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## Optimization and effects of processing on sensory characteristics and nutritional parameters of jams developed from underutilized wild melon (*Cucumis melo*, var *callosus* L. Br.)

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## Abstract

The present study was conducted to optimize and analyse the effects of processing on sensory characteristics and nutritional parameters of jams developed from underutilized wild melon. Three types of jam using underutilized wild melon were prepared using different processing methods, *i.e.*, with seeds, after blanching of wild melon and without seeds. Proximate composition, colour characteristics, bioactive compounds and antioxidant activity, sugar content, dietary fibre, FTIR analysis, sensory parameters were analysed. The prepared products were kept for three months at a temperature of 4°C and analysed for total phenol, flavonoid and antioxidant activity. Proximate composition and mineral content of jam with seeds was significantly ( $p=0.05$ ) higher than the other two. Presence of seeds increased bioactive compounds, antioxidant activity and ascorbic acid content of the jam as seeds possess significant analgesic and antioxidant activity and had better overall acceptability in term of sensory characteristics. Jam without seeds had higher total sugar and non-reducing sugars, however; jam with seeds had higher reducing sugars. Insoluble dietary fibre of blanched jam was also significantly ( $p=0.05$ ) higher. FTIR spectra confirmed the presence of bioactive compounds and sugars. Total phenols, flavonoid, and antioxidant activity in all three jams were also adequately retained during three months storage.

## 1. Introduction

The exploitation of new plant resources with potential for food and fodder has become crucial due to the worrisome increase in the human population and the depletion of natural resources (Feyssa *et al.*, 2011). Low input farming works well for many nutrient-dense, underutilised, and neglected species. The loss of these species may have a direct impact on the food security and nutritional status of the impoverished (Dansi *et al.*, 2012). Utilising underutilised wild food plants helps combat malnutrition and enhances rural residents' health (Salvi and Katewa, 2016). As more people realise that natural products are non-narcotic, have no negative side effects, are widely accessible at low costs, and are sometimes the only source of healthcare available to the impoverished, demand for underutilised plants is rising in both developed and developing countries (Kaur *et al.*, 2011).

Cucumber (*Cucumis sativus*) and Melon (*Cucumis melo*) are two major commercial and commonly grown vegetable crops in the Cucumis genus (*C. melo*). Most *Cucumis* species, including *Cucumis melo*, are thought to have their origins in Africa. In African and Asian countries, it grows as a weed. It is widely distributed in India, including the southern states of Haryana, Himachal Pradesh, Punjab, Rajasthan and Kerala. It is widespread throughout Punjab, but is more common

in the dry and dusty areas (Faridkot, Bathinda, Abohar, Ferozepur, Mansa, Sri Mukatsar Sahib) (Dhillon *et al.*, 2007).

Wild melon is rich in vitamins, minerals, carbohydrates and other nutrients and are known to possess significant analgesic, anti-inflammatory and antioxidant value. Antioxidants derived from food play a vital role in assisting endogenous antioxidants in neutralising excess of free radicals. Free radical-induced oxidative damage appears to have a role in ageing and a number of stress-related illnesses such as cataracts, cognitive impairment, cancer, myocardial infarction and diabetes and a variety of cardiac ailments (Koneru *et al.*, 2011). For food security, rural communities grow *kachri* fruits with other rainfed crops. Its fruits are sliced fresh and then dried in the shade to preserve them for use in the off-season. They are commonly cooked with a variety of vegetable preparations. *Kachri* powder is used in spice premixes and mouth fresheners as a sour ingredient in combination with other spices. Dehydrated *kachris* are used in chutneys, vegetables, and other dishes (Pareek and Samadia, 1998).

Jams have long been an early attempt to preserve fruit for consumption during the off-season. This dish has intermediate moisture level and is produced by boiling fruit pulp with sugar, pectin, acid, and additional substances (colouring, flavouring, and preservatives) until it reaches a thick consistency. Jam should have at least 45% fruit and more than 68.5% total soluble solids (TSS). Jam quality degrades after it is created and before it is eaten (Ferreira *et al.*, 2004). According to earlier research, processing (Poiana *et al.*, 2012), cultivar (Wicklund *et al.*, 2005), storage duration and temperature, as well as other parameters, affect the quality and shelf-life of jams. Because jams are highly perishable, the study

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intends to identify the best formulation and processing conditions in order to create jams that are both aesthetically pleasing and nutritionally superior. The aim of this study was to evaluate jams prepared from wild melon with seeds, blanched and without seeds and examine the impact on nutritive, sensory and rheological qualities. The current research can contribute in enhancing food security, expanding the use of fruits and fostering innovation in functional products while adding value.

## 2. Materials and Methods

### 2.1 Plant material

Physiologically mature but unripe wild melon (*Cucumis melo. var callosus*) (nearly same as variety AHK-119) fruits were collected from Bathinda District of Punjab.

### 2.2 Preparation of jam

After washing and surface drying, the fruits were divided into three parts (500 g each) for the optimization of jam:

**Jam I:** Jam with seeds was prepared by crushing the fruit in the mixer grinder into smooth consistency (along with seeds and peel).

**Jam II:** The wild melon fruits were blanched in hot boiling water for 3-4 min, immediately cooled under running water, further, ground the blanched fruits.

**Jam III:** Seedless jam was prepared by separating the seeds with the help of strainer, peel and pulp were grounded.

The pulp was heated to a steady temperature of 80°C over medium heat. Equal amount of the sugar (500 g) was added gradually after 10 min of simmering, followed by the addition of citric acid (5 g), until the jam reached a Brix of 45-50. The mixture was then concentrated by evaporation in the last stage to attain 68° Brix. Once the TSS had reached its maximum concentration, the jams were finally put into pre-sterilized glass jars. The jars were stored at 5°C after being cooled to room temperature so that the various sensory, physiochemical, nutritional parameters and storage effects on bioactive compounds could be assessed.

