https://doi.org/10.17221/103/2024-CJFS

Enriching wheat flour with grape pomace powder impacts a snack's chemical, nutritional, and sensory characteristics

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Citation: Alshawi A.H. (2024): Enriching wheat flour with grape pomace powder impacts a snack's chemical, nutritional, and sensory characteristics. Czech J. Food Sci., 42: 243–250.

Abstract: Because grape pomace powder (GPP) contains abundant phenolic chemicals and fibres, GPPs can serve as a filler in developing novel food products. This study examined how the GPP amounts affected a composite flour's physicochemical properties and bakery snacks' chemical, technical, and sensory properties. The experimental procedure involved replacing wheat flour (WF) with GPP at 5–20% while maintaining 100% WF as the control. The addition of GPP resulted in a significant decrease in the oil absorption capacity ($P \leq 0.05$), while the rehydration index and water absorption capacity increased ($P \leq 0.05$). The peak length (5.44–5.90 min), pasting temperature (70.20–80.92 °C), peak viscosity (124.72–172.80 RVU; RVU – relative value unit), trough viscosity (60.76–82.04 RVU), breakdown viscosity (69.56–93.74 RVU), final viscosity (162.70–222.30 RVU), and setback viscosity were measured. The addition of GPP to the composite flour and snacks decreased the lightness (L^*) and increased the redness (a^*) and yellowness (b^*). The items' higher dietary fibre (DF) allowed them to claim 'high fibre content' when the maximum GPP was added. The GPP also increased the snacks' total solids, protein, ash, fibre, total phenolics content (TPC), and antioxidant capacity. The sensory acceptability of the snacks made with 5–10% GPP instead of WF was higher.

Keywords: bakery; fibre; grape by-product; phenolic; snacks

Baked goods are cereal-based and heavily marketed due to their widespread consumption and soft texture (Oliveira et al. 2016). Quick, ready-to-eat snacks are popular with the youth worldwide. Food additives are increasingly being studied, especially in snack manufacturing (Forsido et al. 2019). The broadest definition is that snacks can be 'healthy' or 'unhealthy' if eaten between meals (Bellisle 2014). The US Department of Agriculture lists 2 500 products, including corn, rice, wheat snacks, potato crisps, dried pork, sausage fingers, fruit, and fruit candies. Only 171 products have a precise composition and nutritional information (Hess et al. 2016).

Grapes are one of the most widely grown fruits. Grapes contain phenolic compounds, flavonoids, anthocyanins, sugars, acids, pectins, gums, and aromas (Segade et al. 2008). Additionally, the anthocyanins' antioxidant properties improve the consumer's health (de Camargo et al. 2017). Grape pomace (GP), a by-product of winemaking, contains grape skins, the pulp, and seeds. GP flour can be used in drinks, cereal bars, pasta, and cookies (Oliveira et al. 2016). To boost the storage and shelf life, GP was ground and dried into a powder.

Dehydration of the residue allows one to engage the constituents, such as the fibres and phenolic com-

https://doi.org/10.17221/103/2024-CJFS

pounds, to be valuable nutrients and increase the product's nutritional value. GP powder has been tested in yoghurt, tomato puree, and fruit jams. Given the massive amount of grape-based beverages produced and the fact that GP flour can be recycled to make modified-standard meals, consumers and the environment may benefit (Boff et al. 2022). This study aimed to examine the physicochemical and nutritional properties of snacks made from wheat flour enriched with red grape pomace powder (GPP).

MATERIAL AND METHODS

Material

Wheat grains (*Triticum sativum*), other baking materials, and red grape (*Vitis vinifera* L.) fruit were purchased from the local markets in Riyadh, Saudi Arabia. Sigma-Aldrich (USA) was used to purchase the 2,2-diphenyl-1-picrylhydrazyl (DPPH), gallic acid, and other chemicals and reagents.

Methods

Preparation of the wheat flour and grape pomace powder. Using a Buhler laboratory pneumatic flour mill, the wheat grains were ground to obtain flour with a 72% extraction rate. Grape pomace (GP) was dried in a vacuum oven at 40 °C and 30 kPa, then crushed and sieved (200 μm sieve) to create a powder and then kept in the dark and vacuum-sealed.

