Review on Agriculture and Rural Development 2023 vol. 12 (3-4) ISSN 2677-0792
DOI: 10.14232/rard.2023.3-4.28-33

EVALUATION OF TRAPA NATANS L. (WATER CALTROP) HARVESTED FROM LAKE TISZA, HUNGARY

Judit Tarek-Tilistyak[1]*, Gyula Kücsön[2]

[1]Agricultural and Molecular Research and Service Institute, University of Nyíregyháza, Nyíregyháza, HUNGARY

[2]Élményfalu Kft., Budapest, HUNGARY

[*]corresponding author: judit.tilistyak@gmail.com

Abstract: *Trapa natans* L. (TN) is an aquatic weed with high-yield of biomass. Our aim was to study the food potential of TN fruit including the physical attributes, the chemical composition and the suitability for minimal food processing operations. The TN plants with fruits were harvested from the Sarud Basin of Lake Tisza, Hungary. We analyzed the fruits' macro-composition and inorganic elements content. The fruits were selected into groups by size, and by weight. The fruit hardness was examined after a 24-hour, 1% cellulase treatment. The kernel's dry content was obtained by pressing, subsequent centrifugation and by conventional drying. The dry kernel had a 12% protein, 2.5% ash, and 68% carbohydrate content. The raw kernel was high in K, Mg, and Cu, and was low in Sodium, and did not contain As, Hg, Pb, or Cd, either. The dry content of the raw juice was 24.4%, and of the pomace was 36.9%. After centrifugation, the clear juice had a considerable amount of soluble solid content (Brix 6 %). We concluded that the TN fruit harvested from Lake Tisza is a valuable and safe material for the development of food specialties and is a special ingredient of local dishes.

Keywords: Trapa natans, water caltrop fruit, vegetable juice, *Trapa natans* inorganic element

1. Introduction

Trapa natans L. (water caltrop) is an annual aquatic weed, distributed widely but discontinuously in Europe, Asia, and Africa. In the European Union, it is a protected plant (Borojevic 2009). This plant spreads extremely in shallow, quiet waters with muddy bottoms, and can cover large areas of water surfaces that can negatively impact fishing and recreational activities. The plant's floating rosette produces large, woody fruit with four barbed spines. The mature spiky fruits are dangerous to bathers. A single seed may give rise to 10 to 15 rosettes, each producing up to 15 to 20 seeds. (Lim 2013). On Lake Tisza, the floating TN plants are thinned mechanically with a weed mower that simply cuts the long stem without any form of harvest resulting in basically an eutrophication in the water and a plant redevelopment (Molnár 2016). The *Trapa* plant is a minor food crop extensively cultivated for its seed in the Far East e.g. in India, and China (Agrawal & Ram 1995). Chemical contaminants (metals, pesticides) can bioaccumulate in the TN fruit, but this contamination considerably decreases after boiling the fruit (Rai & Sinha 2001). The kernel is gluten-free, and eaten raw, boiled, roasted, fried, and processed into flour for cereal substitution (Fletcher 2016). Raw kernels from the red variety TN

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need color stabilization. There is a growing interest in developing TN food products in Asia (Zhu 2016), and simultaneously in minimally processed foods (drying, juice production, etc.), because these are healthier food choices based on the NOVA food classification system (Monteiro et al. 2016), and also in gluten-free or vegan foodstuffs, including milk replacers from vegetable origin. Due to the continuous fruit development through the vegetation period, the TN fruits are inhomogeneous by volume, size, and weight at harvest time which makes it necessary to apply precious pre-treatment procedures when manufactured.

Regarding the above-mentioned, we aimed to study the TN fruit as a food material from the safety aspect and also quality approaches through minimal processing techniques.

2. Materials and methods

2.1. Materials

Trapa natans (TN) whole plants were harvested in their natural habitat, manually from the Sarud Basin of Lake Tisza, Hungary, on the first week of October 2016 and 2020, by Élményfalu Kft., under official permission from the Hungarian National General Inspectorate of Environment Protection and Nature Reserve and from its successor since TN is a protected species in Hungary. TN fruit (raw, enzyme-treated, dried) and kernel processed into different forms (pressed juice, clarified juice, pomace) were subject to chemical composition analyses.

