

Exploring the Potential of Carrot Pomace in Oat Cakes; Physiochemical and Sensory Evaluation

Fatima Tariq^a, *Omama Maryam^a, Muhammad Sajid Manzoor^a, Ukasha Arqam^a, Ayesha Murtaza^a, Muhammad Sheharyar^a, Muhammad Hamad^a

^a Department of Food Science, University of Central Punjab Lahore-Pakistan

*Corresponding authors: omaimamaryam14@gmail.com

Abstract: Carrot pomace, a rich source of vitamins, antioxidants, and minerals, is often underutilized due to its high moisture content. Oat, a cereal grain, is high in protein, fiber, and minerals, it offers health benefits like hypocholesterolemia and anti-cancerous properties. Carrot pomace is a popular ingredient in various foods, including cakes and oat-based food products are popular due to their nutritional value. This paper focuses on the development of oat-carrot pomace (OCP) cakes, which are gluten-free products. The study investigates the proximate (including ash and moisture), polyphenolic content (TPC), and antioxidant values (DPPH). The treatment plan involves varying amounts of pomace powder in combination with oats flour to create different cake formulations. The moisture test results reveal that the moisture content of the samples ranged from 15.8% to 22.7%, this moisture may affect their stability and quality. Comparing these results with industry guidelines, it is evident that the moisture content exceeds the permissible limit for similar materials. It emphasizes the need for proper handling and storage conditions to minimize moisture absorption. The ash test results demonstrate that the ash content of the samples ranged from 5.33% to 5.82%, indicating minimal inorganic impurities, which is favorable for their potential applications. The Total Phenolic Content (TPC) values showed that with the increase in concentration of carrot pomace from 5 to 15%, the TPC value increased in the range of (423.24-528.70 md/100g GAE). The DPPH test results indicate the antioxidant activity value of the samples decreased with the increasing concentration of carrot pomace and the values ranged from 18.34 to 15.11). Conclusively, Carrot pomace can be added to oat cakes to improve the end product's nutritional profile and sensory qualities, which will support the food industry's commitment to sustainability.

Keywords: Carrot pomace, Oat cakes, Gluten-free, Underutilized, Sensory attributes, Nutritional profile, Sustainability.

Article History

Received: 17 January 2024; Revised: 12 February 2024; Accepted: 19 March 2024

Online: 29 April 2024; Published: Volume (3) Issue (1) May 10, 2024

<https://doi.org/10.69501/7ajnae20>

1. Introduction

Fruit and vegetable waste (FVW) is a significant constituent of food waste, accounting for approximately 0.5 billion tons annually out of the 1.3 billion tons of total food waste generated worldwide (FAO, 2011). Fruit and vegetable losses are a problem in developing nations not only during the agricultural stage but also present a big problem at the processing plant level (Ferreira *et al.*, 2015). Every season, there is a common occurrence of overproduction of fruits and vegetables. If not properly utilized, this can lead to significant waste generation. Additionally, within the food processing industry, raw materials are transformed into desirable products, but a considerable proportion, ranging from 15% to 30%, ultimately becomes waste. As a result, the food processing industry is anticipated to generate substantial amounts of fruit and vegetable waste (FVW) annually, driven by the growing population's consumption demands (Salim, 2017).

Fruit and vegetable waste (FVW) contain valuable components in abundance, called bioactive compounds (BC), which impart significant positive impacts on human health. These BCs include alkaloids, flavonoids, glucosinolates phenolic acids, and carotenoids. These bioactive compounds are considered extra-nutritional constituents that

can modulate metabolic processes and possess various beneficial properties such as antioxidants, anti-cancer, anti-inflammatory, and anti-allergenic properties. Thus, FVW denotes a potential source of these bioactive compounds with potential health benefits (Hamzalioglu and Gokmen, 2016).

The carrot (*Daucus carota*) is an important and popular vegetable among vegetables. Because it is high in beta-carotene and contains considerable amounts of the vitamins B1, B2, B6, and B12, the carrot is a famous root vegetable (Singh *et al.*, 2021). It's a good source of several minerals, too. Since beta-carotene is essential for the production of vitamin A and has been linked to cancer prevention, keeping as much of it as possible during the processing and storage phases is crucial. Carrot juice has gained popularity in the West as a nutritious beverage. The juice yield from carrots is typically around 60-70%, meaning that a significant portion of the carrot's volume remains as leftover pomace after juice extraction. the leftover carrot pomace currently lacks proper utilization (Bohm *et al.*, 1999).