### 2.3 Proximate composition and mineral content

The moisture, crude protein, crude fat, crude fibre, ash, and available carbohydrates were evaluated following AOAC (2000 and 2005) standards. The ICP method was used to analyse calcium, iron, zinc, and phosphorus levels.

### 2.4 Colour characteristics

The colour properties (L, a, b) of wild melon jam were determined using the Color Flex metre (Hunter Lab Color Flex, Hunter Associates Inc., USA). It was possible to assess colour psychophysical properties like chroma (C) and hue angle (h) (Singh *et al.*, 2021). The following equations convert the Cartesian coordinates (a and b) to the polar coordinates (h and C):

$$\text{Hue angle (h}^*) = \arctan \left( \frac{b^*}{a^*} \right),$$

$$\text{Chroma (C)} = (a^2 + b^2)^{1/2}$$

$$\text{Total colour difference } \Delta E^* = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

### 2.5 Preparation of extracts for antioxidant and bioactive compounds

Each sample was weighed 1 g and extracted using 50 ml aqueous methanol (80% v/v). The mixture was continuously stirred for 180 min. Each extract was separated using Whatman No. 1 filter paper and put into a 50 ml volumetric flask for further analysis.

### 2.6 Antioxidant, bioactive compounds and ascorbic acid

The antioxidant activity was done using two standard in vitro assays: the DPPH assay following the method of Brand Williams *et al.* (1995) and the ABTS assay using the protocol of Re *et al.* (1999). The total phenolic activity was determined using the Singleton *et al.* (1999) method, the flavonoid content was determined using the Zhishen *et al.* (1999) method, and the alkaloid content was calculated using the Shamsa *et al.* (2008) method. The per cent preservation of total phenolic content, flavonoids and antioxidant activity was determined using data obtained on day 0 and at the end of each month throughout the three-month storage period. The ascorbic acid content in wild melon jam was determined by employing AOAC (2010) technique.

### 2.7 Sugar content

The total sugars and starch in jam were determined using the Dubois *et al.* (1956) method, whereas the reducing sugars were determined using the Somogyi (1952) method.

### 2.8 Dietary fibre

The AOAC (991.43) method was used to calculate dietary fibre content, including total, soluble, and insoluble fibre.

### 2.9 Fourier transform infrared spectroscopy (FTIR) analysis

The FTIR spectra of jams were examined using an FTIR spectrophotometer (Alpha Bruker, USA). The jam sample was ground into powder and put on the FTIR sample holder. Between 500 and 4,000 cm<sup>-1</sup> wavelengths, various infrared spectra were seen (Kaur *et al.*, 2021).

### 2.10 Sensory characteristics of wild melon jam

A semi-trained panel of 20 members, ranging in age from 22 to 55, from the Department of Food and Nutrition at Punjab Agricultural University in Ludhiana, India, evaluated the jam samples for appearance, colour, flavour, taste, texture, and overall acceptability using a 9-point Hedonic scale.

### 2.11 Statistical analysis

An analysis of variance was performed using the Statistical Package for the Social Sciences (SPSS), Inc., USA, [PASW version 18.0]. Tukey's test used to quantify treatment differences ( $p < 0.05$ ). Results were presented as the mean of three different observations, with standard deviation.

## 3. Results

### 3.1 Nutritional composition

The results of proximate composition and mineral content of wild melon jams were given in Table 1. Moisture content was highest in Jam I (41.57%) and Jam II (39.29%), while Jam I exhibited significantly lower values (27.23%,  $p < 0.001$ ). Protein content declined progressively with seed removal and blanching, ranging from

1.38% in Jam I to 0.72% in Jam III ( $p=0.024$ ). Crude fat content was higher in Jam I (2.36%) and Jam III (2.16%) compared to Jam II (1.88%,  $p=0.004$ ). Crude fibre was markedly higher in Jam II (3.25%) than in Jam I and Jam III (2.30% and 2.20%, respectively,  $p=0.011$ ). Total ash content was maximum in Jam I (0.74%), followed by Jam II (0.58%) and Jam III (0.53%,  $p<0.001$ ). Carbohydrate content was significantly higher in Jam I (66.09%) relative to the blanched and seedless counterparts (Jam II: 53.91%; Jam III: 52.58%,  $p<0.001$ ).

In terms of mineral content, Jam I showed the highest calcium (45.01 mg/100 g), iron (7.05 mg/100 g), zinc (0.84 mg/100 g), and phosphorus (45.10 mg/100 g) contents, whereas Jam III consistently displayed the lowest values for these minerals ( $p<0.001$ ). Magnesium was an

exception, with Jam II recording significantly higher content (61.18 mg/100 g) than Jam I (41.16 mg/100 g) and Jam III (43.39 mg/100 g).

According to sugar analysis, Jam I and Jam III had substantially more total sugars (67.90% and 68.28%) than Jam II (52.53%,  $p<0.001$ ). While non-reducing sugars were highest in Jam III (28.10%) and lowest in Jam II (20.09%,  $p=0.001$ ), reducing sugars were most prevalent in Jam I (42.55%) and least in Jam II (31.38%,  $p<0.001$ ). Based on the dietary fibre analysis, Jam I had the highest total fibre content (9.15%) and Jam II had the lowest (8.75%), while Jam III had the lowest (5.40%,  $p<0.001$ ). The trend for soluble fibre was similar, with Jam I having a considerably greater percentage (6.85%) than Jam III (3.20%,  $p<0.001$ ).