Preparation of the snacks. Various mixes (Table 1 and Figure 1) were combined at a ratio of 100 g of blended flour to 1.5 g of active dry yeast, 1.0 g of sodium chloride, 1 g of sugar, and 1 g of vanilla. One hour was given for the dough to ferment at 30 °C and 85% relative humidity. Each 20 g piece of dough was separated into equal portions. The pieces were placed on trays and allowed to ferment at the same temperature and relative humidity for 30 min. The pieces of fermented dough were baked at 230 °C for 10 min.

Table 1. The flour blends

Sample	Blends (%)	
	WF	GPP
C	100	0
T1	95	5
T2	90	10
T3	85	15
T4	80	20

WF – wheat flour; GPP – grape pomace powder

Chemical composition. The moisture, ash, protein, fat, dietary fibre, and carbohydrate contents were determined in duplicate using the Association of Official Agricultural Chemists (AOAC, 2016) methods.

Functional properties. The water absorption capacity (*WAC*) and oil absorption capacity (*OAC*) of the wheat flour (WF) replaced with 0, 5, 10, 15, and 20 g per 100 g of GPP (*w/w*) were measured with a few minor modifications. Three grams of material were dissolved in 25 mL of distilled water or maize oil for the *WAC* and *OAC* analyses. The samples were centrifuged at 3 000 × g for 25 min and swirled every 30 s. After removing the supernatants, the pellets were weighed. The *WAC* and *OAC* were calculated in grams of water or oil per 100 g of sample. The supernatants were decanted into Petri plates and dried at 105 °C until a constant weight was reached, but the *WAC* and water solubility index (*WSI*) were determined similarly. The *WSI* was calculated using Equation 1:

$$WSI = \frac{weight\ of\ dried\ supernatants}{weight\ of\ sample} \times 100 \quad (1)$$

Determination of the bulk density. A 100 mL graduated measuring cylinder was carefully filled with 10 g of flour to calculate the packed bulk density. After many gentle taps on a lab bench, the cylinder sample level did not decrease. The bulk density was estimated by comparing the bulk sample weight to its volume after tapping.

Rehydration index. Ten grams (10 g) of measured flour was added to boiling water, stirred, and shaken for 90 s. A 100 mL graduated glass cylinder was filled with the mixture and allowed to settle. The rehydration index was calculated from the sediment volume percentage increase after 30 min.

Pasting characteristics. A Rapid Visco-Analyser (Model RVA 3D; Newport Scientific, Australia) was used to evaluate the flour pasting. The test canisters contained 25 mL of water and 3 g of flour. A thoroughly mixed sample was fitted into the Rapid Visco-Analyser (RVA). The 12-min profile heated the slurry from 50 to 95 °C for 2 min, then cooled it to 50 °C for 2 min. Both the heating and cooling occurred at 11.25 $°C \cdot min^{-1}$ with steady shear at 160 rpm (revolutions per minute). A computer connected to the RVA read the pasting profile's peak viscosity, trough, breakdown, final viscosity, setback, peak time, and pasting temperature.

Colour analysis. A Chroma Meter CR-410 (Konica Minolta Sensing, Japan) was used to determine the colour of the flour. The meter readings were used to determine the flour's colour properties in terms

https://doi.org/10.17221/103/2024-CJFS

of CIE L^* (lightness), a^* (redness/greenness), and b^* (yellowness/blueness).

Determination of the total phenolic content. The Folin-Ciocalteau method, which is based on the redox interaction of phenolic compounds with a mixture of phosphotungstic and phosphomolybdic acids in an alkaline medium to generate a blue complex, was used to measure the total phenolics content (TPC) (Kaur and Kapoor 2002). The results were given in mg of gallic acid equivalent (GAE) per 100 g of dry matter.

DPPH radical scavenging activity (RSA). Brand-Williams et al. (1995) used the DPPH assay to measure the antioxidant activity. The scavenging activity percentage (AOA%) was calculated following Equation 2:

$$AOA\% = \frac{A_{\text{control}} - A_{\text{sample (standard)}}}{A_{\text{control}}} \times 100 \quad (2)$$

where: A – absorbance.

