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Research article

Alternative flours from pulp melons (*Cucumis melo* L.): Seasonality influence on physical, chemical, technological parameters, and utilization in bakery product

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ABSTRACT

Fresh vegetables have high water content and low acidity, so drying can extend shelf life, allowing the obtaining of alternative flours for the development of new products. The study aimed to investigate the influence of the melon harvest and off-season on the chemical composition of melon (Cantaloupe, Charentais e Honey Dew) flours and the potential application in products. The flours were evaluated for granulometry, morphology, centesimal composition, lipid and mineral content, total phenolic compound (TPC), antioxidant activity, and technological properties. Cakes containing melon flour were produced to replace wheat flour (0, 25, and 50 %) and evaluated for proximate composition, microbiology, and sensory parameters. Flours were classified as fine-grained (MESH >16), except Charentais off-season (medium - MESH 8–16, and fine-grained - MESH >16), and all presented a rough surface and minimal cell wall ruptures. The harvest homogeneously influenced the humidity, as all the off-season flours showed higher levels [17–22 %] ($p < 0.05$) due to weather conditions. For TPC, Cantaloupe melon flours from the harvest (CFH) [208 mg/100 g] and off-season [877 mg/100 g] stood out ($p < 0.05$), and the latter showed greater antioxidant potential [328 μmol TE/g]. Palmitic, linoleic, and linolenic acid stood out in all flours, and potassium for minerals (63–78 %) in the harvest and off-season. The harvest and off-season specifically influenced the flour of each variety in swelling power, water solubility, oil absorption, and emulsifying capacity. For cakes with CFH, no thermotolerant coliforms and *Escherichia coli* were detected, and the mesophilic count was <1.0 CFU/g. The ash, protein, lipid, and fiber contents increased proportionally to melon flour addition ($p < 0.05$). Sensory acceptance was high for cakes containing 25 and 50 % of CFH [82.78 % and 82.53 %], and most consumers would likely buy the products (4.04 and 3.99) ($p < 0.05$). The study contributed to

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knowledge about the seasonality effect and demonstrated the potential use of melon flour in developing new products.

1. Introduction

Melons (*Cucumis melo* L., Cucurbitaceae) are cultivated in almost all tropical regions of the planet, thus generating a wide diversity of phenotypic characteristics, especially size, shape, skin color and texture, pulp color, sugar content, acidity, flavor, and aroma. Melon is among the most consumed fruits in the world, among those with a large amount of pulp [1]. Some studies have demonstrated consumer preference for orange-fleshed melons [2–4]. These melons are high in vitamin C and provitamin A, minerals, including potassium and magnesium, and antioxidant compounds, such as carotenoids and phenolics [5]. These compounds are associated with a lower risk of chronic diseases due to their anti-inflammatory, antihypertensive, antioxidant, anticancer, and antimicrobial properties [6].

On the other hand, it is known that the chemical composition of fruits can be affected by several internal and external factors, such as ripeness, type of soil, growing conditions, climatic conditions, plant variety, part of the plant consumed, effect pesticides, exposure to sunlight, seasonal conditions, time of year (harvest and off-harvest periods), processing, storage, extraction and analysis conditions, among others [7–9]. In this context, comprehensive investigations to evaluate the correlation of the nutritional value of melons with the time of year are necessary to expand knowledge, considering that studies on this subject are scarce and restricted.

Studies evaluating different parts of melon, such as peels and seeds, to be used as ingredients in the food industry are found in the literature [10–12]; however, studies involving melon pulp are still scarce. Melon pulp's pleasant aroma, color, and high sugar content make it a raw material of interest for the food industry [13]. However, fresh melon has a short shelf life due to rapid deterioration and can last from one to two weeks under ambient conditions or refrigeration, respectively [14]. This rapid deterioration occurs due to the high water content, low acidity, and inadequate storage temperature, which are conditions conducive to developing spoilage microorganisms [15]. Given this, an alternative would be to process the fruit into flour. In this sense, the drying technique is an interesting strategy to promote the preservation and conservation of many foods, reducing water activity and inhibiting the development of microorganisms [16]. Furthermore, studies have reported that drying techniques with milder temperatures (50–60 °C) preserve more bioactive compounds such as carotenoids, vitamins, antioxidants, and polyphenols from fruits and vegetables [17–19].

In addition to extending shelf life, processing to obtain flour represents the insertion of a new ingredient that can improve the nutritional quality of food products consumed by the population. This has been an essential criterion for serving consumers seeking better alternatives and health benefits [20]. The use of alternative flours in food products, such as bakery products, has been investigated to promote the replacement of commonly used refined flours, such as wheat flour, increasing nutritional value and compensating for the loss of nutrients from the processing refining [21–24].

Depending on the type of processing, the characteristics of these flours, and the degree of substitution, total or partial, can benefit products with better nutritional potential than those that use only conventional wheat flour [25,26]. In this sense, functional foods can be considered a favorable option for applying new ingredients in economic, technological, nutritional, and environmental aspects [27]. Baked products are known as high-calorie due to their high carbohydrate content. Therefore, one way to improve these products' nutritional value and functional potential would be to incorporate flours from alternative sources, such as fruits, by partially replacing the wheat flour conventionally used in the formulations. In this way, it improves physical, chemical, and sensory properties [28].

Studies have revealed good sensory acceptance of bakery products made with fruit pulp flour (between 20 and 50 %) replacing wheat flour. In the study by Varastegani et al. [28], using papaya pulp flour (15, 30 and 50 %) replacing wheat flour in the production of cookies, greater global acceptance was found for products made with 50 % papaya flour, demonstrating an Index of Acceptance equal to 92 %. Martins et al. [29] observed in the sensory analysis of bread containing apple pulp flour that tasters preferred bread with 23 % of this ingredient (90 %) compared to the control formulation. Given this, it is observed that, in general, bakery products made with fruit flour (from 10 %) replacing wheat flour have demonstrated good acceptance.

Thus, bakery products widely consumed by the population, such as cakes, are attractive for developing new formulations, as they are easy to prepare, highly acceptable by all age groups, low cost, and allow the replacement of their ingredients [11]. The present study sought to investigate the influence of the harvest period on the chemical composition of flours obtained from the pulp melon varieties and the potential for application as ingredients aiming at the development of new bakery products containing different levels of melon pulp flour to replace wheat flour.

2. Materials and methods

2.1. Obtaining flours from the pulp of commercial melon varieties

Approximately 4 kg per batch (three lots, four melons per batch) of salmon pulp melons (*Cucumis melo* L.) of the Cantaloupe, Charentais and Honey Dew varieties (90 days after flowering, soluble solids content of around 10 °Brix and fruity odor) were purchased in the local market in Natal city (Rio Grande do Norte - RN/Brazil) to obtain the flours in the harvest (September to March) and off-season (April to August) periods. The melons were grown in Mossoró city (Rio Grande do Norte - RN/Brazil) in cambisol-type soil, using organic fertilizers once each harvest and high-frequency drip irrigation.

The raw materials were registered in the National Genetic Heritage Management System and associated traditional knowledge (identification: A5A85DF). The pulp processing was based on Medeiros et al. [30]. After cleaning and sanitization, the pulps were separated from the peels and seeds to be cut (2 cm) and dried in a ventilated oven (TECNAL-TE-394/2-MP) at 55 °C/24 h. After this process, grinding was carried out in an industrial blender until the Cantaloupe, Charentais, and Honey Dew melon pulp flours were obtained during the harvest (CFH, CHFH, and HFH) and off-season (CFO, CHFO, and HFO) periods. They were evaluated for centesimal composition, stored at freezing temperature (−18 °C/approximately twenty days), and protected with aluminum foil during the performance and completion of all analyses.

2.2. Granulometry

Granulometry was determined using a sieve shaker (PRODUTESTE, CIAL Paulínia, model T) at 10 vibrations/second for 20 min. About 65 g of each flour were used, and the separation was carried out on sieves arranged in decreasing order of opening (2000 μm, 1000 μm, 500 μm, 250 μm, 125 μm, 63 μm and <63 μm). Subsequently, the weight of the material retained on each sieve was measured on an analytical balance to determine the classification according to Chen et al. [31].

2.3. Scanning electron microscopy (SEM)

First, a small amount of each flour was inserted into carbon tape fixed to support (stubs) and then metalized with a thin layer of gold. The analyses were carried out in a high vacuum, voltage equivalent to 30 mA/min, with the images accelerated to a voltage of 15 kV and captured at 250× magnification on the Hitachi Tabletop Microscope TM-3000 equipment.

2.4. Centesimal composition

Composition analyses followed the methodologies proposed by the Adolfo Lutz Institute [32] for moisture, ash, and proteins. Lipid determination was based on Hartman and Lago [33] with modifications, adding 17 mL of chloroform, 34 mL of methanol, 14 mL of distilled water, and 5 g of each flour separately, being shaken for 30 min in a shaker at 100 rpm. Then, 17 mL of sodium sulfate solution (1.5 % v/v) were added and stirred for another 2 min. The solution was filtered, and the residue was washed with 17 mL of chloroform, followed by new filtration and separation of the chloroform layer. Subsequently, nitrogen drying was carried out to concentrate the lipids. The total dietary fiber content in the flours was determined according to the Association of Official Analytical Chemistry (AOAC) [34]. The carbohydrate content was determined as proposed by Sniffen et al. [35], and the Atwater factor [32] was used to calculate the total caloric value.

2.5. Mineral profile

The minerals present in the flours were determined using the X-ray Fluorescence technique. First, the samples were prepared by sifting 50 g of each flour through a 150 MESH sieve, and then an amount of flour was added to the sample holder containing a plastic cuvette and film paper. Subsequently, they were evaluated using the EDX-720 equipment (Shimadzu), with a detection limit from Na (11) to U (92) (>0.001 %).

2.6. Fatty acids

The methodology proposed by Hartman and Lago [33] was used with modifications, with previous steps of extraction, saponification, and esterification of the fatty acids. The chromatographic profiles were recorded on a gas chromatograph (Agilent 8860) coupled to a mass spectrometer (Agilent 5977B), autosampler (Agilent G4513A), and Agilent HP-5MS column (30 mm, 0.25 mm and 0.25 μm). Quantification was performed by normalizing the peak areas using the Mass Spectra Database Library (NIST 2017) to identify the fatty acids obtained. The column temperature was 90 °C, and the injector and detector temperature were 230 °C. The elution gradient on the column was 90–150 °C (10 °C/min), 150–200 °C (2 °C/min), and 200–230 °C (10 °C/min) during the run. 39 min. Helium was the carrier gas with a 1 mL/min flow.

2.7. Determination of total phenolic compounds

Methanolic extracts from different flours (5 mg/mL) were obtained according to Ribeiro et al. [36] using ultrasound for 15 min to determine total phenolic compounds. The methodology was based on Singleton et al. [37] with modifications, and the experiment was carried out in triplicate and protected from light. In a 96-well microplate, 75 μL of distilled water, 25 μL of each diluted extract, and 25 μL of Folin-Ciocalteu (50 % v/v) were added, which reacted for 6 min 100 μL of sodium carbonate solution (7.5 % v/v) were added, followed by a 90-min pause to read the absorbances on a microplate reader (Biochrom Asys, UVM 340) at 765 nm. A calibration curve was constructed with different concentrations of gallic acid (Sigma-Aldrich®) (10–90 μg/mL). The result was expressed in milligrams of gallic acid equivalent per 100 g of melon flour (mg GAE/100 g).

2.8. Determination of antioxidant activity

The determination was based on Ribeiro et al. [38] with modifications. The dried extracts containing total phenolic compounds were solubilized in methanol (10 mg/mL), and an ABTS solution (1 mL) was prepared (absorbance = 0.700 at 734 nm). Then, 260 μL of this radical solution were added to the microplate well, with 40 μL of each extract evaluated. The control containing the respective solvent (methanol) and the ABTS + radical was prepared. Subsequently, the absorbances were determined at 734 nm in a microplate reader (Biochrom Asys, UVM 340). The standard curve was prepared with Trolox (100–700 μmol/L). The results were expressed as grams of Trolox equivalent per gram of dry extract (μmol TE/g).