Carrot pomace has an excellent residual level of all vitamins; especially vitamins A, B, and C, nutritional fibers and minerals; nonetheless, it is underutilized as its high moisture content can result in environmental

hazards (approximately 88%). Pomace is a good source of antioxidants, and minerals like calcium, copper, magnesium, potassium, phosphorus, iron, folic acid, and dietary fiber (10 to 20 percent). Owing to its high fiber content and nutritional value, carrot pomace has been added to a variety of foods, such as cookies, wheat rolls, and extruded products (Singh *et al.*, 2021). Apart from being a popular choice for salads, soups, and side dishes, carrots have also made their mark in the world of baking, specifically in the preparation of cakes. One exciting aspect of using carrots in cake recipes is carrot pomace. Carrot pomace, often considered a waste product, has garnered attention recently due to its potential to add nutritional value and enhance the sensory attributes of cakes. By incorporating carrot pomace into cake batter, bakers can introduce natural sweetness, moisture, and a vibrant orange hue, contributing to the overall taste and appearance of the final product. This approach reduces waste and promotes sustainability in the food industry (Gomez *et al.*, 2010).

Oat (*Avena sativa*) is a type of cereal grain. They rank sixth in the world cereal production statistics. They are a good source of protein, fiber, and minerals (Stevens *et al.*, 2004). Oats have drawn a lot of attention due to their high dietary fiber, phytochemical and

nutritional value content. Oat eating is thought to have several health advantages, including hypocholesterolemia and anti-cancerous characteristics. Oats are now thought to be safe for celiac disease sufferers to eat. Oat-based food products such as bread, biscuits, cookies, probiotic drinks, morning cereals, flakes, and infant food are becoming more and more popular due to their high nutritional content (Sabkhi *et al.*, 2013). One of the main elements of soluble fiber is oat beta-glucan (OBG), a viscous polysaccharide formed of a linear branched chain of D-glucose monosaccharides linked by a combination of α (1 $\rightarrow$ 3) and (1 $\rightarrow$ 4) links (Paudel, 2018). It is the primary active ingredient in oats and has a variety of functional and nutritional qualities, especially effects that decrease cholesterol and have anti-diabetic properties (Andrade *et.al.*, 2014).

The purpose of the study was to examine how carrot pomace might be added to gluten-free oat cakes and assess how much nutritional value it could add to oat-based goods. Carrot pomace integration into oat cakes is a potentially beneficial way to improve the finished product's sensory qualities and nutritional makeup. The full potential of this novel ingredient in the creation of oat cakes can be unlocked with additional research and development

activities, including formulation optimization and sensory evaluations.

2. Materials and Methods

2.1. Raw material procurement

The study was conducted at the Department of Food Science and Technology, University of Central Punjab, Lahore-Pakistan. The fresh carrots (*Daucus carota*), and Oats (*Avena sativa*) were selected and purchased from the local market in Lahore, Pakistan. Analytical chemical reagents were purchased from Sigma Aldrich (Sigma-Aldrich Missouri, US).

Table 1. Treatments Plan for Product Development

Treatments	Oat flour %	Pomace powder %
T ₀	100	-
T ₁	95	5
T ₂	90	10
T ₃	85	15

2.2. Preparation of raw materials

Oats were generally prepared by cleaning and sorting, milling, and then finally cooking and processing. Carrot pomace is a by-product that is produced because of carrot

processing, typically from carrot juice or puree production. Carrots are first washed and then processed to extract juice or puree. The extracted pulp known as pomace is usually dried in a hot air oven to reduce moisture content to extend its shelf life. Four different treatments are given in Table 1.

2.3. Proximate analysis of raw material

The raw materials, oats, carrots, and oat flour were evaluated for chemical composition i.e., ash content, and moisture content, and are discussed below:

2.4. Ash content

This method followed by the procedure described in the AACC (2000) method. The ash content of food refers to the mineral content left behind after the complete combustion of the organic matter. It represents the inorganic constituents of the food, including minerals like calcium, phosphorus, potassium, sodium, and others. To measure the ash content of carrots and oats, a method called gravimetric analysis is commonly used. Start by accurately weighing the known amount of the sample you want to analyze. For example, you can weigh 5 grams of finely ground carrots or oats.

The first thing you need to do is to put the sample in a pre-weighed, shallow, and heat-

resistant dish. Put the sample in an oven and dry at a specific temperature, typically around 550°C (1022°F), for a specified period, such as 4-6 hours. This step ensures that all the organic matter in the sample is completely burned off, leaving behind only the inorganic ash.

