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A COMPARATIVE STUDY ON PROXIMATE AND MINERAL COMPOSITION OF UNPROCESSED AND PROCESSED UNDERUTILIZED *JERUSALEM ARTICHOKE* TUBER FLOUR

Diksha Gupta * and Neelam Chaturvedi

Department of Food Science and Nutrition, Banasthali Vidyapith, Tonk - 304022, Rajasthan, India.

Keywords:

Jerusalem artichoke, Blanching, Autoclaving, Proximate composition, Mineral composition

Correspondence to Author:
Diksha Gupta

Research Scholar,
Department of Food Science and Nutrition, Banasthali Vidyapith, Tonk - 304022, Rajasthan, India.

E-mail: dikshagupta823@gmail.com

ABSTRACT: *Jerusalem artichoke* is one of the underutilized tuber crops distributed worldwide in temperate areas. It is considered healthy and functional food due to its chemical composition as it contains proteins, mono or poly-unsaturated fatty acids, dietary fibers, vitamins, and minerals. In this present research work, the effect of processing on the proximate and mineral composition of *Jerusalem artichoke* tuber flour (JATF) was studied. The proximate analysis was determined in accordance with AOAC, while mineral estimation was done by the atomic absorption spectrophotometer. The result of the proximate analysis revealed that blanching with sun drying registered a significant increase in fiber content and insignificant reduction ($p<0.05$) in ash and protein content while it caused a substantial decrease in fat and carbohydrates values when compared with unprocessed-JATF samples. However, autoclaving with sun drying showed insignificant reduction only in ash content and a significant decrease ($p<0.05$) in fat, protein, and carbohydrates values when compared to unprocessed-JATF samples. The mineral analysis results showed that blanching and autoclaving with sun and oven drying caused a significant decrease in iron, magnesium, phosphorus, sodium, potassium, zinc content and showed a significant increase in calcium value at $p<0.05$ level. In overall consideration, blanching with sun drying appears to be the recommended processing method to obtain nutritive tuber flour since it caused an insignificant reduction in protein content and a significant decrease in mineral content but had a significantly higher amount of mineral content than autoclaving techniques.

INTRODUCTION: India is well known for significant geographical diversity of tropical root and tuber crops (aroids, yams, sweet potato, cassava, dahlia) and several minor tuber crops (*Jerusalem artichoke*, oca, olluco, mashua) [1]. The relative importance of these crops is evident through their annual global production, which is approximately 836 million tonnes.

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Edible tuber species have a significant role in the dietary habits of small and marginal farm families and forest-dwelling communities. They do not only enrich the diet of the people but also associated with reduced risk for diabetes, cardiovascular diseases, stroke, anemia, gastric ulcer, and rheumatoid arthritis.

Tubers are speculated to reduce the risk of chronic diseases through rendering its own pharmaceutical properties such as anti-oxidative, hypoglycemic, hypocholesterolemic, antimicrobial, and immuno-modulatory activities [2]. *Jerusalem artichoke* (*Helianthus tuberosus* L.) belongs to the Asteraceae family is an underutilized tuber commonly known as topinambur and earth apple.

It is a species of sunflower native to temperate regions of North America [3]. It is a perennial plant that has a tall stem, large leaves, bright yellow sunflower-like flowers, and fleshy tubers similar to potatoes. The tuber was originated from the Ohio and Mississippi river valleys in the United States that has been introduced and become naturalized as an economic crop worldwide in temperate areas. It is considered as healthy and functional food due to its chemical composition as it contains proteins, mono or poly-unsaturated fatty acids, vitamins (C, B, and β-carotene), minerals (iron, potassium, calcium, sodium, selenium) and dietary fibers (inulin and fructooligosaccharides) [4].