2.9. Technological properties of flours

Flour's water absorption capacity (WAC) was determined using the methodology proposed by Jogihalli et al. [39] with modifications. About 0.5 g of each flour was added to Falcon tubes (previously weighed) containing 10 mL of distilled water. The determination was carried out according to Equation (1).

$$WAC\ (g\,/\,g) : \frac{sediment\ weight}{initial\ weight\ of\ sample} \qquad \text{(Equation 1)}$$

The oil absorption capacity (OAC) was determined based on the methodology described by Jogihalli et al. [39] with modifications. About 0.5 g of each flour was homogenized with 6 mL of soybean oil in previously weighed Falcon tubes. The OAC (g/g) was calculated according to Equation (2).

$$OAC\ (g\,/\,g) : \frac{sediment\ weight}{sediment\ weight\ of\ sample} \qquad \text{(Equation 2)}$$

The flour's water solubility index (WSI) and swelling power (SP) were evaluated according to the methodology proposed by Zhang et al. [40]. Equation (3) was used to calculate WS (%), and Equation (4) was used for SP (g/g).

$$WSI\ (\%) : \frac{dry\ supernatant\ weight}{initial\ weight\ of\ sample} x\ 100 \qquad \text{(Equation 3)}$$

$$SP\ (g\,/\,g) : \frac{wet\ sediment\ weight - initial\ weight\ of\ sample}{initial\ weight\ of\ sample} \qquad \text{(Equation 4)}$$

The emulsifying capacity (EC) and emulsion stability (ES) were evaluated according to the methodology described by Rivera-González [41] with modifications. About 0.5 g of each flour, 4 mL of distilled water, and 4 mL of soybean oil were added to graduated Falcon tubes. The EC (%) was determined according to Equation (5). For ES, the tubes were left to rest for 24 h, and then the determination was carried out according to Equation (6).

Table 1

Proximate composition and mineral profile of flours from the pulps of different melon varieties (Cantaloupe, Charentais, and Honey Dew) obtained in the harvest and off-season periods.

	CFH	CHFH	HFH	CFO	CHFO	HFO
Centesimal Composition						
Moisture (%)	15.70 (1.32)^{aA}	14.00 (0.96)^{bA}	18.80 (0.61)^{cA}	17.20 (0.89)^{aB}	17.60 (1.04)^{aB}	22.10 (0.71)^{bB}
Ash (%)	6.16 (0.44)^{aA}	5.76 (0.18)^{bA}	6.02 (0.31)^{a,bA}	6.43 (0.47)^{aA}	5.25 (0.25)^{bB}	6.17 (0.19)^{aA}
Protein (%)	10.30 (0.58)^{aA}	9.00 (0.87)^{bA}	9.73 (0.87)^{a,bA}	7.13 (0.46)^{aB}	10.80 (0.86)^{bB}	10.70 (1.06)^{bA}
Lipid (%)	3.86 (0.16)^{aA}	3.72 (0.10)^{aA}	3.29 (0.39)^{aA}	5.40 (0.11)^{aB}	3.71 (0.11)^{bA}	4.97 (0.08)^{cB}
Total dietary fiber (%)	7.73 (0.48)^{aA}	5.16 (0.45)^{bA}	7.01 (0.37)^{aA}	10.60 (0.85)^{aA}	11.90 (0.42)^{Ab}	7.05 (0.07)^{bA}
Carboidrates disponible (%)	56.25	62.36	55.15	53.24	50.74	49.01
Caloric value (Kcal/100 g)	301	319	289	290	280	284
Mineral Elements						
Potassium (%)	69.92	78.56	63.02	78.16	78.71	63.82
Calcium (%)	7.64	ND	13.29	ND	ND	13.04
Sulfur (%)	0.89	0.66	0.92	0.88	0.76	0.76
Phosphorus (%)	1.00	1.36	0.74	1.31	1.37	0.96
Iron (%)	0.25	ND	0.41	0.33	ND	0.36
Copper (%)	ND	0.18	0.25	ND	ND	ND
Bromine (%)	ND	ND	0.26	0.18	ND	0.17
Zinc (%)	ND	0.22	ND	ND	ND	ND

CFH, CHFH, and HFH: Flours from Cantaloupe, Charentais, and Honey Dew melon pulps obtained during harvest. CFO, CHFO, and HFO: Flours from Cantaloupe melon pulp, Charentais, and Honey Dew obtained in the off-season.

*Means and SD, n = 9 for each flour (except for fiber, n = 3, available carbohydrates and caloric value).

*The same lowercase letters in different columns do not differ significantly according to Tukey's post-test ($p > 0.05$) for flours from the same harvest or off-season period.

*Equal capital letters in different columns do not differ significantly according to the Student T-test ($p > 0.05$) for flours of the same variety compared between harvest and off-season.

ND: not detected.

$$EC\ (\%) : \frac{Volume\ of\ the\ emulsified\ layer}{Total\ volume}\ x\ 100 \quad \text{(Equation 5)}$$

$$ES : \frac{EC\ after\ 24\ h}{EC\ initial}\ x\ 100 \quad \text{(Equation 6)}$$

2.10. *Preparation of cake containing melon pulp flour*

To prepare the cakes, flour from the pulp of the Cantaloupe melon obtained during the harvest period (CFH) was selected as an ingredient due to the results obtained in the analyses carried out in the present study, and due to the greater availability, easy acquisition, and low cost throughout the year. The formulations were prepared according to Ribeiro et al. [38] with modifications. In this way, cake formulations were produced with different percentages of melon pulp flour (0 %, 25 %, and 50 %) in partial replacement of wheat flour (Table 1 and Fig. 1 – S1). After preparation, the cake batters were placed in rectangular non-stick cake pans (internal length: 35 cm and internal width: 25 cm) previously greased with butter and flour. They were then placed in a preheated oven to bake (180 °C) for approximately 40 min. The cakes were cut using a 2 cm square mold, weighing approximately 15 g (Fig. 2 – S2).

2.11. *Microbiological evaluation and centesimal composition*

The cakes were evaluated for safety by undergoing investigation for coliforms at 45 °C/g [42], mesophiles [42], and *Escherichia coli* [43]. Coliform and *E. coli* cultures were incubated in Levine Eosin Methylene Blue (L-EMB) agar and mesophylls in Standard Counting agar (PCA) for 24 h at 35 °C. The proximate composition analysis followed the methods previously described [32,35], except for the determination of fibers present in the ingredients, which was estimated based on the Brazilian Food Composition Table [44]. Furthermore, the fiber content presented in flour was determined as previously described by the enzymatic gravimetric method [34].

2.12. *Sensory analysis of cakes*

The study protocol was accepted by the Ethics Committee of the Hospital Universitário Onofre Lopes (HUOL) of UFRN (CAAE: 64999417.1.0000.5292). At the beginning of the Analysis, each taster received the Free and Informed Consent Form. One hundred thirty untrained panelists were recruited from the Nutrition Department of the Federal University of Rio Grande do Norte through a questionnaire (Recruitment Questionnaire – S1) aiming to exclude the participation of evaluators with intolerance or allergy to ingredients present in the cake (melon, dairy, wheat, and egg), headache, symptoms as nasal congestion, and aversion to melon. Among the panelists recruited, 69 % were female, and 31 % were male, with an average age of 23 years. The evaluation carried out in individual cabins included global acceptance using a 9-point Hedonic Scale (1 - Disliked extremely to 9 – Like extremely), evaluation of purchase intention on a 5-point scale (1 – Certainly, I wouldn't buy it and 5 – Certainly, I would buy), and the Just About Right (JAR) test (Sensory Questionnaire – S2). All tasters received three cakes containing 0, 25, and 30 % melon flour, duly coded with three random digits in a monadic sequential manner, accompanied by a disposable cup containing mineral water (100 mL) and a cracker type water and salt. From the data obtained, the acceptance index (AI) was calculated (Equation (7)), as proposed by Teixeira et al. [45].

$$AI(\%) = \frac{average\ grade \times 100}{highest\ grade} \quad \text{(Equation 7)}$$

The cakes were evaluated using the JAR scale [46] regarding the attributes of color, sweet smell, sweet taste, and moisture with a variation of 1–5 points (1 = much less intense than I like, 2 = less intense than I like, 3 = ideal the way I like it, 4 = more intense than I like, and 5 = much more intense than I like). The data obtained was investigated using the penalty test, aiming to correlate the tasters' assessment on the JAR scale with the respective global acceptance evaluation for each cake evaluated.

2.13. *Statistical analysis*

Considering the normal distribution of the data obtained, evaluated by the Shapiro-Wilk test, Analysis of Variance (ANOVA) and Tukey's post-test were used ($p < 0.05$) for data on the proximate composition of the flours, total phenolic compounds, lipid profile, and technological properties, compared separately in the harvest and off-season periods, and cake formulations developed. For comparisons between harvest and off-harvest periods of the same type of flour, the data were evaluated by T student test using GraphPad Prism software, version 5.0 (GraphPad Software, San Diego, CA, USA).

For sensory evaluation, the Shapiro-Wilk test was used to analyze data distribution. The non-parametric Kruskal-Wallis test with Dunn's post-test for Multiple Comparisons and Bonferroni correction ($p < 0.05$) was used to investigate the global acceptance data. Principal component analysis was used to create the internal preference map. Penalty analysis was performed to analyze the data obtained for the JAR Scale using the XLStat software (Addinsoft, Paris, France).

3. Results

3.1. Granulometry

According to the results obtained, most flours analyzed (CFH, CHFH, HFH, CFO, and HFO) presented higher retention percentages between MESH 18 and 120 (Table 2–S2), which according to the classification [31] are fine-grained flours (MESH >16). On the other hand, CHFO was the only one that presented a bimodal granule size distribution due to the highest percentages of flour retention being between MESH 10 and 60 (Table 2–S2), classifying it as medium-grained flour (MESH 8–16) and thin (MESH >16).

3.2. Scanning electron microscopy

All flours presented large and small granules (Fig. 3 – S3), with a rough surface and minimal ruptures of the cell walls. Furthermore, all micrographs showed porous particles with small holes on the surface.

3.3. Centesimal composition and mineral profile

Among the harvest flours, HFH had the highest moisture content (Table 1), followed by CFH and CHFH ($p < 0.05$). HFO ($p < 0.05$) showed higher moisture content for the off-season. Comparing the moisture levels found in flours from the same melon variety evaluated in the harvest and off-season periods, a significant difference was observed ($p < 0.05$), achieving an increase equal to 9 %, 25 %, and 17 %, respectively, for CFO, CHFO, and HFO. Regarding ash content, CFH stood out [6.16 (0.44)], especially concerning CHFH [5.76 (0.18)] ($p < 0.05$). In the off-season, the highest ash content was found in CFO and HFO than in CHFO ($p < 0.05$). Furthermore, only Charentais melon presented a significant reduction ($p = 0.0001$) in the off-season than harvest.

For protein content, CFH also stood out [10.30 (0.58)] mainly about CHFH [9.00 (0.87)] ($p < 0.05$). CFO presented the lowest content among the flours evaluated ($p < 0.05$) for the off-season. The comparison between harvest and off-season flours showed a significant reduction (31 %) in CFO and an increase (20 %) in CHFO. For lipid content, there was no significant difference between the flours evaluated during the harvest period ($p > 0.05$), and CFO had the highest lipid content in the off-season [5.40 (0.11)] ($p < 0.05$). Comparing harvest and off-season, there was a significant increase in CFO (40 %) and HFO (51 %), respectively.