Once the drying process is complete, take the dish out of the oven and allow it to cool in a desiccator. After cooling, re-weigh the dish with the residual ash to determine the weight of the ash remaining. Calculate the ash content by deducting the weight of the empty dish from the combined weight of the dish with the ash.

$$\text{Ash content (\%)} = \left[\frac{\text{Weight of ash}}{\text{Initial weight of sample}} \times 100 \right]$$

2.5. Moisture content

This method is followed by the procedure described in AACC (2000) method no: 44-15A. The moisture content of carrots pomace and oats flour can vary depending on factors such as freshness, storage conditions, and processing methods. The moisture content of oats flour-made products can range from 10% to 15%, depending on the specific type and processing. Weigh 10 grams of the sample. Put the sample in a pre-weighed, shallow, and heat-resistant dish. Dry the sample in an oven at a specific temperature, typically around 105°C to 110°C (221°F to

230°F), for a specific period, usually between 2 to 4 hours. Afterward, remove the dish from the oven and allow it to cool in a desiccator.

$$\text{Moisture content (\%)} = \left[\frac{\text{Initial weight} - \text{dried weight}}{\text{Initial weight}} \times 100 \right]$$

2.6. Phytochemical analysis

2.6.1. Total phenolic content (TPC)

The total phenolic content of samples was measured using the Folin-Ciocalteu reagent following the method of Verardo *et al.* (2011). After adding 0.2 mL of the Folin-Ciocalteu phenol reagent to 0.2 mL aliquot of the diluted sample that was mixed with deionized water, the mixture was vortexed and made to rest at room temperature for 6 min. Next, 2 mL of 7% NaCO₃ was added, and the mixture was vortexed, and placed at room temperature in a dark place for 90 min. The absorbance was measured at 750 nm using a spectrophotometer, and the total phenolic content was expressed as mg gallic acid equivalents (GAE)/kg FW.

2.7. Antioxidant profiling of extract

2.7.1. DPPH free radical scavenging assay

All the prepared treatments were tested for their antioxidant activity 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging assay developed by Tong *et al.*

(2014). Preparation of DPPH (Sigma-aldrich. USA) at a concentration of 100 mol L 1-methanol was carried out. A 15mL centrifuge tube is filled with 2mL polyphenol extract solution. After adding 2mL of DPPH solution, it was incubated for 30 minutes at room temperature in the dark. The decrease in absorbance at 517nm caused by free radical scavenging activity was measured using a UV-VIS spectrophotometer. The IC₅₀ value for free radical scavenging activity as measured by 1,1-diphenyl-2-picrylhydrazyl (DPPH) was reported.

2.8. Sensory analysis

To check the acceptability and quality of the product, sensory analysis was carried out on a group of 25 volunteers drawn from the faculty, undergraduate and graduate students of the University of Central Punjab in Lahore, Pakistan. The sensory evaluation parameters like taste, color, flavor, evenness of bake, and overall acceptability characteristics were determined using a 9-point hedonic scale by following the method proposed by Wichchukit *et al.* (2015).

There was no celiac disease among the volunteers. The session, color, texture, appearance, flavor qualities, and description of the gluten-free items were all described to all attendees during a 1-hour training session. The cake samples were allowed to cool to

room temperature before being sliced, coded, and presented to the panelists. The panelists used a 9-point hedonic scale in a testing environment with fluorescent illumination to evaluate the arbitrarily presented gluten-free cakes for texture, color, flavor, appearance, and overall acceptability. To eliminate any effect from consumer situations, the customer evaluation of the cakes in different sessions was individually examined. The sensory analysis was done twice.

3. Statistical Analysis

The data were displayed as mean $\pm$ SD (standard deviation) for every analysis. One-way ANOVA was used to statistically analyze the experimental data (analysis of variance). The p-value of less than or equal to 0.05 was used to determine the level of significance.

4. Results and discussion

The objective is to gain a deeper understanding of the findings and their implications about the research's aims. The discussion will address each test individually, highlighting the key observations and their significance. Additionally, comparisons will be made with relevant literature to provide context and support the interpretations.

4.1. Moisture content

The moisture content is usually expressed as a percentage of the total weight of the sample. The Moisture test results demonstrate that the moisture content of the samples varied from 15.8% to 22.7%. The triplicate measurements for each sample also exhibited consistent values, indicating the reliability of the analysis. The below mentioned table no: 2 suggests that the samples contain a significant amount of moisture, which can influence their stability and quality.