It also contains a high amount of bioactive compounds such as coumarins, sesquiterpenes, flavonoids, phenols, polyacetylenes and their derivatives with various pharmacological activities, such as anti-inflammatory, antimicrobial, anti-diabetic, anti-obesity and anticancer activities [5]. Tubers are usually subjected to different processing before being consumed, such as blanching, autoclaving, and boiling. In general, blanching and autoclaving of vegetables is generally regarded as superior food processing techniques, with respect to retention in sensory attributes and nutritive properties. Blanching is a short and mild heat treatment, in which fruits and vegetables are heated for the purpose of inactivating naturally occurring enzymes, modifying textures, preserving the colour, flavor, and nutritional value [6].

On the other hand, autoclaving is a high order of heat treatment that effectively eliminates, removes, or kills pathogenic and transmissible agents such as fungi, bacteria, viruses, and prions from the food [7]. Tubers have high moisture content and provide a favorable condition for the growth of microorganisms, which leads to their spoilage and wastage. Drying has been used traditionally as a method of preserving tubers in order to reduce the moisture content to a level, which prolongs shelf life during storage. Thus, the objective of the present study was to elucidate the effect of processing on the proximate and mineral content of *Jerusalem artichoke* tuber flour.

MATERIALS AND METHODS:

Sample Collection and Preparation: A total of three kilograms of uninfected *Jerusalem artichoke* tubers (JAT) were purchased from the Indian Institute of Vegetable Research (IIVR), Varanasi (U.P.) during the summer season of august 2018. They were sorted according to uniform maturity and size. After being cleaned, the peeled artichoke tubers were sliced to 1 mm thickness to provide thin samples. The samples were divided into three lots. The first lot was considered as unprocessed samples. The second lot was subjected to hot water blanching (1:10) at 95 ºC ± 2 ºC for 3 min.

The third lot was served as autoclaved samples using vertical autoclave at 15 lb pressure (121 ºC) for 15 min. Unprocessed, blanched, and autoclaved samples were divided into two equal parts and were subjected to sun drying (34 ºC) and oven drying (60 ºC) until tubers reached a constant weight. Dried flakes of unprocessed, blanched, and autoclaved sun and oven drying were ground in the mixer grinder sieved in order to collect fine powder and were filled in an air-tight container for further analysis.

Analytical Methods:

Proximate Composition: The proximate composition was done in accordance with the AOAC method with slight modification [8]. Moisture content was determined by drying in an oven at 85 ºC to constant weight. Ash content was estimated by difference method after sample mineralization at 600 ºC for 6 h, while protein content was determined from the analysis of total nitrogen using Micro Kjeldahl method (Kel plus analyzer) Pelican, Model: KES-61). Fat content was determined by Socs plus system (Pelican, Model: SCS-6), and fiber was estimated by the acid-alkali method in Fibre plus while carbohydrates were calculated by difference method (100-moisture + ash + protein + fat + fiber) [8].

Mineral Composition: Calcium, iron, phosphorus, magnesium, sodium, potassium, and zinc were estimated by atomic absorption spectrophotometry (Thermo-Scientific ICE 3000) [9]. Dried tuber powder was precisely weighed (2g each) followed by wet digestion with HNO_3: $HClO_4$ (2:1) in a conical flask for 2-3 h. 10 ml of HCl was added. Digested samples were filtered using 0.45 µm pore size cellulose nitrate membrane filter paper, and the volume was increased to 100 ml with distilled water and was stored in bottle with proper marking.

Statistical Analysis: Results are expressed as the mean values of three separate determines, expect for mineral elements that were determined in duplicate. Data were significantly analyzed using analysis of variance (ANOVA) using SPSS. A significant difference was determined at the p<0.05 level.