When determining fiber, a significant difference was observed between CHFH and the others evaluated for the harvest, presenting the lowest fiber content [5.16 (0.45)] ($p < 0.05$). On the other hand, among the flours considered for the off-season, HFO had the lowest fiber content [7.05 (0.07)] ($p < 0.05$). In comparing harvest and off-season for flours from the same melon variety, a significant increase (130 %) was only found for CHFO about CHFH ($p > 0.05$). Regarding available carbohydrates and caloric value, it was found

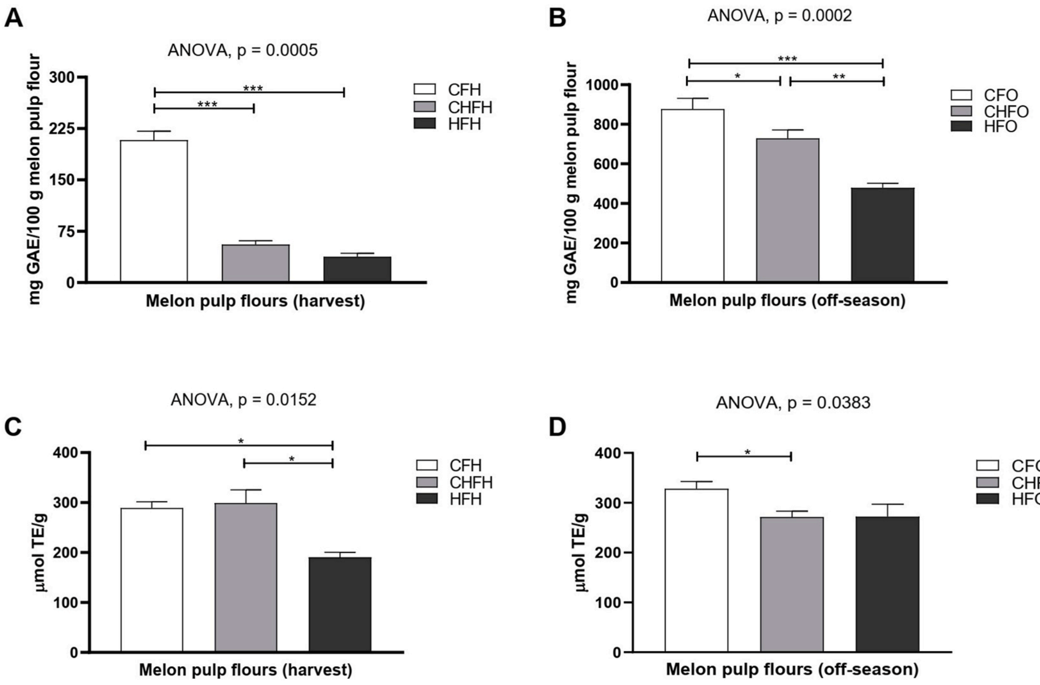

Fig. 1. Total phenolic compounds and antioxidant activity of phenolic extracts from and off-season. ANOVA and Tukey post-test, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. CFH, CHFH, and HFH: Flours from Cantaloupe, Charentais, and Honey Dew melon pulps obtained during harvest. CFO, CHFO, and HFO: Flours from Cantaloupe melon pulp, Charentais, and Honey Dew obtained in the off-season, respectively.

that CHFH had higher content and calories (319 Kcal/100 g).

For the minerals profile, it was observed that potassium was the predominant mineral in all flours evaluated in the harvest (63.02–78.56 %) and off-season (63.82–78.71 %) periods. Calcium was the second principal mineral, but only in Honey melon flour was detected in the harvest (13.29 %) and off-season (13.04 %) periods. Sulfur and phosphorus, despite reduced levels, were detected in all flours from the harvest and off-season, unlike other minerals such as iron, copper, bromine, and zinc.

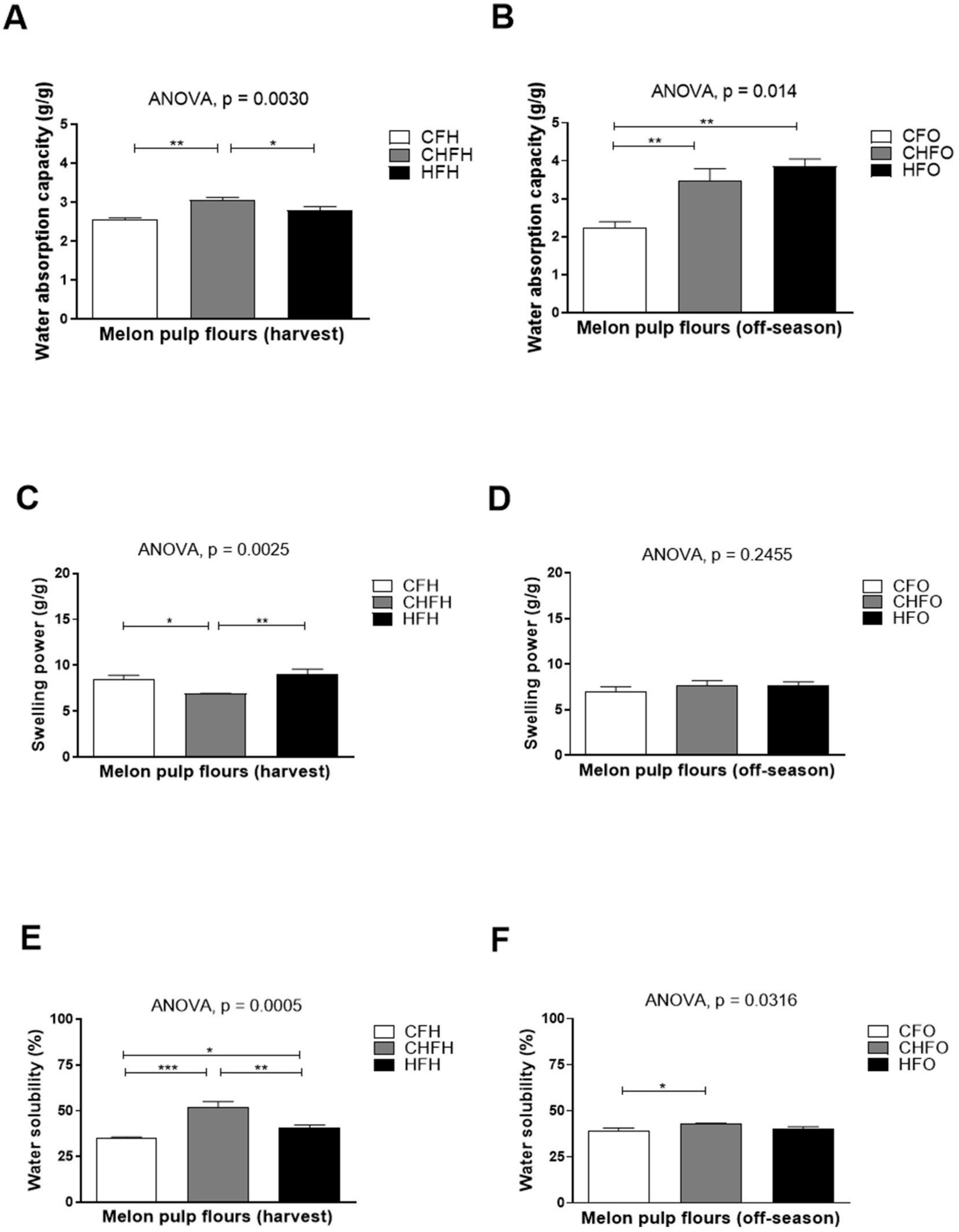

Fig. 2. Results obtained for water absorption capacity, swelling power, and water solubility of the different flours obtained from the pulp of different melon varieties (Cantaloupe, Charentais, and Honey Dew) in the harvest and off-season periods. ANOVA and Tukey post-test, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. CFH, CHFH, and HFH: Flours from Cantaloupe, Charentais, and Honey Dew melon pulps obtained during harvest. CFO, CHFO, and HFO: Flours from Cantaloupe melon pulp, Charentais, and Honey Dew obtained in the off-season, respectively.

3.4. Fatty acid

The results (Table 3–S3) showed higher percentages of palmitic acid (29.40–41.60 %), linolenic acid (20.60–29.30 %), and linoleic acid (11.20–22.0 %) in all flours, both in the harvest period and in the off-season. Regarding comparing flours obtained in the harvest and off-harvest periods, it is clear that palmitoleic acid differed statistically in all flours off-harvest, observing that CFO [9.27 (0.45)] ($p = 0.0362$) and CHFO [11.60 (0.33)] ($p = 0.0032$) presented the highest contents. As for palmitic acid, there was a difference observed for Cantaloupe ($p = 0.0207$) and Honey Dew ($p = 0.0007$) flours with higher levels in the harvest [36.70 (3.27) and 35.90

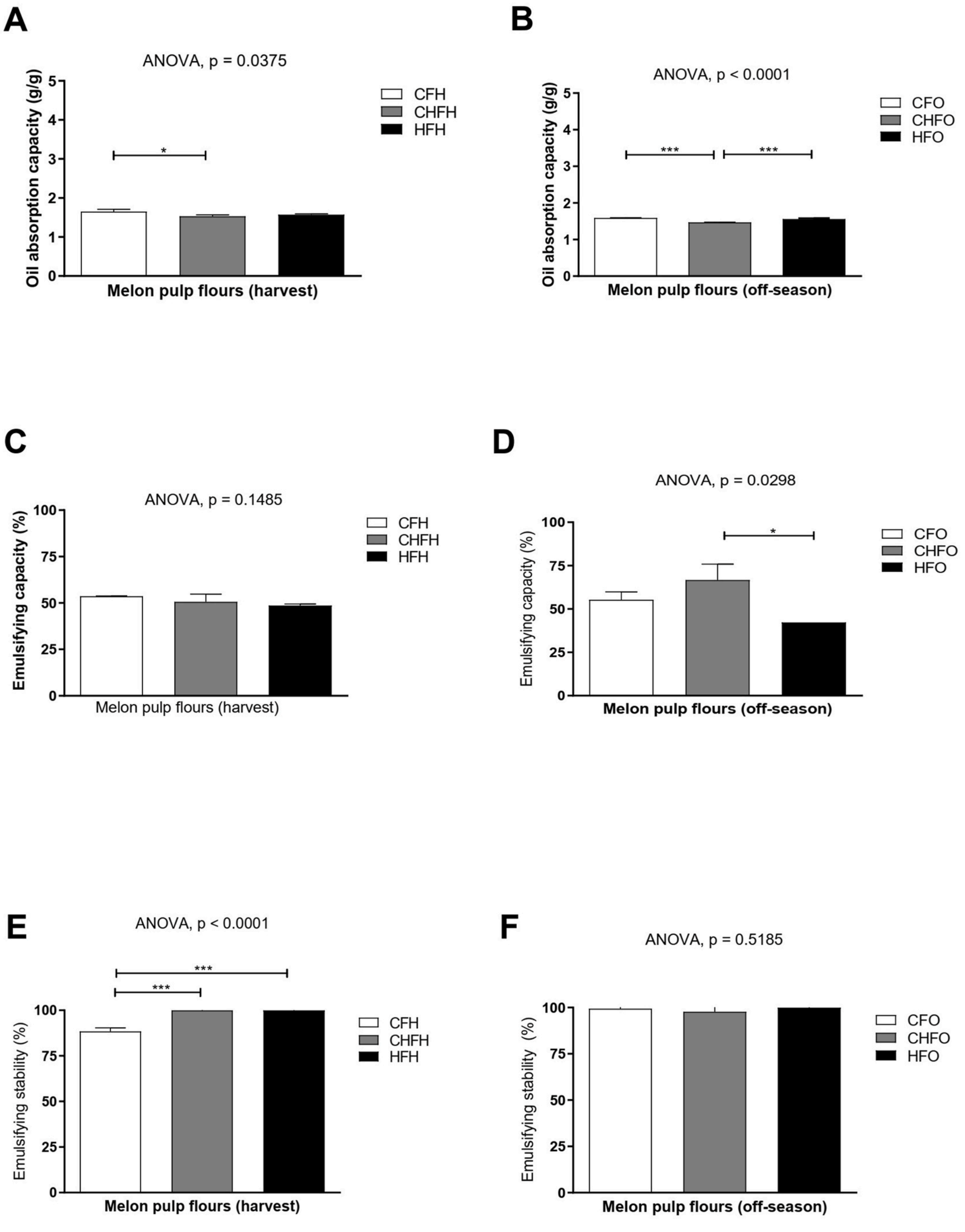

Fig. 3. Results obtained for oil absorption capacity, emulsifying capacity, and emulsifying stability of the different flours obtained from the pulp of different melon varieties (Cantaloupe, Charentais, and Honey Dew) in the harvest and off-season periods. ANOVA and Tukey post-test, $^{*}p < 0.05$ and $^{***}p < 0.001$. CFH, CHFH, and HFH: Flours from Cantaloupe, Charentais, and Honey Dew melon pulps obtained during harvest. CFO, CHFO, and HFO: Flours from Cantaloupe melon pulp, Charentais, and Honey Dew obtained in the off-season., respectively.