Sensory properties. Snack samples were made and stored at room temperature in polyethylene bags with different temperature combinations. A panel of 30 academics, Ph.D. candidates, and students sensory reviewed the snacks. The snack samples were rated on the colour, flavour, taste, crispiness, appearance, and acceptability using a 9-point hedonic scale.

Statistical analysis. SPSS (version 21.0) was used for the statistical analysis. An analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) were conducted, the means were separated, and significant differences were identified at $P \leq 0.05$. Each analysis was performed three times.

RESULTS AND DISCUSSION

Table 2 demonstrates that the GPP content from the fat, ash, fibre, TPCs, and RSAs was notably more significant than that of the WF. Conversely, the WF exhibited elevated levels of L^* and b^*. The results of these findings were consistent with those of other studies (Acun and Gül 2014, Rainero et al. 2022) for GPP.

As shown in Table 3, as the GPP replacement increased, the composite flour's oil absorption decreased, while the water absorption and rehydration index increased significantly ($P \leq 0.05$). The GPP may have more hydrophilic ingredients like fibre, protein, and carbohydrates and fewer lipophilic ingredients than the WF. The oil absorption capacity is positively correlated with the flavour retention, shelf stability, mouth feel, and palatability of the bread; soup mixes, and other foods that absorb fat (Adegunwa et al. 2020). The composite flour's high water absorption capacity suits baking and other hydration-required applications. The higher water absorption is linked to the starch polymers' loose structure, while the lower water absorption is linked to the flour's compact molecular structure (Adebowale et al. 2005). The fibre's high water affinity may explain the GPP's excellent rehydration index readings, which suggest they absorb water faster than the WF. Substituting GPP (5–20%) in the WF significantly ($P \leq 0.05$) reduced the bulk density (0.68–0.82 $g \cdot mL^{-1}$) of the composite flour, with the 10% GPP substituted WF having a comparable bulk density to the 15 and 20% GPP substituted WF. The composite flour's lower bulk density may have been due to the GPP's lower bulk density than the WF.

Table 2. Chemical composition of the wheat flour and grape pomace powder (g per 100 g DW)

Chemical composition	WF	GPP	*P*-value
Moisture	11.0 ± 0.24	6.8 ± 0.18	< 0.000
Crude protein	12.7 ± 0.52	13.0 ± 0.36	> 0.050
Crude lipid	1.7 ± 0.08	3.9 ± 0.12	< 0.000
Ash	0.7 ± 0.04	9.4 ± 0.86	< 0.000
Total dietary fibre	1.0 ± 0.03	55.6 ± 1.74	< 0.000
TPC	120.5 ± 3.14	740.8 ± 5.33	< 0.000
RSA (%)	55.2 ± 2.64	91.7 ± 3.20	< 0.000
L^* value	92.6 ± 3.72	50.7 ± 4.02	< 0.000
a^* value	0.2 ± 0.02	8.3 ± 0.94	< 0.000
b^* value	13.9 ± 1.04	8.6 ± 0.88	< 0.000

Data are expressed as mean ± SD (standard deviation); DW – dry weight; WF – wheat flour; GPP – grape pomace powder; TPC – total phenolic content; *RSA* – radical scavenging activity; L^*– lightness; a^* – redness/greenness; b^* – yellowness/blueness

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Table 3. Functional properties of the wheat flour *vs*. the grape pomace formulas

Treatment	*OAC* (%)	*WAC* (%)	Bulk density (g·mL^{-1})	Rehydration index (%)	*WSI* (%)
C	69.4 ± 0.22^{a}	60.1 ± 0.30^{e}	0.8 ± 0.08^{a}	3.7 ± 0.54^{e}	6.2 ± 0.06^{e}
T1	66.9 ± 0.38^{b}	63.8 ± 0.14^{d}	0.8 ± 0.03^{b}	6.1 ± 0.38^{d}	8.9 ± 0.12^{d}
T2	63.5 ± 0.42^{c}	66.5 ± 0.26^{c}	0.7 ± 0.05^{c}	8.8 ± 0.45^{c}	9.7 ± 0.18^{c}
T3	61.2 ± 0.56^{d}	68.5 ± 0.55^{b}	0.7 ± 0.02^{d}	11.4 ± 0.60^{b}	10.8 ± 0.30^{b}
T4	60.2 ± 0.34^{e}	72.1 ± 0.42^{a}	0.7 ± 0.01^{e}	14.1 ± 0.34^{a}	12.0 ± 0.26^{a}