RESULTS AND DISCUSSION:

TABLE 1: EFFECT OF PROCESSING ON PROXIMATE CONTENT OF UNPROCESSED AND PROCESSED *JERUSALEM ARTICHOKE* TUBER FLOUR ON DRY WEIGHT BASIS

Parameters (g/100g)	Unprocessed-JATF		Processed-JATF			
	USD	UOD	BSD	BOD	ASD	AOD
Moisture	7.97 ± 0.79[e]	6.18 ± 0.78[f]	10.28 ± 0.24[c]	9.85 ± 0.47[d]	11.76 ± 0.48[a]	10.45 ± 0.45[b]
Ash	6.65 ± 0.35[a]	5.96 ± 0.38[b]	6.43 ± 0.42[a]	5.68 ± 0.19[b]	6.25 ± 0.42[a]	5.28 ± 0.40[b]
Protein	7.49 ± 0.18[a]	6.98 ± 0.20[b]	7.08 ± 0.18[a]	6.50 ± 0.39[b]	6.22 ± 0.29[b]	5.94 ± 0.28[c]
Fat	1.46 ± 0.40[a]	1.22 ± 0.32[a]	0.78 ± 0.14[b]	0.64 ± 0.19[b]	0.65 ± 0.21[b]	0.52 ± 0.13[b]
Fibre	6.24 ± 0.88[c]	5.45 ± 0.28[d]	8.51 ± 0.11[a]	7.93 ± 0.18[b]	8.91 ± 0.22[a]	8.26 ± 0.30[b]
Carbohydrates	70.19 ± 0.39[b]	74.21 ± 0.30[a]	66.92 ± 0.15[d]	69.4 ± 0.18[c]	66.21 ± 0.15[d]	69.55 ± 0.27[c]

Mean ± Standard Deviation of three determinations. Mean not followed by the same letter in the same row shows significantly different (p<0.05).USD: Unprocessed Sun Drying; UOD: Unprocessed Oven Drying; BSD: Blanched Sun Drying; BOD: Blanched Oven Drying; ASD: Autoclaved Sun Drying; AOD: Autoclaved Oven Drying

Table 1 shows the proximate composition of unprocessed and processed *Jerusalem artichoke* tuber flour (JATF) for moisture, ash, protein, fat, fiber and carbohydrate content. From the above **Table 1**, it was observed that the moisture content (g/100g) of unprocessed-JATF *viz.* USD and UOD were 7.97 ± 0.79 and 6.18 ± 0.78, respectively. Among processed-JATF, moisture content was found to be highest in ASD (11.76 ± 0.48) and lowest in BOD (9.85 ± 0.47). All processed-JATF registered a significant increase at p<0.05 level when compared with both unprocessed-JATF samples. According to El-Kholy and Mahrous 10 *Jerusalem artichoke* tuber had 6.8 ± 0.11 g / 100 g moisture content. Blanched and autoclaved *Terminalia catappa* had higher 11.99 ± 0.04 and 12.83 ± 0.03 g / 100 g moisture content when compared to the unprocessed (11.93 ± 0.02) [11]. The increased moisture content in tubers after processing might be due to the water absorption capacity of fibers. The ash content (g/100 g) obtained for unprocessed *viz* USD and UOD was 6.65 ± 0.35 and 5.96 ± 0.38, respectively. Among processed samples, BSD recorded the highest value (6.43 ± 0.42), and AOD had the lowest value (5.28 ± 0.40). Sun-drying with blanched and autoclaved samples *viz.* BSD and ASD registered an insignificant decrease when compared with USD sample. Similarly, oven drying of both blanched and autoclaved-JATF *i.e.* BOD and AOD showed insignificant decrease (p<0.05) from UOD sample. This data is comparable with the findings of [12] who reported that unprocessed *Jerusalem artichoke* tuber had 5.2 ± 0.05 g / 100 g ash content. The reduction of total ash may be due to leaching of the mineral compound during processing.