**Table 1: Nutritional composition of wild melon jam**

Parameter	Jam I	Jam II	Jam III	p-value
<b>Proximate composition (%)</b>				
Moisture	27.23 ± 0.14 <sup>c</sup>	39.29 ± 0.09 <sup>b</sup>	41.57 ± 0.13 <sup>a</sup>	< 0.001***
Crude protein	01.38 ± 0.03 <sup>a</sup>	01.11 ± 0.37 <sup>ab</sup>	00.72 ± 0.36 <sup>b</sup>	0.024*
Crude fat	02.36 ± 0.23 <sup>a</sup>	01.88 ± 0.09 <sup>b</sup>	02.16 ± 0.09 <sup>a</sup>	0.004**
Crude fibre	02.30 ± 0.20 <sup>b</sup>	03.25 ± 0.07 <sup>a</sup>	02.20 ± 0.49 <sup>b</sup>	0.011**
Total ash	00.74 ± 0.01 <sup>a</sup>	00.58 ± 0.03 <sup>b</sup>	00.53 ± 0.01 <sup>c</sup>	< 0.001***
Carbohydrates (by difference)	66.09 ± 0.53 <sup>a</sup>	53.91 ± 0.66 <sup>b</sup>	52.58 ± 0.61 <sup>b</sup>	< 0.001***
<b>Mineral content (mg/100 g)</b>				
Calcium	45.01 ± 1.41 <sup>a</sup>	42.77 ± 3.04 <sup>b</sup>	25.63 ± 0.86 <sup>c</sup>	< 0.001***
Iron	07.05 ± 0.15 <sup>a</sup>	06.73 ± 0.08 <sup>a</sup>	05.40 ± 0.17 <sup>b</sup>	< 0.001***
Zinc	00.84 ± 0.04 <sup>a</sup>	00.79 ± 0.01 <sup>a</sup>	00.44 ± 0.03 <sup>b</sup>	< 0.001***
Phosphorus	45.10 ± 2.14 <sup>a</sup>	41.95 ± 1.19 <sup>a</sup>	24.22 ± 1.05 <sup>b</sup>	< 0.001***
Magnesium	41.16 ± 0.14 <sup>c</sup>	61.18 ± 0.69 <sup>a</sup>	43.39 ± 1.03 <sup>b</sup>	< 0.001***
<b>Sugar content (%)</b>				
Total Sugars	67.90 ± 1.22 <sup>a</sup>	52.53 ± 0.70 <sup>b</sup>	68.28 ± 1.25 <sup>a</sup>	< 0.001***
Reducing sugars	42.55 ± 0.49 <sup>a</sup>	31.38 ± 0.49 <sup>c</sup>	38.70 ± 1.07 <sup>b</sup>	< 0.001***
Non-reducing sugars	24.08 ± 0.73 <sup>b</sup>	20.09 ± 0.53 <sup>c</sup>	28.10 ± 2.14 <sup>a</sup>	0.001***
<b>Dietary fibre (%)</b>				
Total dietary fibre	9.15 ± 0.22 <sup>a</sup>	8.75 ± 0.23 <sup>a</sup>	5.40 ± 0.39 <sup>b</sup>	< 0.001***
Soluble dietary fibre	6.85 ± 0.02 <sup>a</sup>	5.50 ± 0.30 <sup>b</sup>	3.20 ± 0.10 <sup>c</sup>	< 0.001***
Insoluble dietary fibre	2.30 ± 0.20 <sup>b</sup>	3.25 ± 0.07 <sup>a</sup>	2.20 ± 0.49 <sup>b</sup>	0.011*

Value represents mean (n=3) ± SD

Values in rows with distinct superscripts differ considerably ( $p\leq 0.05$ ). \* Significant at 5%, \*\* significant at 1%, and \*\*\* significant at 0.1%.

### 3.2 Bioactive compounds, ascorbic acid, antioxidant activity and colour characteristics

Polyphenols, a type of secondary metabolite found in vegetables, play a crucial role in chelating redox-active metal ions, inactivating lipid-free radical chains, and preventing hydroperoxide conversion into reactive oxyradicals (Khorasani Esmaili *et al.*, 2015). There was a significant difference ( $p\leq 0.05$ ) in the phenolic content in the three types of jam. The least content of total phenols was found in Jam II followed by Jam III and maximum were found in Jam I. There was significant difference ( $p\leq 0.05$ ) in the flavonoid content in the

jam. The least flavonoids were found in Jam III followed by Jam II and maximum were found in Jam I. A significant ( $p\leq 0.05$ ) higher alkaloid content was found in Jam I and Jam II as compared to Jam III. A significantly ( $p\leq 0.05$ ) higher ascorbic acid was found in Jam I (12.97 mg/100 g) followed by Jam II (10.31 mg/100 g) and Jam III (6.02 mg/100 g).

The wild melon jam has been analysed for the antioxidant activity both by DPPH and ABTS method and results have been illustrated in Table 2. The results revealed that there was significant difference ( $p\leq 0.05$ ) in antioxidant activity among the three types of jams both

in case of DPPH method and ABTS method. The antioxidant activity (DPPH method) of Jam I was highest followed by Jam II and Jam III. Similar results were obtained via ABTS method in which Jam I had

highest antioxidant activity followed by Jam II and Jam III. Blanched Jam, *i.e.*, Jam II had reduced antioxidant activity in both DPPH and ABTS method.