$^{a-e}$ Mean values superscribed with different letters in the same column are significantly different (P < 0.05); data are expressed as mean ± SD (standard deviation); *OAC* – oil absorption capacity; *WAC* – water absorption capacity; *WSI* – water solubility index; C – wheat flour (WF); GPP – grape pomace powder; T1 – 5% GPP + 95% WF; T2 – 10% GPP + 90% WF; T3 – 15% GPP + 85% WF; T4 – 20% GPP + 80% WF

The *WSI* measures the flour solubility in water and shows the differences in the soluble molecules. The *WSI* rose from 6.18% in the WF to 12.04% in the 20% composite flour (P ≤ 0.05). After adding GPP, the *WSI* rose, suggesting the enriched flour had more soluble elements like dietary fibres.

As illustrated in Table 4, substituting WF with GPP at the 5–20% levels significantly reduced the peak, final, setback, and peak duration (P < 0.05). The trough and breakdown viscosities were similar for the WF, with 100% water absorption and 5% gluten protein fraction substitution. However, the observed values differed significantly (P < 0.05) from the other treated samples. The GPP substitution increased the WF pasting temperature because the higher substitution levels increased the observed values. Nakov et al. (2020) and Lou et al. (2021) found similar results when substituting 0–10% GPP in WF. Both studies found that replacing the WF with GPP increased the peak time, peak viscosity, trough viscosity, breakdown viscosity, final viscosity, and setback viscosity and decreased the peak temperature.

Starch-based meals' 'peak viscosity' is their ability to rapidly expand during heating before disintegrating. Kayode et al. (2019) found that the starch degradation, amylose and amylopectin composition, and starch concentration affect the peak viscosity. Therefore, the composite flour's peak and ultimate viscosities are lower because the GPP has no gluten and little starch. Lou et al. (2021) proposed that the interaction between the GPP's oil and protein and the WF's starch may explain their flour blends' lower peak temperatures. Through the viscosity, the Rapid Visco Analyser's lowest viscosity value during the constant temperature phase measures the paste's resistance to breakdown during cooling (Adegunwa et al. 2020).

The GPP-containing WF's breakdown viscosity decreases, indicating improved thermal and mechanical stability during cooking under high temperatures and shear stress. According to Kayode et al. (2019), the ultimate viscosity of a starch-based food material's paste indicates its stability after chilling (Kayode et al. 2019). The reduced final viscosity of the WF substituted with GPP suggests a reduced composite flour gel strength and elasticity.

The setback viscosity is the anticipated viscosity associated with the starch molecule rearrangement at which

Table 4. Pasting properties of the wheat flour and grape pomace composite flour

Sample	C	T1	T2	T3	T4
Peak viscosity (RVU)	172.8 ± 0.14^{a}	166.5 ± 0.32^{b}	143.2 ± 0.44^{c}	135.6 ± 0.28^{d}	124.7 ± 0.70^{e}
Trough viscosity (RVU)	82.0 ± 0.46^{a}	75.6 ± 0.54^{b}	67.5 ± 0.33^{c}	62.4 ± 0.72^{d}	60.8 ± 0.68^{e}
Breakdown viscosity (RVU)	93.7 ± 1.40a	91.5 ± 2.14^{b}	85.3 ± 4.22^{c}	72.8 ± 3.02^{d}	69.6 ± 2.34^{e}
Final viscosity (RVU)	222.3 ± 3.32^{a}	201.4 ± 2.66^{b}	173.8 ± 1.70^{c}	166.5 ± 0.98^{d}	162.7 ± 1.46^{e}
Setback viscosity (RVU)	138.5 ± 0.56^{a}	120.7 ± 0.48^{b}	99.8 ± 0.76^{c}	91.7 ± 0.52^{d}	86.9 ± 0.80e
Peak time (min)	5.9 ± 0.05^{a}	5.8 ± 0.03^{b}	5.6 ± 0.12^{c}	5.5 ± 0.08^{d}	5.4 ± 0.14^{e}
Pasting temperature (°C)	70.2 ± 0.74^{e}	71.8 ± 0.86^{d}	72.0 ± 0.16^{c}	80.1 ± 0.24^{b}	80.9 ± 0.38^{a}