Table 2. Moisture analysis

Treatment	T ₀	T ₁	T ₂	T ₃
Moisture%	19.3	21.4	22.8	15.8
	21.1	22.4	22.7	16.1
	18.5	15.8	22.5	15.9
Mean	19.63	19.87	22.67	15.93

T₀=100% oat flour cake, T₁=5% OCP cake, T₂= 10% OCP cake and T₃=15% OCP cake

4.2. Variation between prepared treatments

T₃ had a lower moisture content value (15.93%) in the prepared treatment moisture content comparison study, which is close to the permitted moisture contents of carrot pomace oat cake (10–15%). The moisture

content had shown decreasing behavior with the increase of carrot pomace ratio addition in different treatments. There was the significant difference between T₃, T₂ and T₁ values. Therefore, it showed that the major variation of moisture content was because of carrot pomace as it contains high amount of fibers, having absorbent properties and have the ability to bind water, increasing the proportion of carrot pomace in oat cakes reduces the moisture content. By absorbing extra moisture from other ingredients, these fibers lower the amount of free moisture in the mixture. Increased surface area and baking procedures also help to reduce the amount of moisture in the finished product.

Comparing these results with established standards, it is evident that the moisture content exceeds the permissible limit for similar materials. According to industry guidelines Chantaro *et al.* (2008), the acceptable moisture contents of carrot pomace oat cake typically range between 10% and 15%. Therefore, the high moisture content observed in this study raises concerns about the samples' suitability for certain applications, as it may affect their shelf life and overall quality. Also, it is crucial to investigate the source of high moisture content in different prepared treatments.

4.3. Moisture reduction strategies

To reduce moisture absorption and maintain the integrity of the samples, proper handling and storage procedures should be taken into account. The recipe formulation must be adjusted to create an equilibrium in moisture content by fine-tuning ingredient ratios to control moisture levels during the production and storage of carrot pomace oat cakes (Adiaha, 2017). Furthermore, stabilizing moisture levels can be achieved by pre-treating the carrot pomace by dehydrating or drying it to lower its initial moisture content. Incorporating absorbent components like chia seeds or oat bran into the recipe will help manage moisture even more when processing. Both monitoring and controlling the mixing process closely to avoid over-hydrating the ingredients and modifying baking parameters (such as temperature and time) to maximize moisture retention are essential. Let it cool and dry after baking to reduce any remaining moisture. To maintain texture and freshness, store away from direct sunlight and in materials resistant to moisture. (Kamboj *et al.*, 2020)

4.4. Ash content

The Ash test results of carrot pomace oat cake indicate that the ash content of the samples ranged from 5.33% to 5.82%. The

triplicate measurements for each sample showed consistent values, suggesting reliability and precision in the analysis. The relatively low ash content of the samples suggests that they possess minimal inorganic impurities, which is favorable for their potential applications. The tables 3 show the results of ash content analysis.

Table 3. Ash analysis

Treatment	T ₀	T ₁	T ₂	T ₃
Ash %	5.12	5.33	5.82	5.73
	5.23	5.39	5.76	5.68
	5.46	5.41	5.79	5.71
Mean	5.27	5.37	5.79	5.70

Note: T₀=100% oat flour cake, T₁=5% OCP cake, T₂=10% OCP cake and T₃=15% OCP cake

4.5. Variation between prepared treatments

No significant variation was shown by prepared treatments of cakes having different ratios of carrot pomace and oat flour. The ash content of T₃ was the highest and the moisture content of T₀ was lowest. The difference between the ash content was minimal between different treatments. Comparing these results with previous studies, the ash content falls within the

typical range reported for similar samples. Kırbaş *et al.* (2019) found ash contents ranging from 4% to 6% in a study on similar materials. The similarity in ash content suggests that the samples in this study exhibit a comparable level of purity. The low variability among triplicate measurements indicates the robustness of the experimental procedure and reinforces the validity of the obtained results. However, further investigations could be conducted to determine the composition of the ash and its impact on the samples' properties.