**Table 2: Bioactive compounds, ascorbic acid, antioxidant activity and colour characteristics of wild melon jam**

Parameter	Jam I	Jam II	Jam III	p-value
<b>Bioactive compounds</b>				
Phenol (mg GAE/100 g)	144.42 ± 17.85 <sup>a</sup>	100.26 ± 7.23 <sup>b</sup>	120.17 ± 8.65 <sup>ab</sup>	0.013*
Flavonoid (mg QE/100 g)	028.24 ± 2.70 <sup>a</sup>	020.75 ± 1.05 <sup>b</sup>	015.36 ± 0.39 <sup>c</sup>	< 0.001***
Alkaloids (mg/100 g)	019.15 ± 0.22 <sup>a</sup>	017.42 ± 1.75 <sup>a</sup>	013.40 ± 1.24 <sup>b</sup>	< 0.001***
Ascorbic acid (mg/100 g)	012.97 ± 0.07 <sup>a</sup>	010.31 ± 0.12 <sup>b</sup>	006.02 ± 0.09 <sup>c</sup>	< 0.001***
<b>Antioxidant activity</b>				
DPPH (%)	033.08 ± 0.36 <sup>a</sup>	025.75 ± 0.38 <sup>b</sup>	022.71 ± 0.44 <sup>c</sup>	< 0.001***
ABTS (%)	024.26 ± 0.64 <sup>a</sup>	021.06 ± 0.66 <sup>b</sup>	019.09 ± 0.55 <sup>c</sup>	< 0.001***
<b>Colour characteristics</b>				
L*	048.05 ± 0.06 <sup>c</sup>	049.97 ± 0.16 <sup>a</sup>	048.41 ± 0.11 <sup>b</sup>	< 0.001***
a*	01.59 ± 0.04 <sup>b</sup>	00.92 ± 0.03 <sup>c</sup>	02.26 ± 0.06 <sup>a</sup>	< 0.001***
b*	020.86 ± 0.05 <sup>c</sup>	022.09 ± 0.07 <sup>b</sup>	022.53 ± 0.09 <sup>a</sup>	< 0.001***
Hue angle (°)	085.64 ± 0.12 <sup>b</sup>	087.62 ± 0.07 <sup>a</sup>	084.27 ± 0.07 <sup>c</sup>	< 0.001***
Chroma	020.92 ± 0.05 <sup>c</sup>	022.11 ± 0.07 <sup>b</sup>	022.64 ± 0.08 <sup>a</sup>	< 0.001***
ΔE	000.06 ± 0.05 <sup>c</sup>	000.12 ± 0.10 <sup>a</sup>	000.10 ± 0.09 <sup>b</sup>	0.680 <sup>NS</sup>

Value represents mean (n=3) ± SD

Values in rows with distinct superscripts differ considerably ( $p \leq 0.05$ ). \* Significant at 5%, \*\* significant at 1%, and \*\*\* significant at 0.1%.

Table 2 represents the color parameter of wild melon jam. The results showed that the Jam II had highest L\* value which indicated that blanching increased the lightness of the jam. The red-green component of a colour is indicated by the value a\*, where a\* (positive) and a\* (negative) represent the values of red and green, respectively (Ly *et al.*, 2020). The a\* value of Jam III was highest, an increase in the negative a\* value indicated increased green colour intensity. The b\* axis showed yellow and blue components as positive and negative values, respectively. The results signifies that b\* value of Jam II was highest and there was significant difference in L\*, a\* and B\* values among jams.

### 3.3 FTIR analysis

The FTIR spectra of wild melon jams (Figure 1) exhibited characteristic absorption bands corresponding to functional groups of bioactive compounds and polysaccharides. The transmittance bands were observed nearly at 680, 900, 1040, 1100, 1300, 1630, 2930, 3300, 3550  $\text{cm}^{-1}$  regions in most samples prominent peaks were observed in the region of 3,300-3,400  $\text{cm}^{-1}$ , which are attributed to O–H stretching vibrations of hydroxyl groups, reflecting the presence of phenolics, flavonoids, and carbohydrates. Absorption bands around 2,930  $\text{cm}^{-1}$  corresponded to C–H stretching of aliphatic chains, while peaks near 1,740  $\text{cm}^{-1}$  were indicative of C=O stretching of ester or carbonyl groups, associated with organic acids and pectin components. Bands between 1,050-1,150  $\text{cm}^{-1}$  suggested C–O stretching of polysaccharides.

Although, the overall spectral profiles of the three jams were similar, differences in peak intensities were observed. Jam I (with seeds,

unblanched) showed stronger absorption in the hydroxyl and aromatic regions, aligning with its higher phenolic and flavonoid content. Jam II (with seeds, blanched) displayed slightly reduced intensities in these regions, suggesting blanching-induced loss of certain heat-sensitive compounds. Jam III (seedless, unblanched) showed relatively lower aromatic stretching intensities compared to Jam I, which may be linked to the absence of seed-derived compounds. These findings confirm that seed retention contributes to the structural diversity of phytochemicals present in wild melon jam.

### 3.4 Sensory characteristics

The sensory characteristics of jam have been shown in Figure 2. Jam I had the highest overall acceptability followed by Jam II and Jam III and three types of jams differed significantly ( $p \geq 0.05$ ) in terms of flavour and acceptance. Jam I was found to have better ratings in appearance, flavour, taste, and overall acceptability as compared to Jam II and Jam III. On the other hand, Jam II had highest score in terms of color than Jam I and Jam III as blanching enhances the color of the fruits and vegetables.

### 3.5 Effect of storage on bioactive compounds

Figures 3 and 4 show the total phenolic content, flavonoids, and antioxidant activity of wild melon jam after three months of storage. The findings showed that total phenolic, flavonoid, and antioxidant activity (DPPH and ABTS) in Jam I ranged from 79.48 to 144.42 mg GAE/100 g, 13.01 to 28.24 mg QE/100 g, 14.44 to 33.08% and 11.97 to 24.26%, respectively, the corresponding values in Jam II were 66.93 to 100.26 mg GAE/100 g, 11.66 to 20.75 mg QE/100g, 9.33 to 25.75 %, 8.80 to 21.06%, respectively, and in Jam III, the values

ranged between 76.02 to 20.17 mg GAE/100 g, 9.47 to 15.36 mg QE/100 g, 7.47 to 22.71% and 6.78 to 19.09%, respectively.