$^{a-e}$ Mean values superscribed with different letters in the same column are significantly different (P < 0.05); data are expressed as mean ± SD (standard deviation); RVU – relative value unit; C – wheat flour (WF); GPP – grape pomace powder; T1 – 5% GPP + 95% WF; T2 – 10% GPP + 90% WF; T3 –15% GPP + 85% WF; T4 – 20% GPP + 80% WF

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Table 5. Chemical composition of produced snacks (g per 100 g DW)

Snacks	Moisture	Protein	Fat	Ash	Fibre
C	6.7 ± 0.03[a]	12.2 ± 0.30[a]	1.6 ± 0.15[b]	0.7 ± 0.06[e]	1.20 ± 0.17[e]
T1	6.4 ± 0.01[b]	12.3 ± 0.44[a]	1.6 ± 0.14[b]	1.3 ± 0.08[d]	3.82 ± 0.12[d]
T2	5.8 ± 0.04[c]	12.3 ± 0.36[a]	1.8 ± 0.16[ab]	1.7 ± 0.07[c]	6.30 ± 0.26[c]
T3	5.3 ± 0.06[d]	12.3 ± 0.48[a]	1.8 ± 0.12[ab]	2.0 ± 0.05[b]	6.02 ± 0.18[b]
T4	5.0 ± 0.04[e]	12.4 ± 0.52[a]	2.0 ± 0.15[a]	2.5 ± 0.04[a]	8.60 ± 0.24[a]

[a–e] Mean values superscribed with different letters in the same column are significantly different ($P < 0.05$); data are expressed as mean ± SD (standard deviation); DW – dry weight; C – wheat flour (WF); GPP – grape pomace powder; T1: 5% GPP + 95% WF; T2 – 10% GPP + 90% WF; T3 – 15% GPP + 85% WF; T4 – 20% GPP + 80% WF

retrogradation occurs. The setback viscosity measures how much starchy food gels or pastes retrograde when cooled. This study found that the cashew apple fibre reduced the WF setback viscosities. The flour's increased retrogradation resistance allows food products to have lower staling rates. The 'peak time' is when the cooking is expected to finish. Using cashew apple fibre instead of WF would reduce the cooking time and energy use. Ekunseitan et al. (2017) showed that pasting is the lowest cooking temperature at which starch granules change. According to Adebowale et al. (2005), 90% of starch granules should swell irreversibly in hot water while maintaining their crystalline structure and birefringence. The WF replaced by GPP increases the pasting temperatures, which increases the energy expenditure, component instability, gelatinisation, and flour starch granule swelling (Adegunwa et al. 2020).

The results of Table 5 show that the ash content of the WF, and 20% GPP snacks increased between 0.70 g and 2.46 g per 100 g of dry matter. The increased GPP proportion in the formulation led to a significant difference ($P \leq 0.05$) in the ash content. Mohammed Ahmed et al. (2020) found that potassium (K), phosphorus (P), manganese (Mn), iron (Fe), and zinc (Zn) affect the GPP ash concentration. Changing the GPP quantities for the WF resulted in significant moisture content differences ($P \leq 0.05$), and adding GPP to the formula led to a significant increase in overall dietary fibre (DF) content ($P < 0.05$). The DF content increased from 1.20 g to 8.60 g per 100 g of dry matter for the WF and 20% GPP. The GPP samples with concentrations of 10, 15, and 20% have total dietary fibre levels above 6 g per 100 g, making them have a 'high fibre content'. Prior studies have used grape skin powder in bread and cookies and found similar dietary fibre levels of (Walker et al. 2014; Smith and Yu 2015; Kuchtová et al. 2018). Jane et al. (2019) found that high-fibre cereal-based meals can help adults meet their 30 g of their daily fibre requirement. Finally, the protein content was consistent across the samples, averaging 12.22% to 12.38% ($P > 0.05$). The GPP also increased the lipid content, with the WF and GPP values ranging from 1.56 to 1.95 and 20%, respectively.