(0.03), respectively], and there was a difference between Charentais flours ($p = 0.0001$) with higher content in the off-season [41.60 (0.89)]. Regarding linoleic acid, higher levels were noted in the off-season for Cantaloupe [21.10 (0.49)] ($p = 0.0008$) and Honey Dew [22.00 (0.67)] ($p = 0.0110$) flours and for Charentais flours ($p = 0.0004$) with higher content in the harvest [16.30 (0.79)]. And the same pattern was observed for the linolenic acid showed higher levels in the off-season for Cantaloupe [25.20 (0.19)] ($p = 0.0107$) and Honey Dew [29.30 (1.08)] ($p = 0.0038$) flours, and during the harvest for Charentais flours [25.60 (0.62)] ($p = 0.0003$).

3.5. *Total phenolic compounds and antioxidant activity*

During the harvest period (Fig. 1A), CFH showed higher levels of total phenolic compounds [208.1 (13.12) mg GAE/100 g] ($p < 0.05$) than other flours, with the same behavior observed for CFO [877 (54) mg GAE/100 g] ($p < 0.05$) in the off-season (Fig. 1B). Regarding the comparison between the harvest and off-season periods, the results demonstrated a significant difference ($p < 0.05$) between all flours, with the highest levels obtained in the off-season. For the ability to sequester the ABTS+ from extracts of flour obtained in the harvest period (Fig. 1C), CFH and CHFH demonstrated greater antioxidant potential (289 and 299 μmol TE/g, respectively) than HFH ($p < 0.05$). A similar behavior was observed in the off-season (Fig. 1D). CFO had greater antioxidant potential (328 μmol TE/g), differing only from CHFO ($p = 0.0386$). The results demonstrated no significant difference ($p > 0.05$) comparing the harvest and off-harvest periods of flours from the same melon variety.

3.6. *Technological properties of flours*

Regarding water absorption capacity, the results showed that CHFH had the highest capacity among flours ($p < 0.05$) during the harvest period (Fig. 2A), and CFO had the lowest among flours during the off-season ($p < 0.05$) (Fig. 2B). Besides, no significant difference was observed between the harvest and off-season periods ($p > 0.05$). For swelling power (Fig. 2C and D), the results indicated that CHFH presented the lowest value among the flours of the harvest ($p < 0.05$). Furthermore, it was observed that there was a significant difference between harvest and off-season periods for CFH ($p = 0.0205$) and HFH ($p = 0.0326$), being higher in the harvest.

For water solubility (Fig. 2E and F), CHFH stood out concerning other flours during the harvest period ($p < 0.05$), just as in the off-season, there was a difference between CFO and CHFO ($p < 0.05$), presenting higher values for Charentais melon flours both in the harvest and in the off-season. Only CFH e CFO differed statistically ($p = 0.0048$), with water solubility higher in the off-season.

Regarding oil absorption capacity (Fig. 3A and B), CFH and CHFH differed statistically ($p < 0.05$), and in the off-season, CHFO presented the lowest value than the others ($p < 0.0001$). Comparing harvest and off-season, CHFH and CHFO differed ($p = 0.0409$), with the highest value in the harvest. For emulsifying capacity (Fig. 3C and D), CHFO presented the highest index (60.24 %) than HFO ($p = 0.0298$) (Fig. 3D). The results for season flours ranged from 48.6 to 53.7 %, and for off-season flours from 42.20 to 66.7 %, with only Honey Dew flours showing a significant difference ($p = 0.0002$) between the evaluated periods.

The data obtained for emulsion stability (Fig. 3E and F) indicated that, during the harvest, there was a variation of 88.6–100 %, and for the off-season, all presented values equal 100 %. It was found that CFH had the lowest percentage compared to the others during the harvest period. As a result, a difference ($p = 0.0013$) was only observed between Cantaloupe melon flours obtained during the harvest and off-season periods.

3.7. *Microbiological analysis of cakes*

Firstly, it is worth highlighting that the flour chosen as the ingredient for making the cakes was Cantaloupe melon pulp flour obtained during the harvest period. Therefore, the results of the microbiological analyses of the cakes were favorable. No thermotolerant coliforms and *Escherichia coli* were detected, and the mesophilic count was low (<1.0 CFU/g).

Table 2
Proximate composition of the evaluated cakes.

	A	B	C
Moisture (%)	27.90 (0.16)^{a}	24.10 (0.23)^{b}	23.20 (0.18)^{c}
Ash (%)	1.48 (0.04)^{a}	1.90 (0.13)^{b}	2.37 (0.08)^{c}
Protein (%)	7.68 (0.12)^{a}	8.17 (0.35)^{a}	8.86 (0.19)^{b}
Lipid (%)	12.50 (0.15)^{a}	13.90 (0.25)^{b}	14.00 (0.28)^{b}
Fiber (%)	0.69	1.00	1.32
Carboidrates disponible (%)	49.75	50.93	50.25
Caloric value (Kcal/100 g)	342	361	362

A, B, and C: 0, 25, and 50 % CFH replacing wheat flour, respectively.
Mean and SD, n = 3 (except for fiber, available carbohydrates, and caloric value).
The same lowercase letters on the line do not differ significantly according to Tukey's post-test ($p > 0.05$).
*Brazilian Food Composition Table - TBCA (2023) for evaluation of ingredients except for CFH.

3.8. Centesimal composition of cakes

It was found that the moisture content of the cakes evaluated reduced as the percentage of addition of Cantaloupe melon pulp flour increased ($p < 0.05$) (Table 2). On the other hand, an increase in ash was directly proportional to the addition of CFH ($p < 0.05$), reaching 28 % (cake containing 25 % CFH–B) and 60 % (cake containing 50 % CFH–C) than cake containing 0 % CFH (A). Regarding protein content (Table 2), there was a significant difference between the cake containing 50 % CFH replacing wheat flour (C) and the others evaluated ($p < 0.05$), representing an increase of 15 %. An increase was observed for lipids, equivalent to 12 % in cakes containing CFH ($p < 0.05$). Concerning fiber content, the highest percentage was found for cake C (1.32 %) and B (1.00 %), and it was higher than A (0,69 %). Besides, cake B (25 % CFH) presented the highest carbohydrate content (50.93 %). About caloric value, the highest results were evident for cakes B (361 Kcal/100 g) and C (362 Kcal/100 g).

3.9. Sensory analysis of cakes

It is noted that cakes B (25 % CFH) and C (50 % CFH) (Table 3) stood out in the acceptance index (AI) than cake A (0 % CFH). On the other hand, based on the medians obtained, there was no significant difference ($p > 0.05$) for the acceptance of the different cakes evaluated, even B and C presenting higher median values than cake A, which may be an effect of interquartile distance values.

In the preference map (Fig. 4), the cakes are distributed in different quadrants, which exposes the difference between consumer preferences. Furthermore, given the distribution of tasters represented in these quadrants, the cakes were accepted similarly, with a slight reduction in preference for cake A (0 % CFH), corroborating the data obtained for the acceptance index.

The results obtained for the evaluation of purchase intention (Table 4–SS4) showed that cake B (25 % CFH) had the highest percentage for the “I would certainly buy” option (36 %), followed by cake C (50 % CFH) (29 %). Furthermore, these cakes also obtained higher percentages in the “would probably buy” category, meaning a favorable aspect in incorporating melon flour to replace wheat flour. The average purchase intention was higher for B (25 % CFH) and C (50 % CFH) than for A (0 % CFH) (Table 4). Based on the medians obtained (Table 4), it is possible to infer that the cakes containing melon flour stood out concerning cake A (0 % CFH) ($p < 0.05$).

3.10. JAR

Cakes B (25 % CFH) and C (50 % CFH) presented higher percentages for the ideal in color, sweet smell, and moisture compared to cake A (0 % CFH) (Tables 5, 6, and 7– S5, S6, and S7, and Fig. 4 A, B, and C – S4). For cake A (0 % CFH), the penalty assessment (Fig. 4 A – S4) showed that the attributes of sweet taste and sweet smell present in lower intensity caused the highest effect on the mean drop. For cake B (25 % CFH) (Fig. 4 B – S4), it can be seen that for a sweet flavor that was more intense and less humid than ideal, those presented the highest percentages of considerations from the tasters, with the more intense sweet flavor having the most significant impact on the acceptance of this attribute, due to the more substantial effect on the mean drop. The penalty evaluation data for cake C (50 % CFH) (Fig. 4C – S4) indicated that the darker color most affected the acceptance average, as it had a more significant effect on the mean drop, followed by a more intense sweet flavor and more intense moisture.

4. Discussion

The study of physical parameters is critical since the particle size of the flour directly influences several aspects of the bakery product quality, such as the water absorption index, texture, sensory quality, and the product visual aspect [47]. The results revealed that grinding managed to produce smaller granules (<63 μm), with results similar to those obtained by Oliveira et al. [48] for Cantaloupe melon pulp flour. It is worth noting that, in bakery products, the use of medium-grain flour provides more firmness to the final product, while fine-grain flour provides more softness [49].

A limitation of the study was the non-use of a mill to grind the flour. However, it is known that flours with different granule sizes have different nutritional compositions and levels of bioactive activity. Therefore, using all fractions is essential to obtain the maximum nutrients and bioactive compounds from flour [50]. It is worth noting that the differences observed between flours may be related to the characteristics of each melon variety, the preparation of the raw material before crushing (cut size and drying temperature and time), and the crushing process [51].

In all micrographs, it was possible to notice the presence of small holes on the material's surfaces, possibly formed by the removal of water during the drying process [52]. This occurs when drying temperatures reach 50 °C, generating the beginning of the collapse of cell membranes, and consequently, intracellular water is transported to the intercellular environment [53]. Furthermore, it suggests

Table 3
Acceptance Index obtained for the cakes evaluated according to the global acceptance analysis using a nine-point Hedonic Scale.

	A	B	C
Median (interquartile distance)	7.00 (2.00)^a	8.00 (1,00)^a	8.00 (2.00)^a
AI (%)	78.63	82.78	82.53

A, B, and C: 0, 25, and 50 % CFH replacing wheat flour, respectively. AI = acceptance index.
The same lowercase letters on the same line do not differ significantly according to Dunn's post-test ($p > 0.05$).