The total phenols in case of freshly prepared Jam I, II and III were 144.42, 100.26 and 120.17 mg GAE/100 g, respectively. The percent retention of total phenols in Jam I upon storage ranged from 64.62, 61.03 and 55.03%, while in Jam II, it ranged from 86.61, 78.41 and 66.76% and furthermore in Jam III, it ranged from 90.27, 71.18 and 63.26%, on storage after 1, 2 and 3 months, respectively.

The flavonoids in case of freshly prepared Jam I, II and III were 28.24, 20.75, 15.36 mg QE/100 g respectively. No significant difference was found in Jam III up to two months of storage but significant decrease was found in Jam I and Jam II after one month of storage. The percent retention in flavonoids in Jam I upon storage ranged from 73.76, 62.43 and 46.07 %, while in Jam II, it ranged from 87.04, 80.10 and 56.19% and furthermore in Jam III it ranged from 89.06, 82.49 and 61.65%, on storage after 1, 2 and 3 months, respectively.

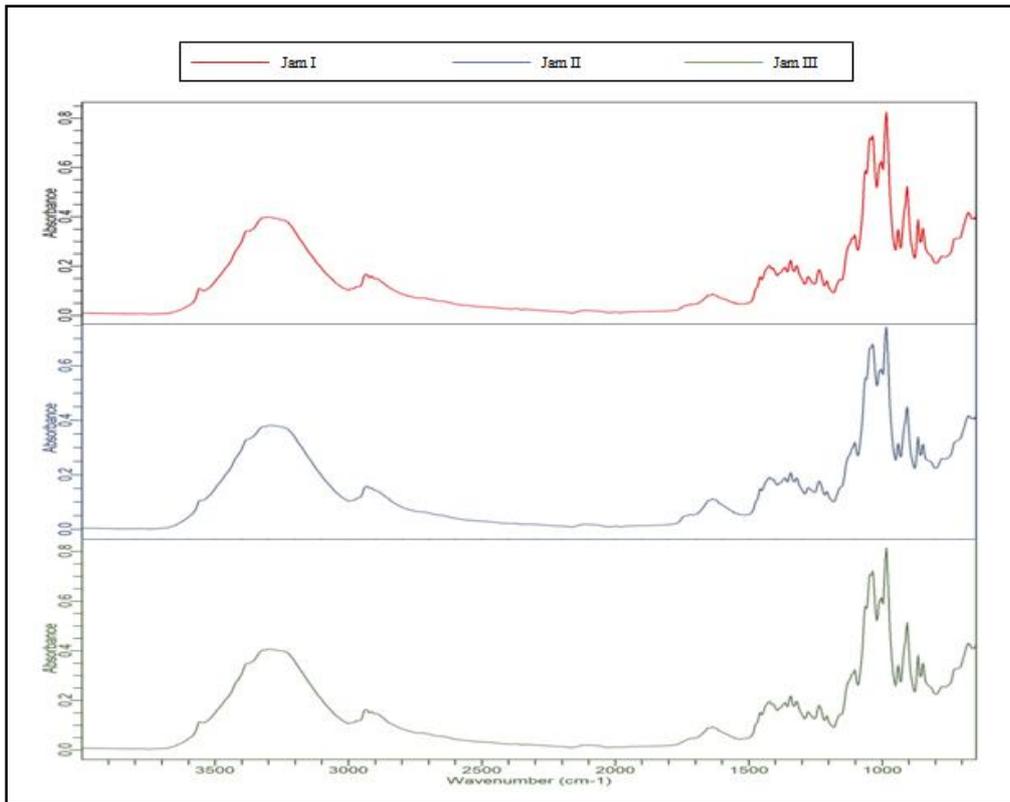


Figure 1: FTIR-spectra of wild melon jam.

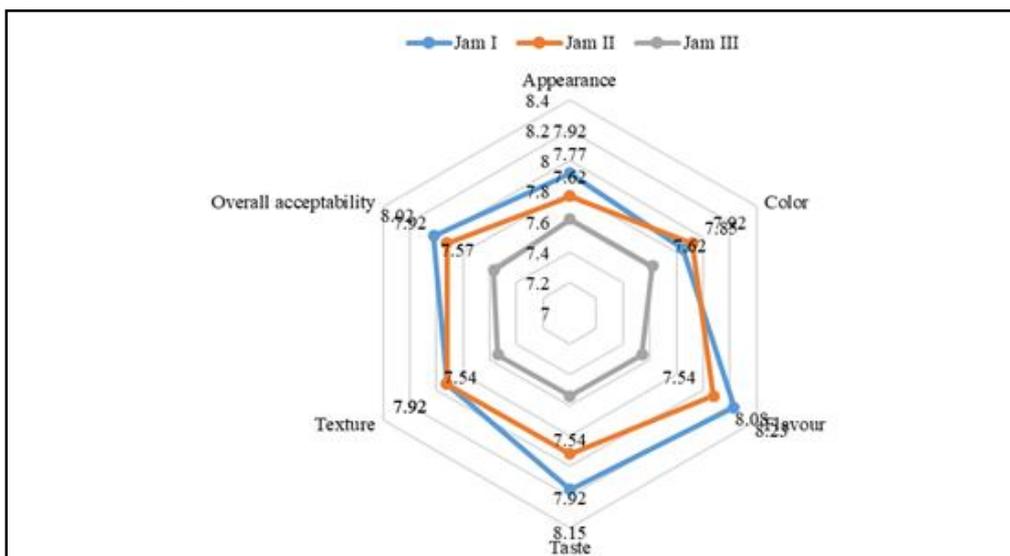


Figure 2: Sensory characteristics of wild melon jam.