Table 6 shows that adding GPP at different levels significantly affects the TPC and antioxidant activity of the snacks ($P \leq 0.05$). The WF and 20% GPP in-

Table 6. Total phenolic content, radical scavenging activity and colour values of the produced snacks

Snacks treatments	Total phenolic content [mg·(100 g)$^{-1}$]	Radical scavenging activity (%)	Colour values		
			L^*	a^*	b^*
C	68.2 ± 1.12[e]	30.7 ± 2.02[e]	60.5 ± 1.75[a]	6.4 ± 0.14[a]	17.1 ± 0.42[a]
T1	90.7 ± 2.25[d]	36.5 ± 1.18[d]	51.6 ± 1.88[b]	5.3 ± 0.16[b]	12.5 ± 0.36[b]
T2	125.3 ± 1.98[c]	40.2 ± 2.22[c]	47.3 ± 2.34[c]	5.0 ± 0.12[c]	9.6 ± 0.62[c]
T3	178.5 ± 2.66[b]	44.4 ± 2.30[b]	44.3 ± 1.14[d]	4.9 ± 0.20[d]	7.7 ± 0.54[d]
T4	214.2 ± 2.28[a]	50.3 ± 1.45[a]	40.8 ± 1.32[e]	4.4 ± 0.18[e]	5.8 ± 0.30[e]

[a–e] Mean values superscribed with different letters in the same column are significantly different ($P < 0.05$); data are expressed as mean ± SD (standard deviation); L^* – lightness (zero = black, 100 = white); a^* ($-a^*$ = greenness, $+a^*$ = redness); b^* ($-b^*$ = blueness, $+b^*$ = yellowness); C – wheat flour (WF); GPP – grape pomace powder; T1 – 5% GPP + 95% WF; T2 – 10% GPP + 90% WF; T3 – 15% GPP + 85% WF; T4 – 20% GPP + 80% WF

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creased the TPC from 68.20 in the control sample to 214.20 mg GAE per 100 g DM. The RSA increased from 30.70% to 50.30% ($P < 0.05$). Bread and pasta with 10 and 15 g per 100 g wine GP flour had a similar TPC (Walker et al. 2014). Walker et al. (2014) found that 5 and 10 g per 100 g GPP muffins had a similar antioxidant capacity. The grape flour's TPC and antioxidant activity depend on the grape variety, seed presence, and drying process (Martins et al. 2017). The addition of GPP significantly affected the snack colour ($P \leq 0.05$), as shown in Table 6. A significant decrease in the luminosity was observed in the GPP-snack treatments due to its deep hue ($P \leq 0.05$). The fortification decreased the a^* and b^* value ($P \leq 0.05$) in the colour parameters.

The studies above also used red grape pomace-infused bread and pasta to adjust the colour (Tolve et al. 2021). However, cakes with a higher red GP content had lower a^* values and higher b^* values (Nakov et al. 2020). However, red grape pomace-fortified muffins and biscuits reduced all the colour parameters (Kuchtová et al. 2018). Finally, the total colour difference used to quantify the colour variability showed that the WF samples had more colour variation than the fortified samples.

Table 7 shows the average ratings for the wheat and GP composite flour snacks' colour (6.25–8.46), flavour (8.32–8.82), taste (8.41–8.91), crispness (7.96–8.55), appearance (5.22–8.46), and overall acceptability (7.55–8.36). The mean sensory scores of the snacks decrease as the GPP content increases. Lou et al. (2021) found similar results for GPP-substituted wheat cookies and Nakov et al. (2020) also found similar results for 0–10% GPP cakes. The colour homogeneity and alveolate structure were better in the control snacks than in the supplemented samples. As the amount of GPP increased, the wine odour of the GPP improved the flavour and taste of the fortified samples, as was seen for pasta and bread with GP (Tolve et al. 2021). The crispness increased dramatically in the enriched samples compared to the controls. However, Petchoo et al. (2021) reported the same issue with resistant starch breadsticks. The astringency increased by the 5% and 10% GPP, possibly due to grape tannins. The acceptability was comparable for the control and the 5% GPP, but worse for the 20% GPP.