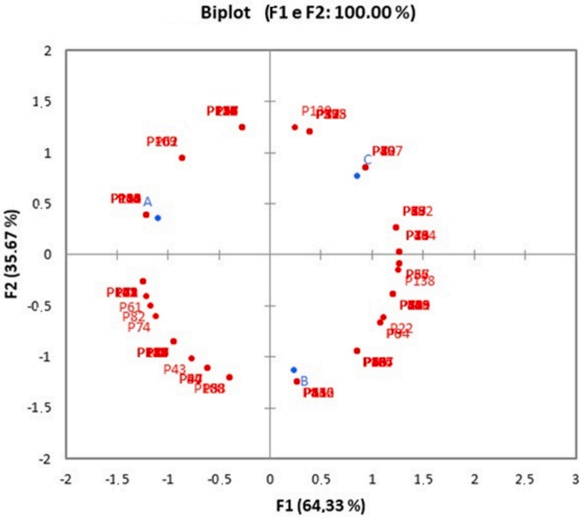

Fig. 4. Internal preference map of the tasters who participated in the sensory evaluation of the cakes. A: Standard formulation without the presence of Cantaloupe melon pulp flour. B: Formulation with 25 % Cantaloupe melon pulp flour replacing wheat flour. C: Formulation with 50 % Cantaloupe melon pulp flour replacing wheat flour.

Table 4
Results obtained for the purchase intention of tasters about the cakes evaluated.

	A	B	C
Average purchase intention (standard deviation)	3.66 (0.96)	4.04 (0.91)	3.99 (0.86)
Median (interquartile distance)	4.00 (1.00)^{a}	4.00 (2.00)^{b}	4.00 (1.00)^{b}

A, B, and C: 0, 25, and 50 % CFH replacing wheat flour, respectively.

that the temperature used in the drying process was sufficient to remove water, not causing greater damage to the cellular matrix [54], reducing the loss of heat-sensitive nutrients and bioactive components of the fruit [55]. Foods of plant origin exposed to drying processes can appear hygroscopic, porous, and amorphous [53], facilitating incorporation into a food matrix.

The harvest and off-season periods can directly influence the nutritional quality of melons due to their relationship with climatic factors. The melon harvest period from September to March is characterized by high temperatures, high light, and low relative humidity, favorable conditions for healthy development [56]. On the other hand, the effect of harvest and off-season periods can be dubious. Therefore, productivity, sensory, and nutritional characteristics may be less beneficial in the off-season. However, other aspects may be favored, such as the content of bioactive compounds [57].

The evaluation of moisture evidenced that Honey Dew melon flours (HFH and HFO) present high humidity, which can be justified by intrinsic factors that constitute the genotype and endogenous hormones of this variety, such as having pulp more juiciness [58]. A homogeneous behavior was also observed concerning the comparison between harvest and off-season, as in the off-season, all flours presented significantly high moisture contents, which can be justified by the climatic condition in the vegetable growing environment (microclimate), which influences plants physiological reactions, and the energy exchange activities between the plant and the environment. Soil moisture and local temperature can affect plants' ability to use water and their flooding mechanisms [59]. Furthermore, during the off-season, greater concentrations of rainfall are observed in the melon-growing region, increasing soil moisture, which will be absorbed by the vegetable [60].

Concerning ash content, CFO stood out, especially concerning CHFO ($p < 0.05$). The lower ash content presented by CHFO may indicate a lower mineral content than the other melons evaluated. It is important to highlight that different growing conditions influence the concentration of minerals in the melon, thus affecting the ash content [60]. Given the other results, it can be inferred that the harvest and off-season periods had a specific influence on the ash, protein, lipid, and fiber contents, not being characterized as a homogeneous behavior observed for the moisture content. Therefore, these levels may have been influenced by different cultivation conditions; salt stress that affects the plant's nutrition system, causing reduced water and nutrient absorption [60,61]; changes at the nutritional level resulting in ionic imbalance generated by the dispute between sodium ions and nutrients, reducing the absorption of minerals [61]; types and frequent use of fertilizers in combination with irrigation, which can promote root growth by substantially increasing protein content and improving fruit quality [62]; by the varieties and genotypes of melons considering the repetitions of observed behavior [58]; soil type and pH, and climatic conditions (temperature and humidity) [63].

Regarding available carbohydrates and caloric value, it was found that CHFH had higher content and calories, which can be justified by the influence of lower values of moisture, ash, and proteins since the same was determined by difference. Furthermore, the carbohydrate content is influenced by favorable cultivation conditions due to the increase in photosynthesis, and thus, an increase in carbohydrate metabolism occurs [5,60]. Therefore, the results highlight the nutritional potential of these flours during the harvest period, mainly CFH and HFH, in terms of ash and protein content, reflecting lower values for total carbohydrates and caloric value.

The predominant minerals in the flours identified in this study (K, Ca, and P) were similar to those obtained by Mahwish et al. [64] when evaluating the mineral profile of Black King melon pulp flour by Atomic Absorption Spectrometry. Mallek-Ayadi et al. [65] observed that potassium was the most abundant mineral in Maazoun melon pulp, followed by calcium. Furthermore, Maietti et al. [66], when analyzing the minerals in the dry pulp of Giusto and Baggio melons in two different harvests, using Atomic Absorption Spectrometry, showed that potassium was the most abundant in both varieties. The authors also highlighted that the potassium content was higher for both melon varieties in the second harvest (less rainy and with lower average temperatures). Therefore, these results may be related to climatic variations that impact the plant's physiological response. Potassium is the most abundant mineral in melon, regardless of the variety. The concentration of antioxidants, such as ascorbic acid and beta-carotene, is directly associated with potassium concentration. Therefore, this parameter depends on melon cultivation's environmental and agricultural conditions [66].

Regarding proteins, Brazilian legislation establishes a minimum limit of 8.00 % for the content in whole wheat flour [67]. Therefore, the average values found for most melon pulp flours evaluated follow the legislation. Finally, good cultivation conditions influence carbohydrate content due to increased photosynthesis and carbohydrate metabolism [5,60]. Refined (white) and whole wheat flours have 75.53 % and 70.02 % carbohydrates [44], respectively, thus demonstrating higher values than the present study, indicating an interesting aspect for the flours analyzed. Regarding caloric value, wheat flour has 360 Kcal [68], and whole wheat flour has 339 Kcal [69], with caloric values higher than those found for all melon pulp flours analyzed. Given this, it can be seen that the melon flour examined has a chemical composition (fibers from 5.16 to 11.90 % and proteins from 7.13 to 10.80 %) that is outstanding about wheat flour commonly used in various food formulations.

Different fatty acids were found between harvest and off-season flours for the lipid profile. These differences may be related to the intrinsic factors that constitute the genotype and endogenous hormones of each melon, to climatic conditions, which can cause lipid oxidation, to post-harvest conditions such as inadequate transportation, storage, and handling, causing damage, and thus may cause lipid oxidation affecting the metabolic activity of the fruit [60,70,71]. According to studies published in the literature, it is clear that linoleic and linolenic acids are those with the highest levels in the different types of melon evaluated, corresponding to the findings of the present study [72–74].

It is known that phenolics can protect cellular components against free radicals generated by stress through their antioxidant, anti-inflammatory, hypolipidemic, antibacterial, and free radical scavenging properties [65]. Therefore, they promote the sequestration of free radicals, harmful products of aerobic metabolism that cause oxidative stress in the body, reducing the risk of developing diseases [75]. In plants, stress conditions such as temperature changes, exposure to ultraviolet radiation, and pest attacks can induce defense mechanisms, influencing the phenolic content [76]. The results showed a homogeneous influence of seasonality, with the off-season being the period of the plant's greatest production of these molecules. The observed variations can be explained by differences in gender, species, cultivar, irrigation frequency, state of maturity, type of fertilizers used in planting, soil [77], and climatic conditions, such as temperature that is lower during this period because phenolic compounds are sensitive to heat [57].

On the other hand, when evaluating antioxidant activity, the results did not indicate a homogeneous influence such as that found for the content of total phenolic compounds. This may be related to the types of bioactives produced by the vegetable during the harvest and off-season periods, which were not evaluated and are considered a limitation of the present study. However, the prominence of Cantaloupe melon flour both in the harvest and in the off-season may be associated with the preservation method, storage temperature, antioxidant enzyme activities, and accumulation of antioxidants in the fruit [78]. It is worth noting that, in the literature, no studies were found related to determining antioxidant activity by ABTS using Trolox in melon pulp flour and similar drying methodology. The results observed in the present study were close to those found for other fruits considered to have a high antioxidant content, such as strawberries, as [79] found an antioxidant activity of 279.89 (18.98) μmol Trolox/g.

Technological properties are known as intrinsic physical-chemical aspects of a given flour, commonly associated with the interaction with water and oil, and may indicate the technical impact of a given ingredient applied to a food product. The success of using fruit flour in food products consists of technological properties [80]. No published studies related to the investigation of technological properties in melon pulp flour, nor comparisons related to seasonality, were found in the literature.

Water absorption and swelling power are relevant for many products due to the water that interferes with texture and juiciness. Furthermore, high water absorption prevents water loss during cooking, reducing product dryness [81]. The presence of hydrophilic groups in flour that bind to water indicates the ability of this flour to absorb water [82]. The values found in the present study for water absorption may be directly related to the dietary fiber content of the flours and the type of fiber. Therefore, flours with low levels of soluble fiber have low water absorption capacity due to less chemical interaction with hydrophilic groups [83]. In addition to the chemical structure and reactions between molecules, the hydration properties of dietary fibers also depend on other factors, such as drying temperature, fiber porosity, and particle size [84]. And this may have influenced the differences between the flours in the present study.

Swelling power is the first phase of the solubilization of polysaccharides with water that disperses in the product structure and generates the dispersion of macromolecules, which can promote solubilization [84]. The results obtained for swelling power were higher than those of Resende et al. [84] when evaluating buriti pulp flour, getting 5.86 g/g. These results may be related to the melon harvest period, as it is the time of year that presents the most suitable climatic conditions for the healthy development of the melon tree, providing balanced absorption of water and nutrients [85].

The water solubility index defines the amount of water-soluble matter in a product [84]. The results may be related to the presence of sugars in flour [86]; therefore, it is worth highlighting that CHFH presented a higher water solubility index and a higher total carbohydrate content. It may also be related to the drying temperature used to obtain the flour, as low drying temperatures (40–70 °C) cause high solubility values [86]. The low water solubility index is undesirable because it limits its application in various food products [81]. Santos et al. [86] evaluated the water solubility of red pitaya peel flours and found 30.14 %, below those found in the present study (35.4–49.3 %), thus demonstrating a more significant advantage of using melon pulp flours as ingredients in the formulation of food products.

The interaction between protein parts of the sample and oil molecules is the main characteristic for determining the oil absorption capacity. High oil absorption rates indicate flour's ability to be used in food products, such as emulsified preparations [87]. Oil absorption capacity is used in cooked foods to increase the fat retention rate during cooking, preserve flavor, improve palatability, increase technological yield, and extend the product's shelf life [84]. Xu et al. [88] reported that the high protein content can improve emulsifying properties, considering that emulsification begins by binding the protein to the oil droplets, considering the surfactant property that proteins present. CFH and CHFO had higher emulsifying capacity indexes (59.5 and 60.24 %, respectively) and higher protein contents among the other flours analyzed. Santana et al. [87] reported that banana flour presented emulsion stability of 40.12 %, thus demonstrating that melon pulp flours stood out in this parameter (88.6–100 %).

From the present study, the investigated melon flours have a prominent chemical composition concerning wheat flour commonly used in various food formulations. It was demonstrated that among the flours evaluated, the best ingredients for the favorable development of bakery products were CFH and HFH, presenting higher ash and protein contents. On the other hand, CFH also showed higher fiber content and lower moisture content (15.7 %), which is close to that established [89], which provides specific moisture requirements maximum for flours of 15.0 %.