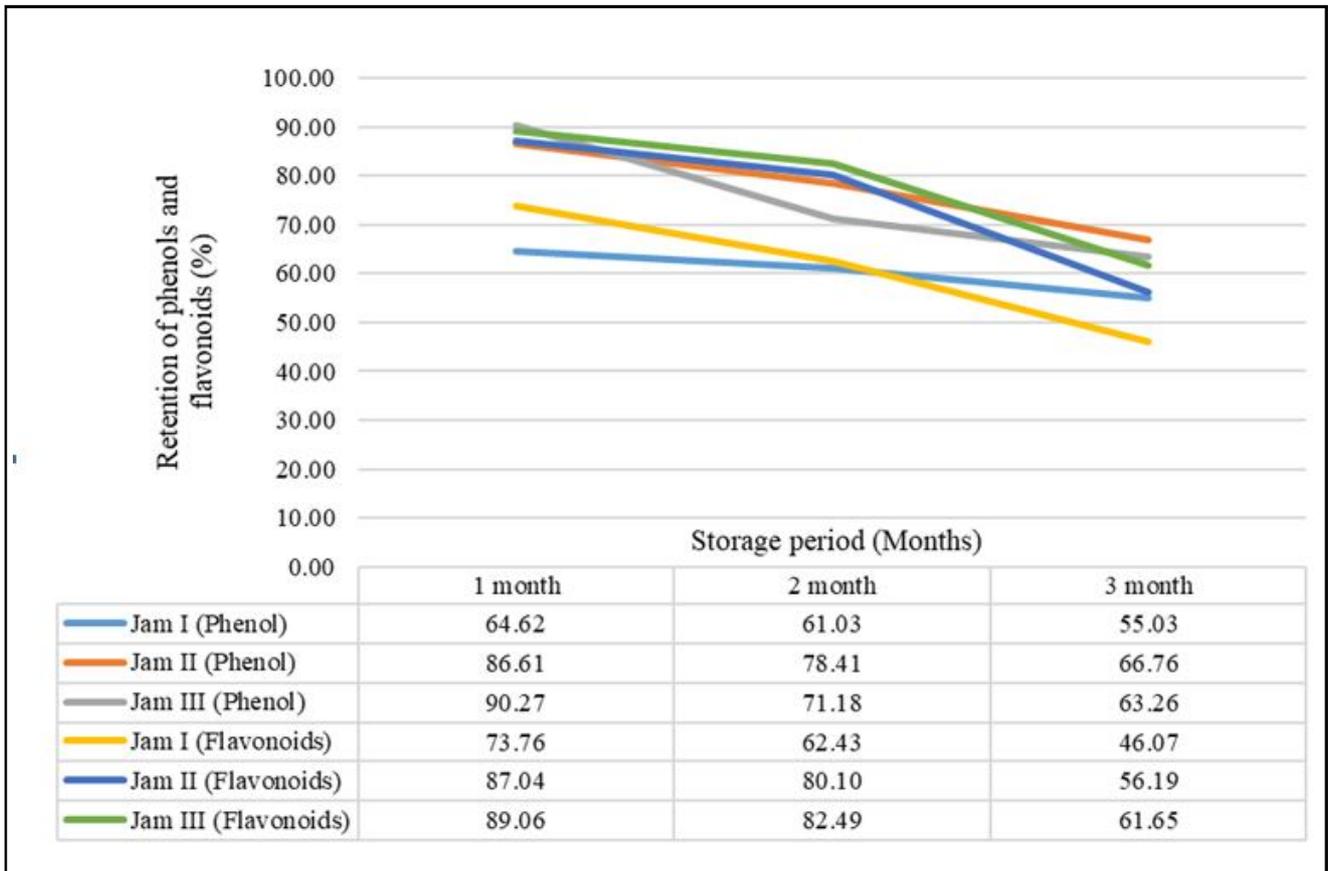


Figure 3: Effect of storage on the phenolic and flavonoid content of wild melon jam.