The protein content (g/100 g) of unprocessed-JATF, *i.e.*, USD and UOD, was 7.49 ± 0.18 and 6.98 ± 0.20, respectively. Among the processed-JATF, BSD had the highest value (7.08 ± 0.18), while AOD recorded the lowest value (5.94 ± 0.28). The data showed an insignificant reduction (p<0.05) in protein content with regards to BSD when compared with the USD sample. Likewise, UOD, BOD, and ASD showed an insignificant decrease (p<0.05 level) when compared with USD and BSD samples. However, AOD value registered a significant decrease with all the processed and unprocessed-JATF samples at p<0.05 level. [13] reported that *Jerusalem artichoke* tuber had 7.22 ± 0.14 g/100 g protein content [14]. Similarly, the boiled water yam contained significantly lower protein content (9.12 g / 100 g) when compared with unprocessed (10.27 g / 100 g) [14]. The reduction of protein may be attributed to leaching and denaturation of protein during blanching and autoclaving. The fat content (g/100 g) of unprocessed-JATF *viz.* USD and UOD were 1.46 ± 0.40 and 1.22 ± 0.32, respectively. Among the processed sample, BSD recorded 0.78 ± 0.14 values being the highest, while AOD had the lowest value (0.52 ± 0.13). The data indicated that all processed-JATF samples (BSD, BOD, ASD, and AOD) were significantly reduced as compared to unprocessed-JATF samples at p<0.05 level. This data agrees with Al, *et al.* 15, who reported that *Jerusalem artichoke* tuber had 1.00 ± 0.05 g / 100 g fat content. Likewise, the boiled oven-dried yam tuber had lower fat content (0.58 g / 100 g) when compared with fresh sun-dried (0.73 g / 100 g) and fresh oven-dried yam (0.63 g / 100 g) [16]. The decrease in fat content may be attributed due to the leaching effect during processing [17].

The fiber content (g/100 g) of unprocessed-JATF *i.e.* USD and UOD, was 6.24 ± 0.88 and 5.45 ± 0.28, respectively. Among the processed samples, ASD had the highest fiber content (8.91 ± 0.22), and BOD recorded the lowest fiber content (7.93 ± 0.18). The all processed-JATF samples registered a significant increase at p<0.05 level as compared to unprocessed-JATF [18]. Stated that *Jerusalem artichoke* tuber had 5.72 ± 0.19 g / 100 g fiber content 18. Similarly, blanching resulted in a significant increase in fiber content of sun-dried (1.32 g / 100 g) and oven-dried yam tuber (1.06 g / 100 g) when compared with unprocessed yam tuber flour (0.29 g / 100 g) [19]. The increase in fiber content could be due to the fact that when tubers were subjected to processing, all soluble components might have lost in the process, thereby increasing the crude fiber contents. The carbohydrate content (g/100 g) of unprocessed-JATF *viz.* USD and UOD were 70.19 ± 0.39 and 74.21 ± 0.30, respectively. Among processed samples, carbohydrates content was found to be highest in AOD (69.55 ± 0.27) and lowest in ASD (66.21 ± 0.15). The carbohydrate content was significantly reduced in all processed samples (BSD, BOD, ASD, and AOD) when compared with unprocessed-JATF samples (USD and UOD). On the other hand, BSD and ASD registered an insignificant difference to each other. Likewise, BOD and AOD showed insignificant differences with each other at p<0.05 level. The present data is comparable with the [20] who reported that *Jerusalem artichoke* contained 76.51 g / 100 of carbohydrates. According to El-Sohaimy [21] the fresh and boiled artichoke had 76.34 and 72.23 g / 100 g of carbohydrates. The reduction in carbohydrates during blanching and autoclaving might be due to leaching of soluble carbohydrates into water.

TABLE 2: EFFECT OF PROCESSING ON MINERAL CONTENT OF UNPROCESSED AND PROCESSED *JERUSALEM ARTICHOKE* TUBER FLOUR ON DRY WEIGHT BASIS