2.2. Minimal processing of TN fruits

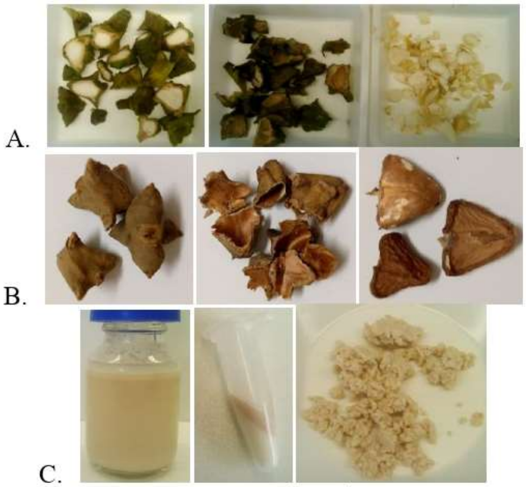
Cleaning: TN raw fruits were cleaned by shaking manually for about 2 minutes in excess tap water put into a covered bowl containing tap water, and then in a covered mesh sieve to separate the excess water from the surface.

Sorting and enzymatic treatment: Raw TN fruits (n=64) grouped by size were weighted individually using an analytical balance. From each group, two pieces of fruits received enzymatic treatment using 150 ml, 1% cellulase enzyme solution in a 200-ml volume plastic container closed with a screw cap, then left for 24 hours at room temperature. We rated the fruits' hardness on a 4-point scale by cutting manually with a knife and noted if the hull was woody.

Juice preparation (Figure 1A, 1C): The fully matured, cleaned fruits were halved with an electric meat slicer, and then the kernel was picked out manually from the hull. Hull particles contaminated the kernel bulk, which was removed with washing and a slight manual shaking. Then the kernel was screw pressed into juice, and the pomace was also studied, with special emphasis on their yield, dry matter, and water-soluble solid content (Brix). The raw juice underwent a centrifugation (5 min, 4000 rpm) to obtain the solid content (wet sediment).

Powder preparation (Figure 1B): Fully matured TN fruits (n=15) were dried in an oven at 60°C and then peeled by hand with a knife. The dried whole TN fruit, the kernel, and the hull were weighted to calculate the kernel yield. The kernel was ground into powder for proximate analysis.

Figure 1: *Trapa natans* samples: A. and B.: fruits and particles: raw (top) and dried (center); whole fruit (left), hull (middle), kernel (right). C.: *Trapa natans* kernel juice, sediment, and pomace from the raw kernel.



Source: Author's photo.

2.3. Determination of the chemical composition and the yield

Inorganic elements were quantified on raw fruit kernel (wet-state, moisture content: 45.53%) sample. For sample preparation, EN 13805:2015 method was used. The Fe, Se, Zn, Cu, As, Hg, Cd, and Pb content were determined using the EPA 6020A:2007 method, while for the Ca, K, Mg, Si the EPA6010C:2007 method was used. The proximate composition of the dry kernel was analysed using specific and Hungarian national standard (MSZ) methods: MSZ 4420:1980 for dry matter; MSZ 1385:1987 for protein; WBSE 78:2012 for fat; MSZ 3610:1983 for ash; Hungarian Codex Alimentarius method MÉ 1 1 90/496 section V. for carbohydrates and energy content, ASU L.000.00 18 for dietary fiber, and MSZ 3625:1986 for sugar content.

Analytical methods applied during drying and juice production, in brief: dry matter content was measured with a halogen moisture analyzer (HG63, Mettler Toledo), and the water-soluble solid content of clarified juice was measured with a refractometer (RE 40D, Mettler Toledo). We calculated the wet sediment yield (%) as the wet sediment weight divided by the juice weight, and the kernel yield (%; in wet and in dried state) as the kernel weight divided by the fruit weight. The weight was measured on an analytical balance (PB 303-S/PH, Mettler Toledo).

The measurements of inorganic elements and the proximate composition were achieved by a certified laboratory in Hungary. The measurements during drying and the juice processing were achieved by the Agricultural and Molecular Research and Service Institute, at the University of Nyíregyháza, Hungary.

The data were calculated as mean and standard deviation for three replicates.

3. Results

3.1. Safety and quality of *Trapa natans* kernel

The yield of dry kernel obtained from the fully matured dried fruit was 50%. The main focus was on the fruit contaminants' toxaemic inorganic element content, such as Arsenic, Cadmium, Lead, and Mercury, as food safety indicators, and the overall nutritional parameters were measured (Table 1, Table 2) The TN kernel contained no heavy metals and Sodium in "specifically low" amount.

Table 1: Concentration of the inorganic elements in TN raw kernel (mg/kg), and their ratios (%) relative to the Recommended Daily Intake* provided by 100 g unprocessed kernel, in parenthesis

K	Mg	Ca	Na	Fe	Zn	Cu
3950 (20%)	670 (18%)	420 (5%)	130 (1%)	20 (14%)	12 (12%)	2 (20%)
Si	**Se**	**As**	**Pd**	**Cd**	**Hg**	
<100	<0.5	<1	<1	<0.1	<0.1	

Source: Authors' editing. * https 1.