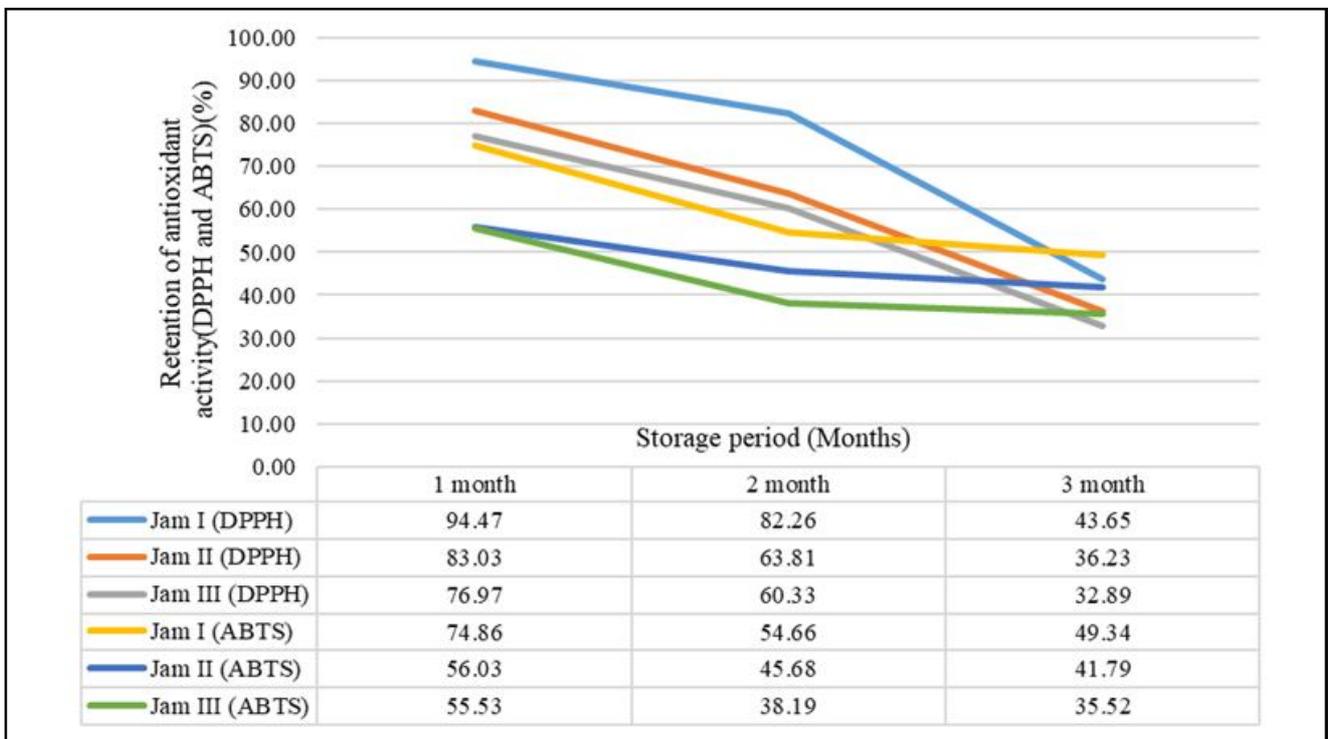


Figure 4: Effect of storage on the antioxidant activity (DPPH and ABTS) of wild melon jam.

Freshly produced jams I, II, and III showed antioxidant activity of 33.08, 25.75, and 22.71%, respectively, as measured by the DPPH technique. Antioxidant activity in all three jams dropped considerably after three months of storage. Antioxidant activity in Jam I remained at 94.47, 82.26, and 43.65% after storage. The corresponding values in Jam II were 83.03, 63.81 and 36.23% and in Jam III were 88.73, 63.17 and 59.50% after 1, 2 and 3 months, respectively.

The antioxidant activity by ABTS method in case of freshly prepared Jam I, II and III were 24.26, 21.06 and 19.09%, respectively. The percent retention of antioxidant activity in Jam I upon storage ranged from 74.86, 54.66 and 49.34% after 1, 2 and 3 months of storage, respectively. The corresponding values in Jam II were 56.03, 45.68, 41.79% and in Jam III was 55.53, 38.19 and 35.52%, respectively. Significant decrease in antioxidant activity was found after one month in Jam I and II but after two months of storage in Jam III.

#### 4. Discussion

The current study showed that processing techniques, specifically the inclusion or removal of seeds and the blanching procedure, had a substantial impact on the nutritional, functional, and sensory quality of wild melon jams.

##### 4.1 Nutritional composition

Jam with seeds (Jam I) exhibited superior protein, fat, ash, and carbohydrate content compared to the blanched and seedless variants. This trend may be attributed to the nutrient-dense nature of wild melon seeds, which are known to be rich in proteins, lipids, and minerals (Gill *et al.*, 2011). The moisture content of jams differed significantly ( $p < 0.05$ ) and ranged between 27.23 to 41.57% which is close to results given by Benmezziane *et al.* (2018) as 24.20% moisture in melon jam. Pérez-Herrera *et al.* (2020) reported that the moisture content in *Physalis* spp. fruits jam ranged between 34.47 to 48.68%. It is crucial to remember that product preservation during storage directly correlates with moisture level. Hence, jams with reduced levels of moisture have a longer shelf-life. There was significant difference in crude protein and crude fat content of jams. Tanongkankit *et al.* (2012) reported that the decrease in protein concentration might be due to leaching of water-soluble substances including free amino acids and nucleotides during blanching. The loss of volatile molecules and water-soluble fatty acids during the blanching process may be the cause of the decrease in fat content (Luo *et al.*, 2020). With respect to ash and dietary fibre, the jam with seeds contained more dietary fibre and ash content. The water-binding capacity of fibre enhances product qualities such as reduced syneresis and an extended shelf life. Fibre also increases viscosity and enhances the sensory and textural qualities of food (Pérez-Herrera *et al.*, 2020). According to Macagnan *et al.*, (2016), the jam's oligosaccharide and phenolic component concentration was also linked to dietary fibre, increased prebiotic benefits, and antioxidant properties.

Jam III (without seeds) contained the highest total sugars, reflecting the higher proportion of fruit pulp relative to seed mass. Conversely, reducing sugars were greater in Jam I, suggesting enzymatic or compositional influences from seeds. These differences are comparable to reported sugar levels in melon and other fruit-based jams *i.e.*, melon jam (56.18%), apple jam (66.84%), and peach jam (69.14%) (Benmezziane *et al.*, 2018).

##### 4.2 Bioactive compounds, ascorbic acid, antioxidant activity and colour characteristics

The presence of seeds enhanced the concentration of total phenols, flavonoids, and alkaloids, thereby contributing to the higher antioxidant potential of Jam I. Seeds of *Cucumis* species are rich in polyphenols and secondary metabolites with strong free radical scavenging capacity (Kaur and Arora, 2011). Removal of seeds significantly lowered these compounds, explaining the weaker antioxidant activity of Jam III. Blanching (Jam II) further reduced phenolics and ascorbic acid due to heat-induced degradation and leaching into boiling water, consistent with earlier observations (Volden *et al.*, 2009; Oboh, 2005). Pérez-Herrera *et al.* (2020) which also reported that phenolic compounds and flavonoids in with seeds and without seeds jam prepared from wild species of *Physalis* spp. differed significantly. Jam with seeds of wild species had highest phenolic compounds and flavonoids. Benmezziane *et al.* (2018) reported the vitamin C, polyphenols, flavonoids, carotenoids, lycopene and DPPH potential in *Cucumis melo* L jam as 5.4 mg/100 g, 14.04 mg GAE/100 g, 8.62 mg CEQ/100 g, 1.44 mg  $\beta$ -CE/100 g, 0.93 mg LE/100 g and 4.95%, respectively.