Table 4. Total phenolic content (TPC)

Treatments	TPC (mg/100g GAE)
T ₀	384.88± 0.37 ^a
T ₁	432.24 ± 0.54 ^d
T ₂	478.65 ± 0.83 ^b
T ₃	528.79 ± 0.74 ^c

Note: T₀=100% oat flour cake, T₁=5% OCP cake, T₂=10% OCP cake and T₃=15% OCP cake

4.6. Food with low ash content

Food items with low ash content are pure and have several advantages. It denotes the presence of few non-organic materials or contaminants, guaranteeing higher quality and nutrient richness. Foods with less ash typically have smoother textures and cleaner

tastes, which improve the sensory experience as a whole. They are also less harmful to the environment and simpler to stomach. Low ash level is therefore preferred by consumers who are looking for goods that are healthful, minimally processed, and have the best possible purity and nutritional value. (Spranghers *et al.*, 2017)

4.7. Significance of ash content

In addition, food products' ash level is an important measure of their mineral content and general nutritional quality. It is mostly made up of important minerals that are necessary for many body processes, including calcium, magnesium, potassium, and phosphorus. Additionally, the minerals found in the ash fraction serve as organic preservatives by preventing the growth of spoilage bacteria and lengthening the shelf life. Ash content monitoring helps with quality control, guarantees nutritional composition uniformity, and complies with regulations Anjos *et al.*, 2019). Decisions on storage and packaging are guided by knowledge of the correlation between ash content and shelf life, which helps to preserve product integrity over time. To put it simply, ash content plays a crucial role in formulating products to maximize stability

and shelf life as well as evaluating nutritional quality.

Table 5. Antioxidant activity through free radical scavenging activity

Treatments	DPPH IC50 (ug/mL)
T ₀	21.28 ± 0.70 ^b
T ₁	18.34 ± 0.92 ^a
T ₂	17.46 ± 0.32 ^c
T ₃	15.11 ± 0.23 ^d

T₀=100% oat flour cake, T₁=5% OCP cake, T₂= 10% OCP cake and T₃=15% OCP cake

4.8. Total phenolic content (TPC)

The Total Phenolic Content (TPC) Test provides insights into the phenolic composition of the samples, which is crucial for understanding their potential health benefits and antioxidant capacity.

4.9. Variation between prepared treatments

Comparing the TPC values obtained from the measurements, it is evident that there is variation within each sample. So, with the increase of carrot pomace ratio from 5 to 15%, total phenolic content was increased. The highest TPC value was exhibited by T₃, having 15% carrot pomace and the lowest TPC value was shown by T₀ as it was

prepared with 100% oat flour. There was a significant variation between different prepared treatments.

In comparison to the standard reading, it is evident that the samples exhibit higher TPC values. This suggests that the samples contain a significant number of phenolic compounds, which are known for their antioxidant and health-promoting properties. The TPC values observed in this study are consistent with previous research findings. Ziobro *et al.* (2022) conducted a study on similar samples and reported TPC values, aligning with the TPC values obtained in this study. These results support the notion that the samples possess notable phenolic content.

4.10. Significance of phenolic content

The samples potential as natural sources of antioxidants and their applicability for use in the nutraceutical and functional food industries are indicated by the presence of phenolic compounds in the samples. Food-based phenolic compounds have strong health benefits for consumers because of their antioxidant qualities (Minatel *et al.*, 2017). These substances lower the risk of chronic illnesses like cancer, heart disease, and neurological problems by shielding cells from oxidative damage. By stopping the oxidation of LDL cholesterol, phenolic antioxidants also support cardiovascular

health. They also enhance cognitive performance by lowering brain inflammation. Subsequent investigations may concentrate on pinpointing the particular phenolic compounds found in the specimens and examining their distinct roles in the aggregate antioxidant activity.

4.11. DPPH Analysis

DPPH radical scavenging assay is a common laboratory method used to evaluate the antioxidant activity of substances. It is based on the ability of antioxidants to neutralize or scavenge free radicals, specifically the stable radical 2,2-diphenyl-1-picrylhydrazyl (DPPH). In the DPPH test, a solution of DPPH radical is mixed with the sample being tested, which could be a natural extract, synthetic compound, or a product. The DPPH radical is deep violet in color, but when it reacts with an antioxidant, the color changes to a lighter shade, indicating the reduction or scavenging of the radical. The degree of color change is used to measure the antioxidant activity of the sample.

The DPPH Test results reveal the antioxidant activity of the samples, as indicated by the recorded values. The values from table no: 5 demonstrate the ability of the samples to scavenge free radicals and inhibit oxidation.

To assess the antioxidant capacity of the samples accurately, a standard reading was

utilized, with DPPH values, corresponding to 5%, 10%, and 15% concentrations, respectively. Comparing the sample readings with the standard values, it is evident that the product containing a 5% concentration of carrot pomace exhibits the highest antioxidant activity. This suggests that the samples possess promising antioxidant potential. With the increase in the ratio of carrot pomace, the DPPH value had shown a reduction in antioxidant values. These results align with similar studies conducted on related materials. Manzoor *et al.* (2023) investigated the antioxidant activity of similar samples and reported comparable DPPH values. This consistency reinforces the validity of the findings and supports the notion that the samples possess notable antioxidant properties.