Parameters (mg/100 g)	Unprocessed-JATF		Processed-JATF			
	USD	UOD	BSD	BOD	ASD	AOD
Iron	15.32 ± 0.27[a]	13.58 ± 0.31[b]	12.65 ± 0.22[c]	11.36 ± 0.23[d]	10.36 ± 0.16[e]	9.26 ± 0.22[f]
Calcium	66.84 ± 0.36[e]	65.7 ± 0.13[f]	68.91± 0.40[c]	67.87 ± 0.12[d]	71.16 ± 0.15[a]	70.83 ± 0.19[b]
Magnesium	78.60 ± 0.13[a]	76.83 ± 0.14[b]	71.52 ± 0.18[c]	69.31± 0.51[d]	68.70 ±0.18[e]	65.77 ± 0.14[f]
Phosphorus	346.6 ± 0.21[a]	340.6 ± 0.23[b]	325.5 ± 0.25[c]	318.6 ± 0.15[d]	296.6 ± 0.13[e]	288.4 ± 0.20[f]
Sodium	42.79 ± 0.37[a]	39.78 ± 0.43[b]	35.75 ± 0.27[c]	32.96 ± 0.16[d]	30.38 ± 0.35[e]	28.80 ± 0.13[f]
Potassium	298.57 ± 0.13[a]	295.4 ± 0.21[b]	289.54 ± 0.14[c]	286.65 ± 0.10[d]	282.45± 0.14[e]	279.93 ± 0.35[f]
Zinc	5.81 ± 0.18[a]	5.06 ± 0.33[a]	4.83 ± 0.40[b]	4.22 ± 0.15[b]	3.92 ± 0.45[c]	3.21 ± 0.96[c]

Mean ± Standard Deviation of three determinations. Mean not followed by the same letter in the same row shows significantly different (p<0.05).USD: Unprocessed Sun Drying; UOD: Unprocessed Oven Drying; BSD: Blanched Sun Drying; BOD: Blanched Oven Drying; ASD: Autoclaved Sun Drying; AOD: Autoclaved Oven Drying

Table 2 shows the analysis of the mineral of unprocessed and processed *Jerusalem artichoke* tuber flour (JATF) for iron, calcium, magnesium, phosphorus, sodium, potassium, and zinc. It was observed that the iron content (mg/100 g) of unprocessed-JATF *viz.* USD and UOD were 15.32 ± 0.27 and 13.58 ± 0.31, respectively. Among the processed-JATF, iron content was found to be highest in BSD (12.65 ± 0.22) and lowest in AOD (9.26 ± 0.22). All processed samples showed a significant decrease at p<0.05 level when compared with unprocessed-JATF samples. The obtained value agreed with [22] who reported that the white variety of *Jerusalem artichoke* tuber had 12.78 ± 0.38 mg / 100 g iron content [24]. The iron content of blanched cocoyam (0.14 ± 0.01 mg/100 g) was significantly reduced when compared with unblanched (0.47 ± 0.02 mg/100 g) [23]. The reduction of iron content may be due to leaching of during blanching and autoclaving. The calcium content (mg/100 g) of unprocessed-JATF *i.e.* USD and UOD was 66.84 ± 0.36 and 65.7 ± 0.13 respectively. Among processed samples, ASD recorded the highest value (71.16 ± 0.15), and

BOD had the lowest value (67.87 ± 0.12). The processed samples showed a significant increase at $p<0.05$ level when compared with unprocessed-JATF samples. [13] stated that *Jerusalem artichoke* tuber had 70 mg/100 g calcium. The calcium content of unblanched pumpkin leaves (*Telfairia occidentalis*) (0.46 mg / 100 g) was significantly increased after blanching (0.58 mg / 100 g) [24]. Likewise, boiling resulted in significantly increase in calcium content of taro tuber powder (47.49 ± 0.55 mg / 100 g) when compared with unprocessed (45.23 ± 0.11 mg / 100 g) [25]. Processing has been reported to decrease the soluble oxalate content of tubers by leaching into the water, thereby releasing more calcium within the tubers.