Antioxidant activity measured by DPPH and ABTS assays was strongly associated with phenolic and flavonoid levels. The reduction in antioxidant activity upon blanching underscores the sensitivity of bioactive compounds to thermal processing, as reported for other fruits and vegetables (Amin *et al.*, 2006; Lafarga *et al.*, 2017).

Colour is one of the most crucial jam quality characteristics which has a significant impact on how the product is perceived and received. This factor is assessed at the time of purchase and is crucial to determining whether or not a customer would accept the goods. Jams' colours can change due to a variety of factors, including pH, metal ions, temperature, light, oxygen, enzymes, sugars, and the products of their breakdown (Anna Bana, 2018). The chromaticity coordinates  $a^*$  and  $b^*$  describe colour attributes, while the  $L^*$  value represents brightness.  $L^*$  is shown as a vertical axis on the colour space diagram, with values ranging from 0 (black) to 100 (white). Bhat *et al.* (2017) also reported that due to an increase in  $L^*$  and  $a^*$  reduction, the blanched bottle gourd cubes had greater E (total colour difference) than the unblanched samples. The increasing E implies a rise in the lightness of samples, this could be because of the temperature, causing the inactivation of enzymes that are mostly responsible for the creation of dark-coloured compounds.

##### 4.3 FTIR analysis

The fundamental vibrations in the sample specimen were measured by FTIR, and these vibrational frequencies are very responsive to the structure of the substances under investigation. The functional group region, which spans the range of 4000 to 1500  $\text{cm}^{-1}$ , and the fingerprint region, which spans the range of 1500 to 500  $\text{cm}^{-1}$ , are the two unique regions under the MIR spectroscopy. The majority of the pertinent information needed to build MIR spectra, including information on X-H stretching, C-H stretching in aldehydes, double-bonded functional groups, triple bonds, is provided by the functional group area. The fingerprint region, despite being more intricate and overlapping, is used to estimate the amount of carbohydrates in diverse foods (Pandiselvam *et al.*, 2023).

The amorphous nature of the starch granules was detected by peaks at 1,000  $\text{cm}^{-1}$  regions, which fundamentally correspond to the

stretching of C-O-H vibrations. The peaks at 900-1150  $\text{cm}^{-1}$  showed C-O and C-C stretching vibrations (Bawa *et al.*, 2022). As the creation of the pectin polymeric chain network in fruit jam samples is caused by hydrogen bonding and hydrophobic interactions, the C-O and C-C stretching vibrations indicated gel strength (Oakenfull, 1991). Peak at 1148  $\text{cm}^{-1}$  was unique to sucrose, 1087 and 1043  $\text{cm}^{-1}$  to glucose and fructose, and 983  $\text{cm}^{-1}$  and 965  $\text{cm}^{-1}$  to fructose (Anjos *et al.*, 2015). The occurrence of peaks near 1,650  $\text{cm}^{-1}$  was often a sign that the amide I band region had reached its peak concentration. Peaks between 3,200 and 3,650  $\text{cm}^{-1}$  were associated with the O-H bond's stretching vibration and indicates the presence of water (Bawa *et al.*, 2022)

#### 4.4 Sensory characteristics

The overall acceptability of Jam I was superior, highlighting the positive contribution of seeds to flavour, texture, and nutritional quality. Although, Jam II had better colour attributes, its lower bioactive content and antioxidant activity limited its overall consumer preference. These results suggest that wild melon seeds not only enhance functional properties but also improve sensory appeal, which is critical for consumer acceptance (Pérez-Herrera *et al.*, 2020). Márquez-Cardozo *et al.* (2021) also reported that in order to inactivate enzymes, retain nutrients, and enhance colour, hot water blanching and steam blanching are the two pre-treatment techniques that are frequently employed in the food processing industry.

#### 4.5 Effect of storage on bioactive compounds

During storage, all jams exhibited gradual reductions in phenolics, flavonoids, and antioxidant activity, a trend widely reported in fruit-based products. Similar findings were reported by Lafarga *et al.* (2017) that the temperature and length of storage had a substantial impact on the antioxidant activity. Patras *et al.* (2011) reported that strawberry jam's antioxidant capacity decreased by 78.6 and 77.5% after 28 days of storage at 4°C and 15.8°C, respectively. In black currant, blackberry, raspberry, red currant, and strawberry jam's antioxidant activity was decreased by 50-60% as reported by Amakura *et al.* (2000). However, Jam I retained higher levels of bioactive compounds throughout the three-month period, indicating that seed components provided better oxidative stability. The observed decline in vitamin C and polyphenols was consistent with their sensitivity to oxygen, light, and temperature during storage (Klimczak *et al.*, 2007). Similar results were reported by Lafarga *et al.* (2017), that there was a steady decline in total phenolic compounds of blueberry jams during storage. The short shelf-life and polyphenol degradation during storage of blueberries and products produced from blueberries are two of the key issues.

### 5. Conclusion

Jams prepared from the wild melon fruit have high fibre and protein content along with nutraceutical and sensory qualities comparable to those of commercial jams. Compared to jams without seeds and blanched, jams with seeds had increased levels of phenols, flavonoids, and antioxidant activity. There was adequate retention of bioactive compounds and antioxidants during three months storage. The study concluded that wild melon jam with high antioxidant content can be marketed to health-conscious, expanding the use of wild melon fruit in the form of health products.

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### Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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