The cakes were made using flour from Cantaloupe melon pulp, in partial replacement of wheat flour (0, 25, and 50 %) commonly used in bakery products, aiming to improve the nutritional value of this product widely sold on the market and consumed by the population. The products were previously investigated for microbiological safety, confirming correct hygienic-sanitary control during the preparation and conservation of food, following Good Practices for Food Handling [90], which guaranteed the safety of using CFH.

About the proximate composition of the cakes, it can be inferred that using 25 and 50 % melon flour replacing wheat flour promotes effects such as reducing moisture. This effect was also observed by Martins et al. [29] when evaluating the proximate composition of bread developed with apple pulp flour, presenting 49.71, 47.18 and 45.93 % moisture, respectively, for control bread, and added 17 % and 23 % of apple flour. This decrease in moisture may be due to the Cantaloupe melon pulp flour having a lower water absorption capacity than wheat flour (56 %).

On the other hand, for ash, it should be noted that replacing wheat flour with melon pulp flour promotes an increase in the nutritional potential of the product. Studies have also observed this increase in baked products with other fruit flour. Varastegani et al. [28] found 2.62 %, 3.30 %, and 3.84 % ash values, respectively, for biscuit formulations containing 15, 30 and 50 % papaya pulp flour. The same pattern of increase in protein content was also noticed, and some studies with bakery products made with fruit flours demonstrated a positive effect [91]. According to Normative Instruction No. 75 of October 8, 2020 [92], food classified as a source of protein must contain at least 5 g per 60 g/portion of cake. Therefore, the cake made with 50 % melon flour was classified as a source of protein, presenting 5.32 g/portion.

For lipid content, it was possible to observe that the presence of melon flour may have increased the percentage of lipids in the product. Compared to other bakery products, coconut cake has 11.3 % lipids [68], and carrot cake has 17.26 % lipids [93].

Regarding fiber content, it was found that there was also an increase directly proportional to the addition of CFH. The daily fiber recommendation for a healthy adult is 25 g [92]. Therefore, a 100 g portion of cake (equivalent to a medium slice) with 50 % replacement of wheat flour with melon pulp flour contributes 5.28 % of the daily fiber recommendation. It is worth noting that, to evaluate the fiber content present in cakes with melon flour, the fibers present in this flour were determined using the enzymatic method, which is considered the gold standard for this determination. On the other hand, this determination cannot be carried out on cakes due to laboratory limitations. Therefore, this data was associated with the fiber content present in the other ingredients of the cake [44] to estimate the content present in cakes B (25 % CFH) and C (50 % CFH).

For carbohydrates, it was noted that adding melon flour contributed to the slight increase in content. Finally, it was evident that melon flour contributed to the rise in caloric value, which may be related to the highest carbohydrate, protein, and lipid content among other cakes. A 100 g portion of coconut cake has 333 kcal [68], and carrot cake has 345 kcal in a 100 g portion [93], which are caloric values close to those obtained for cakes with melon flour. Furthermore, including Cantaloupe melon pulp flour in the cakes proposed in the present study adds more excellent nutritional value, in addition to bioactive compounds such as carotenoids and phenolic compounds.

Sensory analysis data revealed good acceptance of cakes containing melon pulp flour replacing wheat flour (25 and 50 %), similar to other studies, such as Varastegani et al. [28], using papaya pulp flour to replace wheat flour in the production of biscuits (15, 30 and 50 %), which achieved greater global acceptance for products made with 50 % papaya flour, demonstrating an acceptance rate of 92 %. Therefore, it is observed that bakery products made from 15 % fruit flour instead of wheat flour are well accepted. Many positive evaluations were observed regarding the tasters' comments for cake B (25 % CFH), such as soft texture, adequate sweet flavor, and looks like carrot cake. For cake C (50 % CFH), there were also some positive comments, such as smooth texture and good cake moisture, but some negative comments, such as too sweet, intense melon taste, and more intense color, which may displease the tasters.

For purchase intention, from the results obtained, it was noticed that the partial replacement of wheat flour with Cantaloupe melon pulp flour had a positive evaluation by the tasters. Therefore, developing new products containing this ingredient is a very favorable aspect. Considering that in the present study, cakes B (25 % CFH) and C (50 % CFH), depending on their chemical composition, have better nutritional characteristics and obtained similar evaluations by tasters regarding purchase intention, it is feasible to infer that consumers would likely buy products with melon pulp flour. Furthermore, it is worth noting that 50 % melon flour was used in cake C and was also accepted as B. The literature shows that many studies typically use a maximum of 30 % fruit flour to develop food products.

The attributes most penalized in the three cakes were sweet flavor and moisture, varying from less intense and less moist than ideal, respectively, for the cake without melon flour to more intense and more humid than ideal, for the cake with 50 % melon flour. Therefore, it can be seen that these penalties were observed as the concentrations of melon pulp flour increased in the cakes. That is, the incorporation of melon flour directly contributed to the cake's greater sweet flavor and moisture. However, more was needed to reduce acceptance of suboptimal products or reduce purchase intention. For the three cakes, the statistical analysis showed that most consumers would likely buy the products, demonstrating that consumers would be willing to purchase and get used to the penalized sensory aspects.

5. Conclusions

The present study contributed to expanding knowledge related to the influence of seasonality on the physical and chemical parameters of flours obtained from varieties of salmon pulp melons. The homogeneous effect of the off-season on the increase in moisture content and total phenolic compounds is evident. The Cantaloupe melon pulp flour as an ingredient in the composition of cakes, replacing wheat flour, improved chemical parameters, adding minerals, fibers, and bioactive compounds to the final product. In addition to presenting high potential in the production of cakes, considering the technological parameters and excellent acceptance and intention to purchase cakes with this flour instead of wheat flour. Thus, this demonstrates an excellent alternative to be used as an ingredient in the food industry to promote the development of new bakery products.

Ethics statement

This study was reviewed and approved by the Ethics Committee of the Hospital Universitário Onofre Lopes (HUOL) of UFRN, with the approval number: CAAE: 64999417.1.0000.5292.

All participants provided informed consent to participate in the study.

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Data availability statement

The data associated with the study have not been deposited into a publicly available repository. Data will be made available on request.

CRediT authorship contribution statement

Luciana Daniela Gurgel de Medeiros: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation. **Leticya Bianca Almeida de Carvalho:** Methodology, Formal analysis, Data curation. **Erika Paula Silva Freitas:** Methodology, Data curation. **Dayanne Lopes Porto:** Validation, Methodology, Formal analysis, Data curation. **Cícero Flávio Soares Aragão:** Validation, Methodology, Investigation, Data curation. **Francisco Canindé de Sousa Júnior:** Validation, Supervision, Methodology, Investigation, Data curation. **Karla Suzanne Florentino da Silva Chaves Damasceno:** Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation. **Cristiane Fernandes de Assis:** Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation. **Ana Heloneida Araújo Morais:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Funding acquisition, Data curation. **Thaís Souza Passos:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare no potential competing interests. All authors have approved the manuscript for submission, and the manuscript's content has not been published or submitted for publication elsewhere.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e29609.

References

[1] E. Oren, A. Dafna, G. Tzuri, et al., Pan-genome and multi-parental framework for high-resolution trait dissection in melon (Cucumis melo), J. The Plant 112 (2022) 1525–1542. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/tpj.16021.

[2] E.M.M. Ayres, S.M. Lee, L. Boyden, J.X. Guinard, Sensory properties and consumer acceptance of cantaloupe melon cultivars, J. Food Sci. 84 (2019) 2278–2288. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/1750-3841.14724.

[3] E. Park, Y. Luo, S.C. Marine, et al., Consumer preference and physicochemical evaluation of organically grown melons, Postharvest Biol. Technol. 141 (2018) 77–85, https://doi.org/10.1016/j.postharvbio.2018.03.001.

[4] R. Safter, J.A. Abbott, G. Lester, B. Vinyard, Sensory and analytical comparison of orange-fleshed honeydew to cantaloupe and green-fleshed honeydew for fresh-cut chunks, Postharvest Biol. Technol. 42 (2006) 150–160, https://doi.org/10.1016/j.postharvbio.2006.02.011.

[5] N. Lecholocholo, T. Shoko, V.E. Manhivi, M.M. Maboko, S.A. Akinola, D. Sivakumar, Influence of different rootstocks on quality and volatile constituents of cantaloupe and honeydew melons (Cucumis melo. L) grown in high tunnels, Food Chem. 393 (2022) 133388, https://doi.org/10.1016/j.foodchem.2022.133388.

[6] V. Ravindranath, J. Singh, G.K. Jayaprakasha, B.S. Patil, Optimization of extraction solvent and Fast Blue BB Assay for Comparative analysis of antioxidant phenolics from Cucumis melo L, Plants 10 (2021) 1379, https://doi.org/10.3390/plants10071379.

[7] V.R. Souza, P.A.P. Pereira, F. Queiroz, S.V. Borges, J.D.D.S. Carneiro, Determination of bioactive compounds, antioxidant activity and chemical composition of Cerrado Brazilian fruits, Food Chem. 134 (2012) 381–386, https://doi.org/10.1016/j.foodchem.2012.02.191.

[8] G.L.S. Orbea, R.G. Villalba, M.J. Bernal, A. Hernández, F.A.T. Barberán, L.M.S. Siles, Stability of phenolic compounds in apple and strawberry: effect of different processing techniques in industrial set up, Food Chem. 401 (2023) 134099, https://doi.org/10.1016/j.foodchem.2022.134099.

[9] R. Rey-Giménez, A.C. Sánchez-Gimeno, Crop year, harvest date and clone effects on fruit characteristics, chemical composition and olive oil stability from an Empeltre clonal selection grown in Aragon, J. Sci. Food Agric. 102 (2022) 5778–5786. https://doi-org.ez18.periodicos.capes.gov.br/10.1002/jsfa.11927.

[10] R. Gómez-García, D.A. Campos, A. Oliveira, C.N. Aguilar, A.R. Madureira, M. Pintado, A chemical valorisation of melon peels towards functional food ingredients: bioactives profile and antioxidant properties, Food Chem. 335 (2021) 12757, https://doi.org/10.1016/j.foodchem.2020.127579.

[11] J.A. Cunha, P.M. Rolim, K.S.F.S.C. Damasceno, F.C.S. Júnior, R.C. Nabas, L.M.A.J. Seabra, From seed to flour: Sowing sustainability in the use of cantaloupe melon residue (Cucumis melo L. var. reticulatus), PLoS One 2 (2020), https://doi.org/10.1371/journal.pone.0219229.

[12] S.R. Gade, M. Meghwal, P.K. Prabhakar, A.M. Giuffré, A comparative study on the nutritional, antioxidant, thermal, morphological and diffraction properties of selected cucurbit seeds, Agronomy 12 (2022) 2242, https://doi.org/10.3390/agronomy12102242.

[13] S.M.B. Hashemi, A. Gholamhosseinpour, M. Niakousari, Application of microwave and ohmic heating for pasteurization of cantaloupe juice: microbial inactivation and chemical properties, J. Sci. Food Agric. 99 (2019) 4276–4286. https://doi-org.ez18.periodicos.capes.gov.br/10.1002/jsfa.9660.

[14] T.K. Tepe, C. Kadakal, Determination of drying characteristics, rehydration properties, and shrinkage ratio of convective dried melon slice with some pretreatments, J. Food Process. Preserv. 46 (2022) 16544. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/jfpp.16544.

[15] J. Zhang, X. Yu, Y. Sun, et al., Effects of dimethyl dicarbonate on improving the aroma of melon spirits by inhibiting spoilage microorganisms, J. Food Process. Preserv. 46 (2022) 16499. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/jfpp.16499.

[16] K. Pravallika, S. Chakraborty, R.S. Singhal, Supercritical drying of food products: an insightful review, J. Food Eng. 343 (2023) 111375, https://doi.org/10.1016/j.jfoodeng.2022.111375.