4.12. Mechanism underlying antioxidant activity

There are various reasons for the increased antioxidant activity seen in carrot pomace oat cakes. First of all, phenolic chemicals and carotenoids, both of which are recognized for their antioxidant qualities are abundant in carrot pomace and oats. Furthermore, by binding to free radicals, the fiber in these substances may enhance their antioxidant action. By creating components of the Maillard reaction, baking increases

antioxidant activity even more. Increased antioxidant levels can also be attributed to the synergistic effects of carrot pomace and oats, as well as particular processing and formulation techniques (Olawuyi *et al.*, 2019)

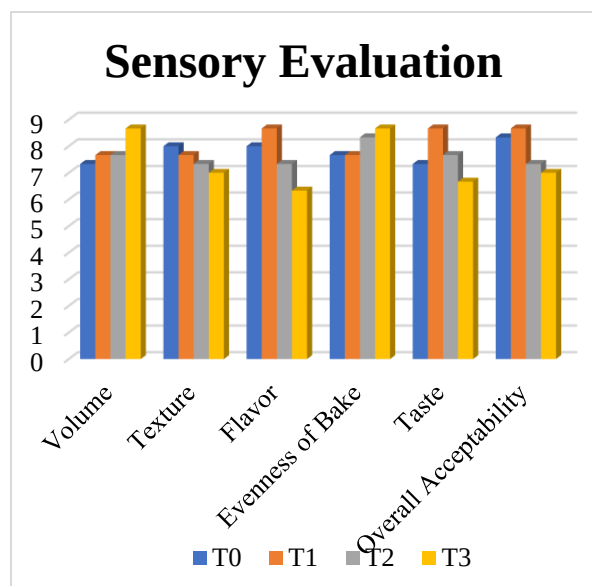


Figure 1. Sensory evaluation of different treatments of cupcakes. T₀=100% oat flour cake, T₁=5% OCP cake, T₂= 10% OCP cake and T₃=15% OCP cake

4.13. Significance of antioxidant activity

Antioxidants are essential for consumer health and product development. They act as organic preservatives in product creation, preserving the freshness and caliber of the final product. Additionally, antioxidants improve stability and draw in clean-label buyers who are health-conscious. Antioxidants shield the body from oxidative damage, which lowers the risk of chronic

illnesses including cancer and cardiovascular disease (Zehiroglu and Sarikaya, 2019). Promoting the consumption of foods high in antioxidants enhances longevity and general health. All things considered, antioxidants are essential for creating healthier products and promoting consumer well-being. To determine which particular antioxidants are in the samples and investigate their modes of action, more research could be done.

4.14. Sensory analysis

To check the acceptability and quality, of the oat cakes different prepared treatments were offered to a panel of judges. The sensory evaluation parameters like taste, volume, aroma, texture, evenness of bake and overall acceptability characteristics were determined using a 9-point hedonic scale. The statistical results regarding the sensory characteristics of oat cakes are presented in Figure 1. It showed variation in different analyzed sensory characteristics of cake treatments prepared with different ratios of oat flour and carrot pomace. The statistical analysis further applied on prepared treatments, proved them as highly significant factors for variations of results. The results depicted non-significant behavior for different treatments.

4.15. Taste and flavor

The mean values for taste depicted decreasing behavior with increasing substitution of carrot pomace from 5 to 15%. The mean score of T₁ was higher than T₂ and T₃ and from control. T₁ has the highest value of taste followed by T₂ and then T₃ which indicated significant variations. The treatment T₀ had also shown less mean value than possessed by T₁. The mean values for flavor had shown decreasing behavior with increasing substitution of carrot pomace from 5 to 15%. There was no significant difference between T₀ and T₁. The mean score of T₁ was higher than T₂, T₃, and from control. T₁ has the highest value flavor followed by T₁. The lowest mean value for flavor was shown by T₃.

4.16. Texture and volume

The mean values for texture had shown decreasing behavior with increasing substitution of carrot pomace from 5 to 15%. The mean score of T₁ was not significantly higher than T₂ and T₃ and was lower than T₀. T₀ had the highest value of texture followed by T₁, T₂, and T₃. The lowest volume mean value was shown by T₃. Mean values for volume depicted increasing behavior with increasing substitution of carrot pomace from 5 to 15%. The mean score of T₃ was higher

than T₁ and T₂ and from control. T₃ has the highest value of volume followed by T₂ and T₁ which exhibited the same mean values for volume. The lowest volume mean value was shown by T₀.