Economically, drying and grinding grape pomace may be inexpensive when compared to the many uses of grape pomace powder in juices, baked goods, and animal feed. Small quantities can be dried in ordinary drying ovens, but, in the case of large quantities, there are special machines for drying and grinding grape pomace, as well as tomato pomace and some fruits and vegetables. To confirm this, research must be conducted on this point.

The changes of some elements in the raw materials may have a significant impact on the acrylamide level for certain food product categories. At the same time, food manufacturers are compelled to release updated items enhanced with plants and plant by-products onto the market due to the growing consumer awareness and current trends for functional, tasty, and healthful foods. This could be advantageous from two angles: it could improve the food items' functional qualities and reduce some of so-called food-borne toxins, such acrylamide. Fruits, vegetables, and their processed products are used in baking as an additional source of water-insoluble or soluble fibre (pectin) or physiologically active compounds (polyphenols) that have been shown to benefit human health. Therefore, it is expected that fortifying wheat flour with grape pomace flour will reduce the acrylamide content in the product. To confirm this, scientific research must be conducted to indicate this effect.

Table 7. Sensory evaluation of the produced snacks (total score of sensory evaluation = 9)

Snacks treatments	Colour	Flavour	Taste	Crispness	Appearance	Overall acceptability
C	8.5 ± 0.04^{a}	8.3 ± 0.04^{e}	8.4 ± 0.05^{e}	8.0 ± 0.06^{e}	8.5 ± 0.05^{a}	8.4 ± 0.08^{a}
T1	8.3 ± 0.05^{b}	8.5 ± 0.08^{d}	8.5 ± 0.04^{d}	8.1 ± 0.04^{d}	8.3 ± 0.03^{b}	8.3 ± 0.06^{a}
T2	8.2 ± 0.06^{c}	8.6 ± 0.04^{c}	8.7 ± 0.05^{c}	8.3 ± 0.05^{c}	7.5 ± 0.04^{c}	8.3 ± 0.12^{ab}
T3	7.0 ± 0.04^{d}	8.7 ± 0.06^{b}	8.8 ± 0.03^{b}	8.4 ± 0.04^{b}	6.3 ± 0.06^{d}	7.6 ± 0.10^{b}
T4	6.3 ± 0.06^{e}	8.8 ± 0.08^{a}	8.9 ± 0.05^{a}	8.6 ± 0.05^{a}	5.2 ± 0.05^{e}	7.6 ± 0.12^{b}

$^{a–e}$ Mean values superscribed with different letters in the same column are significantly different ($P < 0.05$); data are expressed as mean ± SD (standard deviation); C – wheat flour (WF); GPP – grape pomace powder; T1 – 5% GPP + 95% WF; T2 – 10% GPP + 90% WF; T3 – 15% GPP + 85% WF; T4 – 20% GPP + 80% WF