[17] A.S. Bhanu, E. Elavarasan, S.K. Natarajan, A. Anandu, H.M. Senin, Experimental investigation of drying kinetics of Poovan Banana under forced convection solar drying, Current adv mech engin 52 (2021) 621–631. https://link.springer.com/chapter/10.1007/978-981-33-4795-3_56.

[18] V. Gupta, P.K. Prabhakar, S. Gharde, A. Nimbaria, V. Sharma, A. Rawat, Foam mat drying of Jujube (Ziziphus mauritiana) juice: process optimisation, physico-functional, phenolic content and an-tioxidant analysis, J. Inst. Engin. (India). 102 (2021) 1013–1025, https://doi.org/10.1007/s40030-021-00566-5.

[19] R. Kaur, K. Kaur, J.S. Sidhu, Drying kinetics, chemical, and bioactive compounds of yellow sweet pepper as affected by processing conditions, J. Food Process. Preserv. 46 (2022) 1–14. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/jfpp.16330.

[20] M. Ungureanu-Iuga, M. Dimian, S. Mironeasa, Development and quality evaluation of gluten-free pasta with grape peels and whey powders, LWT 130 (2020) 109714, https://doi.org/10.1016/j.lwt.2020.109714.

[21] Q. Ni, V. Ranawana, H.E. Hayes, N.J. Hayward, D. Stead, V. Raikos, Addition of broad bean hull to wheat flour for the development of high-fiber bread: effects on physical and nutritional properties, Foods 9 (2020) 1192, https://doi.org/10.3390/foods9091192.

[22] S.M.G. Saeed, S.A. Ali, K. Faheem, R. Ali, A.M. Giuffré, The impact of innovative plant sources (Cordia myxa L. Fruit (assyrian plum) and Phoenix dactylifera L. Biowaste (date pit)) on the physicochemical, microstructural, nutritional, and sensorial properties of gluten-free biscuits, Foods 11 (2022) 2346, https://doi.org/10.3390/foods11152346.

[23] R. Gaglio, L. Tesoriere, A. Maggio, E. Viola, A. Attanzio, A. Frazzitta, N. Badalamenti, M. Bruno, E. Franciosi, G. Moschetti, F. Sottile, L. Settani, N. Francesca, Reuse of almond by-products: functionalization of traditional semolina sourdough bread with almond skin, Int. J. Food Microbiol. 395 (2023) 110194, https://doi.org/10.1016/j.ijfoodmicro.2023.110194.

[24] T.T. Le, A.P. Vo, V.T.N. Dang, V.V.M. Le, Crackers fortified with various ratios of cynara scolymus L. Leaf extract residue: nutritional, physical and sensory quality, Chemical Engineering Transactions 106 (2023), https://doi.org/10.3303/CET23106144.

[25] B. Antonić, S. Jančíková, D. Dordević, B. Tremlová, Grape pomace valorization: a systematic review and meta-analysis, Foods 9 (2020) 1627, https://doi.org/10.3390/foods9111627.

[26] J.M. Boff, V.J. Strasburg, G.T. Ferrari, H.O. Schmidt, V. Manfroi, V.R. Oliveira, Chemical, technological, and sensory quality of pasta and bakery products made with the addition of grape pomace flour, Foods 11 (2022) 3812, https://doi.org/10.3390/foods11233812.

[27] M.C. Cunha, L.H. Terra, P.C. Sousa, et al., Physical, chemical and sensory implications of pequi (*Caryocar brasiliense* Camb.) sweet bread made with flour, pulp and fruit by-product, Chemical sci. An. Acad. Bras. Ciênc. 95 (2023), https://doi.org/10.1590/0001-3765202320201550.

[28] B. Varastegani, W. Zzaman, T.A. Yang, Investigation on physicochemical and sensory evaluation of cookies substituted with papaya pulp flour, J. Food Qual. 38 (2015) 175–183. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/jfq.12129.

[29] R.B. Martins, M.C. Nunes, I. Gouvinhas, et al., Apple flour in a sweet gluten-free bread formulation: impact on nutritional value, glycemic index, structure and sensory profile, Foods 11 (2022) 3172, https://doi.org/10.3390/foods11203172.

[30] A.K.O.C. Medeiros, C.C. Gomes, M.L.Q.A. Amaral, et al., Nanoencapsulation improved water solubility and color stability of carotenoids extracted from Cantaloupe melon (Cucumis melo L.), Food Chem. 270 (2019) 562–572, https://doi.org/10.1016/j.foodchem.2018.07.099.

[31] R.Y. Chen, Y. Wang, D. Dyson, Breadings-what they are and how they are used. Batters and Breadings in Food Proces, 2011, pp. 169–184, https://doi.org/10.1016/B978-1-891127-71-7.50015-2.

[32] Instituto Adolfo Lutz, Normas analíticas do instituto Adolfo Lutz, Métodos físico-químicos para análises de alimentos 4 (2008) 1020. http://www.ial.sp.gov.br/ial/publicacoes/livros/metodos-fisico-quimicos-para-analise-de-alimentos.

[33] L. Hartman, R.C.A. Lago, Rapid preparation of fatty acid methyl esters, London, Laboratory Pratice 22 (1973) 475–476. https://pubmed.ncbi.nlm.nih.gov/4727126/.

[34] AOAC (Association of Official Analytical Chemistry), Official Methods of Analysis of AOAC International, Dr. George W Latimer, Jr 21 (2019). https://www.aoac.org/wp-content/uploads/2019/08/Front-Matter-List-of-Changes-2.pdf.

[35] C.J. Sniffen, J.D. O'connor, P.J.V. Soest, D.G. Fox, J.B. Russell, A net carbohydrate and protein system for evaluating cattle diets: II.Carbohydrate and protein availability, J. Animal Sci. 70 (1992) 3562–3577. https://doi-org.ez18.periodicos.capes.gov.br/10.2527/1992.70113562x.

[36] P.P.C. Ribeiro, F.C.S. Júnior, C.F. Assis, et al., Perfis fenólicos de sementes de faveleira (Cnidoscolus quercifolius Pohl) e extratos de torta de prensa: potential para uma nova tendência em alimentos funcionais, Braz. J. Food Technol. 23 (2020), https://doi.org/10.1590/1981-6723.31519.

[37] V.L. Singleton, R. Orthofer, R.M. Lamuela-Raventós, Analysis of total phenols and Other oxidation substrates and antioxidants by means of folin-ciocalteu reagent, Methods Enzymol. 299 (1999) 152–178, https://doi.org/10.1016/S0076-6879(99)99017-1.

[38] P.P.C. Ribeiro, F.H.X. Junior, C.G.N. Silva, et al., Faveleira (Cnidoscolus quercifolius Pohl) seed press cake flour: production, characterization and application for use in cookies, J. Sci. Food Agric. 103 (2022) 627–636. https://doi-org.ez18.periodicos.capes.gov.br/10.1002/jsfa.12174.

[39] P. Jogihalli, L. Singh, K. Kumar, V.S. Sharanagat, Physico-functional and antioxidante properties of sand-roasted chickpea (Cicera rietinum), Food Chem. 237 (2017) 1124–1132, https://doi.org/10.1016/j.foodchem.2017.06.069.

[40] X. Zhang, Y. Chen, R. Zhang, et al., Effects of extrusion treatment on physicochemical properties and in vitro digestion of pregelatinized high amylose maize flour, J. Cereal. Sci. 68 (2016) 108–115, https://doi.org/10.1016/j.jcs.2016.01.005.

[41] G. Rivera–González, C.A. Amaya–Guerra, J. Rosa–Millán, Physicochemical characterisation and in vitro Starch digestion of Avocado Seed Flour (Persea americana V. Hass) and its starch and fibrous fractions, Int. J. Food Sci. Technol. 54 (2019) 2447–2457. https://doi-org.ez18.periodicos.capes.gov.br/10.1111/ijfs.14160.

[42] J.L. Kornacki, J.B. Gurtler, B.A. Stawick, in: Y. Salfinger, M.L. Tortorello (Eds.), Enterobacteriaceae, Coliforms and Escherichia coli as Quality Ans Safety Indicators, vol. 9, American Public Health Association (APHA), 2015, pp. 103–120, https://doi.org/10.2105/MBEF.0222.014. Compendium of Methods for the Microbiol. Examin. of Foods.

[43] ANVISA/Ministério da Saúde. INSTRUÇÃO NORMATIVA - IN Nº 161, DE 1º DE JULHO DE 2022. Disponível: https://www.in.gov.br/en/web/dou/-/instrucao-normativa-in-n-161-de-1-de-julho-de-2022-413366880/[16 de junho de 2023].

[44] Tabela Brasileira de Composição de Alimentos (TBCA), Universidade de São Paulo (USP), Food Research Center (FoRC). Versão 7.2. São Paulo (2023). http://www.fcf.usp.br/tbca/, 16 de junho de 2023.

[45] E. Teixeira, E. Meinert, P.A. Barbeta, Análise sensorial dos alimentos, Florianópolis: UFSC (1987) 180. https://books.google.com.br/books/about/An%C3%A1lise_sensorial_de_alimentos.html?id=Pm9bMwEACAAJ&redir_esc=y.

[46] S.D. Dutcosky, Análise sensorial de alimentos, Curitiba: Champagnat 3 (2011), 426, ID: lil-614029.

[47] J.F. Lima, M.I. Dias, C. Pereira, et al., Characterization of nonconventional food plants seeds *Guizotia abyssinica* (L.F.) cass., *Panicum miliaceum* L., and *Phalaris canariensis* L. for application in the bakery industry, Agronomy 11 (2021) 1873, https://doi.org/10.3390/agronomy11091873.

[48] G.L.R. Oliveira, I. Medeiros, S.S.C. Nascimento, et al., Antioxidant stability enhancement of carotenoid rich-extract from Cantaloupe melon (Cucumis melo L.) nanoencapsulated in gelatin under different storage conditions, Food Chem. 348 (2021) 129055, https://doi.org/10.1016/j.foodchem.2021.129055.

[49] M. Marchini, E. Carini, N. Cataldi, et al., The use of red lentil flour in bakery products: how do particle size and substitution level affect rheological properties of wheat bread dough? LWT 136 (2021) 110299 https://doi.org/10.1016/j.lwt.2020.110299.

[50] J. Ahmed, L. Thomas, Y.A. Arfat, Functional, rheological, microstructural and antioxidant properties of quinoa flour in dispersions as influenced by particle size, Food Res. Int. 116 (2019) 302–311, https://doi.org/10.1016/j.foodres.2018.08.039.

[51] V. Greffeuille, J. Abecassis, N. Barouh, et al., Analysis of the milling reduction of bread wheat farina: physical and biochemical characterization, J. Cereal. Sci. 45 (2007) 97–105, https://doi.org/10.1016/j.jcs.2006.07.003.

[52] P.M. Rolim, S.D.O. Júnior, A.C.S.M. Oliveira, E.S. Santos, G.R. Macedo, Nutritional value, cellulase activity and prebiotic effect of melon residues (Cucumis melo L. reticulatus group) as a fermentative substrate, J. Food Nutr. Res. 57 (2018) 315–327. https://repositorio.ufrn.br/handle/123456789/32672.

[53] M.I.H. Khan, R.M. Wellard, S.A. Nagy, M.U.H. Joardder, M.A. Karim, Experimental investigation of bound and free water transport process during drying of hygroscopic food material, Int. J. Therm. Sci. 117 (2017) 266–273, https://doi.org/10.1016/j.ijthermalsci.2017.04.006.

[54] N.S. Mendes, M.C.P. Santos, M.C.B. Santos, L.C. Cameron, M.S.L. Ferreira, E.C.B.A. Gonçalves, Characterization of pepper (Capsicum baccatum) - a potential functional ingredient, LWT–Food Sci. Technol. 112 (2019) 108209, https://doi.org/10.1016/j.lwt.2019.05.107.