4.17. Evenness of bake and overall acceptability

The mean values for evenness of bake depicted increasing behavior with increasing substitution of carrot pomace from 5 to 15%. The mean score of T₃ was higher than T₁ and T₂ and from the control, T₃ has the highest value of volume followed by T₂ and then T₁. The lowest volume mean value was shown by T₀. Mean values for overall acceptability of cakes show decreasing behavior with increasing substitution of carrot pomace from 5 to 15%. The mean score of T₁ was higher than T₂ and T₃ and from the control, T₁ has the highest value of overall acceptability followed by T₂ and T₃. The lowest volume mean value was shown by T₃. The mean value of T₀ has no significant difference with T₁.

Comparing these results with previous studies, there is a similarity of obtained results with the study of Majzoobi *et al.* (2017). The similarity sensory analysis results suggest that the samples in this study exhibit a comparable level. The low variability among triplicate measurements

indicates the robustness of the experimental procedure and reinforces the validity of the obtained results. However, further investigations could be conducted to determine other sensory characteristics of the different prepared treatment properties.

5. Conclusion

In conclusion, this research focused on the development of oat-carrot pomace cakes as gluten-free products. The study involved proximate analysis (moisture content, and ash content) physiochemical analysis, phenolic content analysis (TPC), antioxidant analysis (DPPH) and sensory analysis. The treatment plan involved incorporating varying amounts of carrot pomace powder in combination with oats flour to create different cake formulations. Incorporating carrot pomace into oat cakes not only adds nutritional value but also helps in reducing waste by utilizing a by-product of carrot processing. The sensory analysis indicated its potential for commercial production and consumer acceptance. The comparative analysis of different prepared treatments of the product showed that T₃ containing 15% carrot pomace had better chemical composition, shelf-life stability, and quality parameters. T₁ having 5% carrot pomace comprises high antioxidant values, also the

most acceptable by the consumers on sensory analysis as it possesses good texture, color, flavor, and appearance characteristics contributing to its quality. The incorporation of carrot pomace into oat cakes to develop nutritious bakery products is a favorable idea from a food industrial point of view. The product was acceptable in the market and provided a great solution in overcoming carrot waste worldwide. Further research is needed to enhance its sensory, nutritional and functional properties. Also, there is a need to analyze the product's impact on human health and well-being. Alternate ways to utilize carrot pomace in other products must be investigated to transform it into a valuable and beneficial food ingredient rather than being just a food waste. So, this research can help in the creation of different nutritious food products that could be ecologically friendly, and appealing to a broad range of consumers.

References

- Adiaha, M. S. (2017). Complete guide to agricultural product processing and storage. World Scientific News, 81(1), 1-52.
- American Association of Cereal Chemists. Approved Methods Committee. (2000). Approved methods of the American association of cereal chemists (Vol. 1). American Association of Cereal Chemists.