Table 2: The proximate composition of TN kernel (%, dry kernel)

moisture	protein	fat	ash	carbo-hydrates	sugar	dietary fiber	Energy (Kcal/100 g)
10.57	12.00	0.48	2.46	68.40	8.00	6.10	338.00

Source: Authors' editing.

3.2. Sorting and enzymatic treatment of raw *Trapa natans* fruit

The continuous fruit development results in differently matured TN fruits with different physical attributes (Figure 2.). In groups No.1-3., there was no significant difference among the individual fruits' weight (35% of the samples), and likewise when comparing groups No.4 and 5 (taking 28% of the samples). A significant difference in weight was found between groups No. 6 and 7. The mean weight in groups No. 4 and 5 is half (4.4 g) of that of groups No. 6 and 7 (9.1 g).

3.3. Wet processing of *Trapa natans* kernel

The products of wet processing can be seen in Figure 1C. As a result of the wet processing, the raw kernel dry content decreased from 54.5% to 30.3 % due to rinsing off the hull particles. The juice pressing resulted in a so-called vegetable milk product, full of dispersed material. The dry content of juice was 24.4%, and of the pomace was 36.9%. The dispersed material was separated from the juice by centrifugation and resulted in a clarified, transparent liquid in the ratio of 60.5% with a 6.4% water-soluble solid content and a two-layered sediment in the ratio of 39.5%, with 58.4% dry content. Of the sediment volume, the darker, upper, low-density layer incorporated about 30-40% expected as dietary fiber; the lower, heavier layer of the sediment was the major part expected to contain digestible polysaccharides, like starch.

Figure 2: Representatives of *Trapa natans* fruits grouped by size, the individual weight (g) and other physical attributes by groups.

group No.	1	2	3	4	5	6	7.
mean weight	0.1	0.6	0.9	3.7	4.8	6.8	10.5
range	0.1 - 1.1			3.1 - 5.3		5.9 - 15.0	
mean ±STD	0.5 ±0.3			4.4 ±0.6		9.1 ±2.5	
woodiness	-	-	+	+	+	+	+
hardness	0	0	0	2	3	4	4
n=	7	11	5	7	11	9	14
n=	23			18		23	

Source: Author's photo and editing.

4. Discussion

Our dry kernel yield result is consistent with data provided by Gao et al.(2014). Based on the heavy metal results, the TN kernel from Lake Tisza is a safe food material, which is necessary according to European food safety regulations and like the findings of Rai &Sinha (2001). Five hundred grams of raw TN kernel can provide the daily K, Cu, and Mg intake for the human body. TN kernel is suitable for a controlled Sodium diet. Our results for the mineral content and proximate composition are in line with the data provided by Lim (2013) and Zhu (2016), with a slight difference. The TN kernel corresponds to the macro-composition of whole grain oatmeal and pseudo flour (like quinoa) and is rich in fiber, which contributes to the prevention of obesity and cardiovascular diseases

Cellulase treatment facilitated the softening of fruits' hull up to 5 grams per piece of weight. For fruits weighing at least 6 g (are considered as matured fruits), the hull remained hard, so a cutting machine is necessary to free the kernel. The fruits with individual weight between 3-6 g, may mash during machine-assisted cutting reducing the efficacy of processing, this hypothesis needs further studies. Taking into account various aspects (weight, woodiness, hardness), it is necessary to sort TN fruits into no more than 3 groups before taking into food processing procedures and find economical use of fruits under 1 gram. During the wet processing, we tried to separate the solid content as much as possible which essentially resulted first in a white, opaque, highly turbid juice (due to the starch content) and after the centrifugation a clear, transparent liquid similar to water with a considerable amount of water-soluble-solid content. These liquids are suitable for non-alcoholic fermentation (Zhou & Chang 2013) and for other foods e.g. soups, pudding, isotonic drinks, and vegetable milk. The pomace and the sediment have considerable solid content, but a short shelf-life due to their high moisture content. Their immediate processing e.g. heat treatment or preparing ready-to-eat dishes is needed to preserve these valuable materials and their nutrients.

The TN plant, especially its fruit is a potential ingredient for the economical production of plenty of high-value-added countryside food or specialties; meanwhile, harvesting it ameliorates the area for recreational activities, and tourism, including gastro-tourism. Investing in the TN fruit processing contributes to overall rural development.

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