[55] J. Liu, Y. Liu, X. Wang, Effects of bioactive compounds and pharmacological activities in medicinal fruits and vegetables by thermal processing, J. Future Foods 3 (2023) 252–262, https://doi.org/10.1016/j.jfutfo.2023.02.009.

[56] SENAR (Serviço Nacional de Aprendizagem Rural), Melão: manejo, colheita, pós-colheita e comercialização. Brasília, DF, SENAR 3 (2010). https://www.cnabrasil.org.br/assets/arquivos/131-MEL%C3%83O.pdf.

[57] R.A. Mattietto, C.R.A.S. Preza, N.E.N.P. Paracampo, J.J.S.N. Lanes, Teores de compostos bioativos em amostras de açaí comercializados em belém-pará durante safra e entressafra, Congr Bras, Ciên. Tecnol. Alim (2018) 1–6. https://ainfo.cnptia.embrapa.br/digital/bitstream/item/192822/1/acai-4096-12072018-150917.pdf.

[58] K. Gill, P. Kumar, S. Negi, et al., Physiological perspective of plant growth regulators in flowering, fruit setting and ripening process in citrus, Sci. Hortic. 309 (2023) 111628, https://doi.org/10.1016/j.scienta.2022.111628.

[59] D. Presti, J. Tocco, S. Cimini, et al., Plant growth monitoring: design, fabrication, and feasibility assessment of wearable sensors based on fiber bragg gratings, Sensors 23 (2023) 361, https://doi.org/10.3390/s23010361.

[60] EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária), A Cultura Do Melão, vol. 3, Embrapa, Brasília, DF, 2017. https://ainfo.cnptia.embrapa.br/digital/bitstream/item/11920/2/00068380.pdf.

[61] A. Lopez-Zaplana, N.M. Garcia, M. Carvajal, G. Bárzana, Relationships between aquaporins gene expression and nutrient concentrations in melon plants (Cucumis melo L.) during typical abiotic stresses, Environm. and Exper, Botany 195 (2022) 104759, https://doi.org/10.1016/j.envexpbot.2021.104759.

[62] T. Sun, Y. Zhao, D. Zhou, Z. Gao, X. Hu, Effects of amount, electric conductivity, and frequency of a nutrient solution on melon yield and flavor quality, Sci. Hortic. 310 (2023) 111737, https://doi.org/10.1016/j.scienta.2022.111737.

[63] B.N.B. Lima, F.F. Lima, M.I.B. Tavares, A.M.M. Costa, A.P.T.R. Pierucci, Determination of the centesimal composition and characterization of flours from fruit seeds, Food Chem. 151 (2014) 293–299, https://doi.org/10.1016/j.foodchem.2013.11.036.

[64] M. Mahwish, F. Saeed, M. Nisa, M.T. Nadeem, Minerals and phytochemical analysis of bitter melon fruits and its components in some indigenous and exotic cultivars, Biosci. J. 34 (2018) 1622–1631, https://doi.org/10.14393/BJ-v34n6a2018-39827.

[65] S. Mallek-Ayadi, N. Bahloul, S. Baklouti, N. Kechaou, Bioactive compounds from Cucumis melo L. fruits as potential nutraceutical food ingredients and juice processing using membrane technology, Food Sci. Nutr. 10 (2022) 2922–2934, https://doi.org/10.1002/fsn3.2888.

[66] A. Maietti, P. Tedeschi, C. Stagno, et al., Analytical traceability of melon (Cucumis melo var reticulatus): proximate composition, bioactive compounds, and antioxidant capacity in relation to cultivar, plant physiology state, and seasonal variability, J. Food Sci. 77 (2012) 646–652, https://doi.org/10.1111/j.1750-3841.2012.02712.x.

[67] Brasil, Ministério da Agricultura, Pecuária e Abastecimento, Regulamento técnico de identidade e qualidade da farinha de trigo, Instrução Normativa nº 8, de 2 de junho de (2005). https://www.normasbrasil.com.br/norma/instrucao-normativa-8-2005_75598.html.

[68] TACO (Tabela brasileira de composição de alimentos), Campinas: NEPA – UNICAMP, vol. 4, 2011, p. 161. https://www.cfn.org.br/wp-content/uploads/2017/03/taco_4_edicao_ampliada_e_revisada.pdf.

[69] S.T. Philippi, Tabela de composição de alimentos: suporte para decisão nutricional, vol. 6, Manole, 2018. https://repositorio.usp.br/item/002881762.

[70] V.R.P. Bauer, A.P. Wally, M.Z. Peter, in: Inst Fed (Ed.), Tecnologia de frutas e hortaliças, Ciên. e Tecn. do RS – IFSUL, 2014. https://proedu.rnp.br/bitstream/handle/123456789/1480/Tec_Frut_Horta_Book_Ag.pdf?sequence=1&isAllowed=y.

[71] R.O. Anese, D. Fronza, Fisiologia pós-colheita em fruticultura, santa maria: UFSM, colégio Politécnico, Rede e-Tec Brasil, 130 p, (2015). https://www.ufsm.br/unidades-universitarias/ctism/cte/fruticultura-politecnico.

[72] D.R. Morais, E.M. Rotta, S.C. Sargi, et al., Proximate composition, mineral contents and fatty acid composition of the different parts and dried peels of tropical fruits cultivated in Brazil, J. Braz. Chem. Soc. 28 (2017) 308–318, https://doi.org/10.5935/0103-5053.20160178.

[73] Y. Li, H. Qi, Y. Jin, X. Tian, L. Sui, Y. Qiu, Role of ethylene in the biosynthetic pathway of related-aroma volatiles derived from fatty acids in oriental sweet melon, J. A. Soc. Hort. Sci. 141 (2016) 327–338, https://doi.org/10.21273/JASHS.141.4.327.

[74] J.H. Hao, Z.Y. Qi, J.R. Li, et al., Effects of grafting on free fatty acid contents and related synthetic enzyme activities in peel and flesh tissues of oriental sweet melon during the different development period, IOP Conf. Series: earth and Environm, Sci. 185 (2018) 012009, https://doi.org/10.1088/1755-1315/185/1/012009.

[75] A. Mir-Cerdà, O. Nuñez, M. Granados, S. Sentellas, J. Saurina, An overview of the extraction and characterization of bioactive phenolic compounds from agri-food waste within the framework of circular bioeconomy, Trends in Analyt, Chemistry 161 (2023) 116994, https://doi.org/10.1016/j.trac.2023.116994.

[76] F.A. Miller, J.F. Fundo, C.L.M. Silva, T.R.S. Brandão, Physicochemical and bioactive compounds of 'cantaloupe' melon: effect of ozone processing on pulp and seeds, J. Intern. Ozone Assoc. 40 (2018) 209–215. https://doi-org.ez18.periodicos.capes.gov.br/10.1080/01919512.2017.1414582.

[77] J.A. Salas-Millán, A. Aznar, E. Conesa, A. Conesa-Bueno, E. Aguayo, Fruit wine obtained from melon by-products: physico-chemical and sensory analysis, and characterization of key aromas by GC-MS, Foods 11 (2022) 3619, https://doi.org/10.3390/foods11223619.

[78] Y. Wang, M. Guo, W. Zhang, et al., Exogenous melatonin activates the antioxidant system and maintains postharvest organoleptic quality in Hami melon (Cucumis. melo var. inodorus Jacq.), Front. Plant Sci. 14 (2023), https://doi.org/10.3389/fpls.2023.1274939.

[79] M.D. Navarro-Hortal, J.M. Romero-Márquez, A. Esteban-Muñoz, et al., Strawberry (Fragaria × ananassa cv. Romina) methanolic extract attenuates Alzheimer's beta amyloid production and oxidative stress by SKN-1/NRF and DAF-16/FOXO mediated mechanisms in C. Elegans, Food Chem. 372 (2022) 131272, https://doi.org/10.1016/j.foodchem.2021.131272.

[80] Z.E. Martins, O. Pinho, I.M.P.L.V.O. Ferreira, Food industry by-products used as functional ingredients of bakery products, Trends Food Sci. Technol. 67 (2017) 106–128, https://doi.org/10.1016/j.tifs.2017.07.003.

[81] L.B. Cangussu, P. Fronza, A.S. Franca, L.S. Oliveira, Chemical characterization and bioaccessibility assessment of bioactive compounds from umbu (Spondias tuberosa A.) fruit peel and pulp flours, Foods 10 (2021) 2597, https://doi.org/10.3390/foods10112597.

[82] M. Mudau, S.E. Ramashia, M.E. Mashau, Mineral content, functional, thermo-pasting, and microstructural properties of spontaneously fermented finger millet flours, Foods 11 (2022) 2474, https://doi.org/10.3390/foods11162474.

[83] V.L. Xavier, G.S. Feitoza, J.M.L. Barbosa, et al., Nutritional and technological potential of Umbu (Spondias tuberosa Arr. Cam.) processing by-product flour, an Acad, Bras. Cienc. 94 (2022) 20200940, https://doi.org/10.1590/0001-3765202220200940.

[84] L.M. Resende, A.S. Franca, L.S. Oliveira, Buriti (Mauritia flexuosa L. f.) fruit by-products flours: evaluation as source of dietary fibers and natural antioxidants, Food Chem. 270 (2019) 53–60, https://doi.org/10.1016/j.foodchem.2018.07.079.

[85] M.C.B. Figueirêdo, R.S. Gondim, F.A.S. Aragão, Produção de melão e mudanças climáticas: sistemas conservacionistas de cultivo para redução das pegadas de carbono e hídrica, Embrapa, Brasília, DF, 2017, p. 302. https://ainfo.cnptia.embrapa.br/digital/bitstream/item/163048/1/OLV17001.pdf.

[86] A.L. Santos, R.A. Morais, C.M.S. Soares, et al., Effect of gamma irradiation on the physicochemical, functional and bioactive properties of red pitaya (Hylocereus costaricensis) bark flour, Radiat. Physics and Chemistry 199 (2022) 110371, https://doi.org/10.1016/j.radphyschem.2022.110371.

[87] G.S. Santana, J.G.O. Filho, M.B. Egea, Características tecnológicas de farinhas vegetais comerciais, Rev. Agric. Neotrop. 4 (2017) 88–95, https://doi.org/10.32404/rean.v4i2.1549.

[88] K. Xu, M.M. Martinez, B. Yang, M. Guo, Fine structure, physicochemical and antioxidant properties of LM-pectins from okra pods dried under different techniques, Carboidr Polim 241 (2020) 116272, https://doi.org/10.1016/j.carbpol.2020.116272.

[89] ANVISA (Agência Nacional de Vigilância Sanitária), Resolução RDC n° 263, de 22 de setembro de 2005. Brasília, DF, 2005. : https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2005/rdc0263_22_09_2005.html/, 30 de janeiro de 2023.

[90] ANVISA (Agência Nacional de Vigilância Sanitária). Resolução RDC N° 216, de 15 de setembro de 2004. Disponível: https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2004/res0216_15_09_2004.html/[30 de janeiro de 2023].

[91] V. Filipović, B. Lončar, J. Filipović, et al., Addition of combinedly dehydrated peach to the cookies—technological quality testing and optimization, Foods 11 (2022) 1258, https://doi.org/10.3390/foods11091258.

[92] ANVISA (Agência Nacional de Vigilância Sanitária), Instrução Normativa n° 75, de 8 de outubro de 2020, Disponível, Brasília, DF, 2020. https://www.in.gov.br/en/web/dou/-/instrucao-normativa-in-n-75-de-8-de-outubro-de-2020-282071143/, 02 Abril de 2023.

[93] Instituto Brasileiro de Geografia e Estatística – IBGE, Pesquisa de orçamento familiar 2008-2009: Tabelas de composição nutricional dos alimentos consumidos no Brasil, 2011. Rio de Janeiro, https://biblioteca.ibge.gov.br/visualizacao/livros/liv50002.pdf.