- Anjos, O., Paula, V. B., Delgado, T., and Estevinho, L. M. (2019). Influence of the storage conditions on the quality of bee pollen.
- Cubas, C., Lobo, M. G., and González, M. (2008). Optimization of the extraction of chlorophylls in green beans (*Phaseolus vulgaris* L.) by N, N-dimethylformamide using response surface methodology. *Journal of Food Composition and Analysis*, 21(2), 125-133.
- Food, F. S. (2014). Global initiative on food loss and waste reduction. Definitional Framework of Food Loss. Food And Agriculture Organization of The United Nations; FAO: Rome, Italy.
- Hamzalıoğlu, A., and Gokmen, V. (2016). Investigations on the reactions of α -dicarbonyl compounds with amino acids and proteins during in vitro digestion of biscuits. *Food & function*, 7(6), 2544-2550.
- Ikram, A., Rasheed, A., Ahmad Khan, A., Khan, R., Ahmad, M., Bashir, R., and Hassan Mohamed, M. (2024). Exploring the health benefits and utility of carrots and carrot pomace: a systematic review. *International Journal of Food Properties*, 27(1), 180-193.
- Jahanbakhshi, A., Momeny, M., Mahmoudi, M., and Zhang, Y. D. (2020). Classification of sour lemons based on apparent defects using stochastic pooling mechanism in deep convolutional neural networks. *Scientia Horticulturae*, 263, 109133.
- Jahanbakhshi, R., and Ansari, S. (2020). Physicochemical properties of sponge cake fortified by olive stone powder. *Journal of Food Quality*, 2020, 1-11.
- Kamboj, S., Gupta, N., Bandral, J. D., Gandotra, G., and Anjum, N. (2020). Food safety and hygiene: A review. *International Journal of Chemical Studies*, 8(2), 358-368.
- Kırbaş, Z., Kumcuoglu, S., and Tavman, S. (2019). Effects of apple, orange and carrot pomace powders on gluten-free batter rheology and cake properties. *Journal of food science and technology*, 56, 914-926.
- Luca, M. I., Ungureanu-Iuga, M., and Mironeasa, S. (2022). Carrot pomace characterization for application in cereal-based products. *Applied Sciences*, 12(16), 7989.
- Manzoor, M. S., Pasha, I., Younas, S., Zhu, M., Hussain, R., Arqam, U., and Chughtai, M. F. J. (2023). Phenolic acid profile of oat cultivars, and their suppressive effect on intracellular reactive oxygen species. *International Food Research Journal*, 30(1).
- Minatel, I. O., Borges, C. V., Ferreira, M. I., Gomez, H. A. G., Chen, C. Y. O., and Lima, G. P. P. (2017). Phenolic compounds: Functional properties, impact of processing and bioavailability. *Phenolic Compd. Biol. Act*, 8, 1-24.
- Olawuyi, I. F., and Lee, W. Y. (2019). Quality and antioxidant properties of functional rice muffins enriched with shiitake mushroom and carrot pomace. *International Journal of Food Science & Technology*, 54(7), 2321-2328.
- Patwa, A., Malcolm, B., Wilson, J., and Ambrose, K. R. (2014). Particle size analysis of two distinct classes of wheat flour by sieving. *Transactions of the ASABE*, 57(1), 151-159.
- Salim, N. S. M., Singh, A., and Raghavan, V. (2017). Potential utilization of fruit and vegetable wastes for food through drying or extraction techniques. *Nov. Tech. Nutr. Food Sci*, 1(2), 1-12.
- Sarkar, S., and Das, R. (2016). Photoluminescence study of silver nano-hexagons. *Plasmonics*, 11, 551-556.
- Singh, M. N., Srivastava, R., and Yadav, I. (2021). Study of different varieties of carrot and its benefits for human health: a

- review. *Journal of Pharmacognosy and Phytochemistry*, 10(1), 1293-1299.
- Sprangers, T., Ottoboni, M., Klootwijk, C., Oryn, A., Deboosere, S., De Meulenaer, B., and De Smet, S. (2017). Nutritional composition of black soldier fly (*Hermetia illucens*) prepupae reared on different organic waste substrates. *Journal of the Science of Food and Agriculture*, 97(8), 2594-2600.
- Stevens, D. R., Platfoot, G. J., Hyslop, M. G., Knight, T. L., Corson, I. D., and Littlejohn, R. J. (2004). Dairy cow production when supplemented with whole-crop cereal silages in spring and autumn. In *Proceedings of the New Zealand Grassland Association* (pp. 75-82).
- Tong, L.T., L.Y. Liu, K. Zhong, Y. Wang, L.N. Guo and S.M. Zhou. (2014). Effects of Cultivar on Phenolic Content and Antioxidant Activity of Naked Oat in China. *J. Integ. Agric.* 13: 1809-1816.
- Van der Ploeg, R. R., Böhm, W., and Kirkham, M. B. (1999). On the origin of the theory of mineral nutrition of plants and the law of the minimum. *Soil science society of America journal*, 63(5), 1055-1062.
- Verardo, V., Serea, C., Segal, R., and Caboni, M. F. (2011). Free and bound minor polar compounds in oats: Different extraction methods and analytical determinations. *Journal of Cereal Science*, 54(2), 211-217.
- Wichchukit, S., and O'Mahony, M. (2015). The 9-point hedonic scale and hedonic ranking in food science: some reappraisals and alternatives. *Journal of the Science of Food and Agriculture*, 95(11), 2167-2178.
- Zehiroglu, C., and Ozturk Sarikaya, S. B. (2019). The importance of antioxidants and place in today's scientific and technological studies. *Journal of food science and technology*, 56, 4757-4774.
- Ziobro, R., Ivanišová, E., Bojňanská, T., and Gumul, D. (2022). Retention of antioxidants from dried carrot pomace in wheat bread. *Applied Sciences*, 12(19), 9735.