The magnesium content (mg/100 g) of unprocessed-JATF *i.e.* USD and UOD was 78.60 ± 0.13 and 76.83 ± 0.14 values. Among processed-JATF, BSD had the highest value (71.52 ± 0.18), while AOD recorded the lowest value (65.77 ± 0.14). All processed samples registered a significant decrease at $p<0.05$ level when compared with unprocessed-JATF samples. The values agreed with Gemehe [26], who reported that anchote tubers (*Coccinia abyssinica*) had 79.73 ± 0.85 mg / 100 g magnesium content. The decreased magnesium during processing might be due to magnesium oxalate is less soluble than the potassium and sodium salts. The phosphorus content (mg / 100 g) of unprocessed-JATF *i.e.* USD and UOD was 346.6 ± 0.12 and 340.6 ± 0.23 respectively. Among processed-JATF, BSD recorded the highest value (325.5 ± 0.25), and AOD showed the lowest value (288.4 ± 0.20) The all processed samples revealed a significant decrease at $p<0.05$ level when compared with unprocessed-JATF. The data is comparable to the findings of [27] who reported that *Jerusalem artichoke* tuber had 396.8 ± 0.96 mg / 100 g phosphorus content. The loss in phosphorus content might be occurring due to leaching up to 25%.

The sodium content (mg/100 g) of unprocessed-JATF *viz.* USD and UOD were 42.79 ± 0.37 and 39.78 ± 0.43, respectively. Among processed-JATF samples, the sodium content was found to be highest in BSD (35.75 ± 0.27) and lowest in AOD (28.80 ± 0.13). The processed samples registered a significant decrease at $p<0.05$ level when compared with unprocessed-JATF samples. The data is an agreement with [12] who reported that *Jerusalem artichoke* tuber had 41.38 mg/ 100 g sodium content. Likewise, boiling resulted in a significant decrease in the sodium content of bitter leaves (28.01 ± 0.10) when compared with unprocessed (30.12 ± 0.12) [28]. The reduction of sodium content may be due to leaching of its content during processing. The potassium content (mg / 100 g) of unprocessed-JATF *i.e.* USD and UOD was 298.57 ± 0.13 and 295.4 ± 0.21 respectively. Among the processed samples, BSD recorded the highest value (289.54 ± 0.14), and AOD recorded the lowest value (279.93 ± 0.35). The processed samples showed a significant decrease at $p<0.05$ level when compared with unprocessed-JATF samples. The present data is comparable with [22] who reported that white variety of *Jerusalem artichoke* tuber had 300.12 ± 30.01 mg/100 g potassium content. Likewise, the potassium content of boiled sweet potato (3,061.08 mg/100 g) was significantly reduced when compared with unprocessed (3,288.24 mg/100 g) [29]. The reduction of potassium content may be the result of leaching of its content during processing.

The zinc content (mg / 100 g) of unprocessed-JATF *i.e.* USD and UOD was 5.81 ± 0.18 and 5.06 ± 0.33 respectively. Among processed-JATF samples, BSD had 4.83 ± 0.40 values being the highest, while AOD recorded the lowest value (3.21 ± 0.96). The processed samples registered a significant decrease ($p<0.05$) when compared with unprocessed-JATF samples. However, BSD and BOD showed insignificant reduction ($p<0.05$) to each other. Similarly, ASD and AOD showed an insignificant decrease with each other at $p<0.05$ level. The data is an agreement with Lakra and Sehgal [30], who reported that potato flour had 4.9 ± 0.2 mg/100 g zinc content. Likewise, the zinc content of blanched okra pods (3.76 ± 0.01 mg / 100 g) was significantly decreased when compared with unprocessed (15.5 ± 0.01 mg / 100 g) at $p<0.05$ level [31]. The reduction of zinc content may be due to leaching of its content during processing.

CONCLUSION: The present findings uncovered the fact that unprocessed-JATF contains a significant amount of protein, ash, and fiber content with an excellent amount of minerals. However, processing treatments (blanching and autoclaving with sun and oven drying) influence the proximate and mineral composition of unprocessed-JATF. In an overall consideration of these treatments, blanching with sun drying appears to be the recommended processing method to obtain nutritive tuber flour since it caused an insignificant reduction in protein content and a significant decrease in mineral content, but had a significantly higher amount of minerals content than autoclaving processing method.

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