https://doi.org/10.17221/103/2024-CJFS

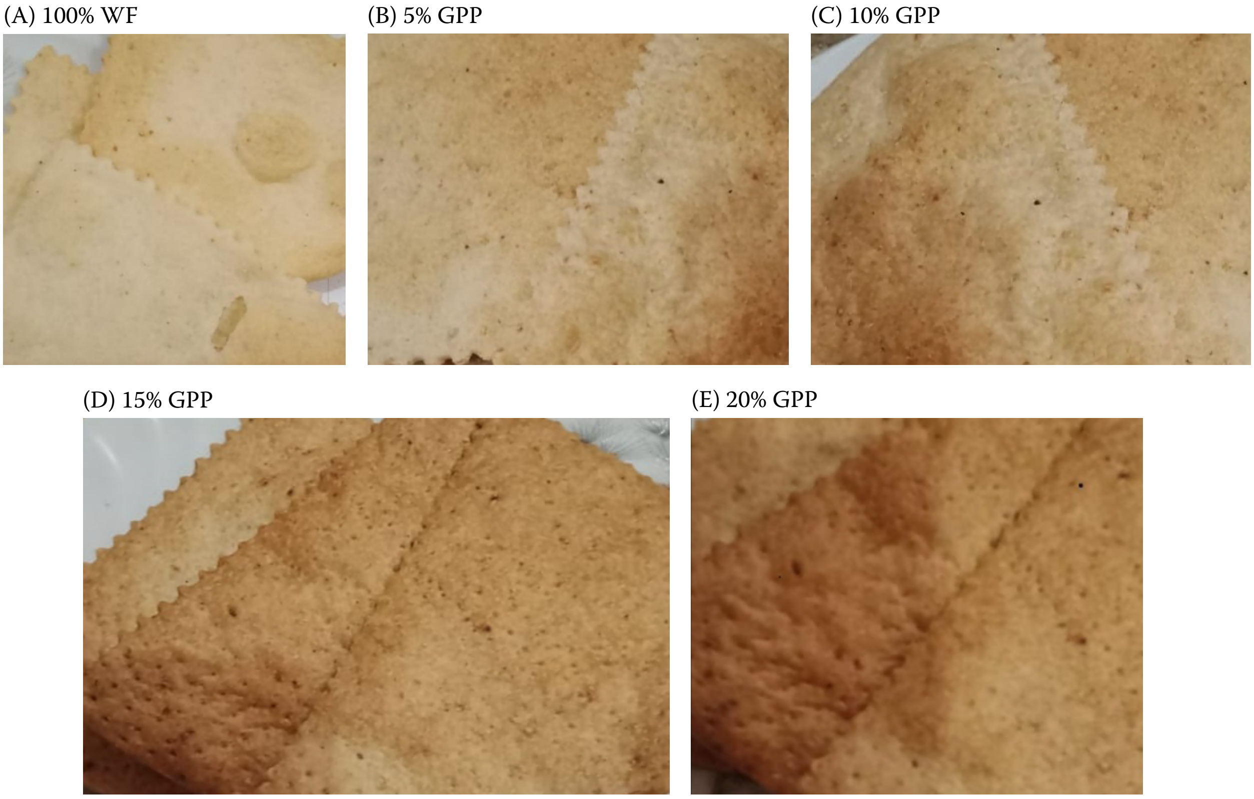

Figure 1. Snacks with (A) 100% WF, (B) 5% GPP, (C) 10%GPP, (D) 15%GPP, and (E) 20%GPP

WF – wheat flour; GPP – grape pomace powder

CONCLUSION

This study used characterisation and value-enhancement methods to show that GP flour, a waste product of grape juice production, could be used. WF replaced with GPP reduced the composite flour bulk density, oil absorption capacity, and pasting characteristics (excluding the pasting temperature). Fibre-rich GPP improves the composite flour's rehydration index and water absorption. This suggests that these blended flours make moist baked goods. The use of proper packaging to reduce the rising moisture content equilibrium caused by the higher GPP substitution to keep the flour fresher longer. The GPP colour affected the composite flour and snack product pigmentation. Nutritionally, GPP-fortified snacks had more phenolic compounds and dietary fibre. More than 6 g of dietary fibre per 100 g is considered as having 'high fibre content', as indicated by the GPP percentages of 10, 15, and 20%. User feedback confirmed that snacks with 5–20% GPP instead of wheat were acceptable. The study found that 100% wheat snacks had more robust sensory qualities than snacks with 5% and 10% GPP. Using the suggested replacement amounts for snacks and similar goods is advised. In conclusion, adding GPP to baked goods and other foods improved their nutritional value and convenience while reducing the wheat imports.

Acknowledgement. We thank everyone who helped in achieving this research. The work has been approved by the Institutional Review Board (IRB), Princess Nourah Bint Abdulrahman University, Riyadh, Kingdom of Saudi Arabia (IRB Log No. 23-0679).

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Received: May 26, 2024
Accepted: July 16, 2024
Published online: August 20, 2024