons. Calutoiu and Misca, (2018) used almond flour to get pastries with flavor and nutrition, which were appreciated by evaluators. Use of almond press cake flour to develop functional snacks was also experimented by Naseer et al. (2021), and was reported that 20% addition of almond flour along with 80% peal millet flour produced good quality snacks. Guyih et al. (2020) used carrot and almond flours in different combinations with wheat flour, and performed sensory evaluation of cookies, the results revealed that all the formulations were appreciated by evaluators, just as current product developed with a combination of AP and CPP was well accepted by sensory panel experts. Kırbaş et al. (2019) studied the effect of addition of carrot, apple and orange pomace powders on sensory properties of the cakes, and results revealed that color, texture, appearance, flavor and overall acceptability of cakes with 5% incorporation these powders received the highest acceptance scores. Similarly, Bellur Nagarajaiah and Prakash (2015) reported that 4 to 8% replacement of carrot pomace powder was good enough to produce acceptable cookies. Similar results for sensory evaluation of carrot pomace incorporated biscuits were also present in studies of Kausar et al. (2018). In another study, Badjona et al. (2019) replaced wheat flour with carrot and pineapple pomace powder to develop rock buns and found that 15% replacement with these substitute flours produced good quality rock buns, which were liked well by consumers, as higher moisture retention by fiber present in pomace powders might provide the soft texture to the incorporated food items. Salehi et al. (2016) replaced wheat flour with infrared-hot air-dried carrot pomace powder at different replacement levels and found that 10% replacement level was most acceptable for development of good quality sponge cake. Baljeet et al. (2014) investigated that 8% substitution of carrot pomace powder and chickpea flour were helpful to produce nutritional biscuits with required sensory characteristics. Fiber enriched chicken sausages with moderate acceptability were developed by incorporation of 6% each wheat bran and dried carrot pomace powder by Yadav et al. (2018). Although carrot pomace powder at high levels cannot provide the specific product requirements for acceptable quality, but its appropriate combination with AP and SGWG could be used to develop cakes, which would not only provide health promoting potential, but also could be liked by a variety of consumers.

4 Conclusion

Both carrot pomace (obtained as a waste in the juice extraction process) and almond powder were found rich in various nutrients and were evaluated for their suitability for the cake preparation. The proximate analysis showed that CPP and AP were higher in fiber, ash, minerals, TPC, TFC and antioxidant activity, as compared to SGWF, and incorporation of both these powders caused a significant ($p \leq 0.05$) increase in the crude protein, crude fat, ash, and crude fiber content of the cakes. Mineral and phytochemical studies also revealed the significant ($p \leq 0.05$) improvements in the developed functional cakes. Based on the sensory data, the cakes prepared by adding 10% CPP and 5% AP showed better scores for texture and moistness, whereas cakes prepared by adding 15% CPP and 5% AP obtained significantly high ($p \leq 0.05$) scores for crust and crumb color, flavor, appearance, and overall acceptability. Thus, CPP and AP can be successfully used to improve the nutritional contents such as ash, fiber and mineral, and bioactive contents such as TPC, TFC and antioxidant activity, of the cake with sensory acceptability, and can be recommended to use for other cereal products in an industrial setting.

5 Recommendations

Although there are various kinds of bakery products in the market, most of them lack necessary amounts of ash, fiber, and other nutrients. As a result, the food industry has given boosting the nutritional worth of these food items, more attention. CPP and AP can be used to enhance foods produced with wheat flour because these powders are easily accessible source of essential nutrients and important bioactive components. Owing to the enhancement of the products' nutritional content, sensory appeal, and quality, the industrial ramifications of this research could lead to the creation of new goods and better marketing strategies. Pomace of fruits and vegetables can be combined into different food formulations to improve their functionality owing to functional properties of this valuable ingredient. Variety of fruits and vegetables pomaces can be utilized to develop a range of bakery items including buns, cakes, cookies, biscuits, crackers, breads muffins, noodles, and rolls, with increased acceptability, antioxidant capacities and greater shelf life.

6 Practical applications

The addition of fruit and vegetable powders to bakery items can be used to increase the nutritional value, with fibre and other phytochemicals like polyphenols, carotenoids, and minerals. Bakery products are consumed all over the world. Among these sources, which have a lot of potential as a nutritive and practical food, are carrot and almond. In this study, a brand-new recipe for making cakes using carrot pomace and almond powder was created, which could expedite industrial food formulations with increased consumers acceptance rate.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

TK: Writing – original draft, Methodology, Conceptualization. SL: Writing – original draft, Methodology, Conceptualization. AH: Writing – original draft, Methodology, Conceptualization. YN: Writing – review & editing, Visualization, Formal analysis. MB: Writing – review & editing, Visualization, Resources. RM: Writing – review & editing, Investigation, Funding acquisition. ON: Writing – review & editing, Visualization, Funding acquisition. AM: Writing – review & editing, Formal analysis. NF: Writing – review & editing, Visualization. SA: Writing – review & editing, Visualization, Validation. SY: Writing – review & editing, Software. KE: Writing – review & editing, Validation, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Annex 1: Nine point hedonic scale performa.