



Utilization of Water Chestnut and Kitchen Waste in the Development of Instant Soup Mix

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ABSTRACT

Background: The study aimed to develop an instant soup mix powder using water chestnut and vegetable waste from cauliflower and radish, which are both nutrient-rich. This approach addresses the utilization of underutilized and discarded plant resources to create a nutritious, value-added food product.

Methods: Water chestnut flour and kitchen waste was utilized for the manufacturing of instant soup mix for these firstly water chestnut flour (5-50 gram) was optimized and after those levels of cauliflower and radish leaves (1-7 gram) was optimized. Constant ingredients included corn flour, spices and dried vegetable cubes. Statistical analysis of physical and organoleptic data identified the optimal soup mix formulation.

Result: The optimal soup mix contained 33.98% water chestnut flour and 2.91% vegetable leaves, receiving high sensory scores for appearance (8.33), aroma (7.96), flavor (8.60) and overall acceptability (8.16). Increased vegetable leaves reduced true density, porosity and solubility. The mix offered 88.8±0.3% moisture, 1.39±0.04% crude fat, 4.73±1.76% crude protein, 2.24±0.34% crude fiber, 2.18±0.53% ash content, 82.90±2.45% carbohydrates, 53.00±2.45 mg/100 g calcium, 3.80±1.38 mg/100 g iron, 0.46±0.25 mg/100 g β -carotene and provide 363.03±2.71 Kcal energy.

Key words: Instant mix, Sustainable, Vegetable waste, Water-chestnut.

INTRODUCTION

The food processing industry has expanded significantly, driven by the demand for a diverse range of high-quality food products that cater to consumers' convenience. With the fast-paced lifestyles of many Indians, especially in urban areas, there is an increasing need for quick and practical food solutions, such as instant mixes for ice cream, kulfi, gulab jamun and soup. Soup, which derives its name from the Teutonic word "suppa," traditionally consists of a thick stew served over bread. It is typically made from vegetables, fish, or meat, combined with water, juice, or stock and may include thickening agents. Soups can be classified into two main types: thick soups, made with cereal or pulse flour, cream and eggs (Radha *et al.*, 2015) and clear soups, which are made from clear extracts of plant or animal sources. Instant soups offer a nearly ready-to-eat option that requires minimal cooking time (Dhiman *et al.*, 2017). The growing popularity of instant foods reflects a demand for meals that are quick, hygienic, easy to prepare and convenient to consume (Islam *et al.*, 2018). Instant mixes have become popular for their convenience, with the global instant food market growing at around 12 to 15% annually (Gandhi *et al.*, 2017). Available products include instant mixes for idli, gulab jamun and soups, which only require boiling water for preparation. Traditionally, soup serves as an appetizer or comfort food, especially during illness, but homemade soups are increasingly being replaced by commercially prepared options like canned, dehydrated and frozen soups. Instant soup is particularly suitable for breakfast due to its high

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energy and nutrient content and quick preparation time (Sunyoto and Futiawati, 2012). The concept of soup as a convenience food originated in France, where it is often the main component of evening meals (Abdel-Haleem and Omran, 2014). Dry soup mixes offer health benefits through the incorporation of functional ingredients and have advantages such as long shelf stability (6 to 12 months) without refrigeration, making them ideal for working families, hospitals, hotels and military rations. Additionally, their lightweight nature facilitates shipping and they are available year-round (Igwenyi and Azoro, 2014).

The Indian instant soup market has witnessed significant growth in recent years, driven by changing lifestyles and increasing demand for convenient food options. Several companies have established a strong presence in this sector, offering a variety of flavors to cater

to diverse consumer preferences. The Indian instant soup market is led by several key players, each catering to different consumer preferences. Hindustan Unilever Limited (HUL) dominates the segment with its Knorr brand, offering a diverse range of flavors and continuously innovating to meet changing consumer demands. Capital Foods Limited, known for its Ching's Secret brand, specializes in Indo-Chinese flavored soups, attracting consumers who enjoy bold and spicy options. MTR Foods Pvt. Ltd. focuses on traditional Indian flavors, providing instant soups that offer the convenience of quick preparation while maintaining familiar, authentic tastes. Meanwhile, Bambino Agro Industries Ltd. has expanded its product portfolio to include instant soups, emphasizing affordability and taste to appeal to a broad customer base. Together, these companies contribute to the growing popularity of instant soups in India, offering a balance of convenience, taste and variety to suit different palates. The Indian instant soup market has seen rapid expansion, driven by evolving consumer preferences and the growing demand for ready-to-eat food products. Industry reports estimate that the market will exceed INR 1,000 crore by 2025, with the top three brands dominating nearly 90% of sales. Knorr (Hindustan Unilever Limited) leads the segment, followed by Ching's Secret, MTR Foods and Bambino Agro Industries. The increasing popularity of instant soups across urban and rural areas, combined with strong marketing strategies and innovative flavor offerings, has significantly contributed to this market's growth. Commercial instant soups are crafted for convenience and taste, but their nutritional composition varies across brands. Typically, they provide 50 to 100 kcal per serving, with carbohydrates as the main macronutrient, moderate protein levels and minimal fat. However, many contain high sodium levels, along with additives and preservatives to enhance flavor and extend shelf life. While these soups serve as a quick and easy meal option, consumers are encouraged to read nutritional labels carefully, choosing products with lower sodium and fewer artificial additives for a healthier alternative.

Typically, corn starch or rice starch is used as a thickening agent in soups, while the edible portions of fresh vegetables are included as dried vegetable pieces. However, nowadays, vegetable-based starches, such as water chestnut powder, can replace traditional cereal starches. Additionally, vegetable waste can be incorporated into processed products, enhancing both consistency and nutritional value. Water chestnut (*Trapa natans*), known as Singhara in India, is an annual aquatic crop belonging to the Trapaceae family. It thrives in tropical and subtropical regions, growing best in nutrient-rich water with a neutral to slightly alkaline pH. This plant prefers warm, humid conditions and is primarily found in states such as Punjab, Bihar, Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Maharashtra and parts of Uttarakhand (Takano and Kadono, 2005). Water chestnut is cultivated on approximately

603,076 acres worldwide, yielding a total production of 2,327,495 tonnes (Rajput and Singh, 2023). In India, the recorded production of water chestnut is 67,600 tonnes from an area of 16,900 hectares (Jana, 2023). In the Indian subcontinent, water chestnuts are consumed as edible nuts and serve as a cereal substitute during fasting. They can be eaten as vegetables, ground into flour for making bread or chapatti, cookies and used in sweet dishes (Singh *et al.*, 2010; Sharma and Devi, 2021). Despite its nutritional benefits, water chestnut products remain under commercialized. Water chestnuts are rich in carotenoids, phenolic acids, phytosterols and polyphenolic compounds, including flavonoids, proanthocyanidins and stilbenes (Hussain *et al.*, 2016). Medicinally, it has been used as a nerve tonic and is known for its therapeutic properties, including treatment for diarrhea, as an intestinal astringent and for its anti-inflammatory, antioxidant and hepatoprotective effects (Ambikar *et al.*, 2010; Kirtikar and Basu, 1993; Kar *et al.*, 2004; Song *et al.*, 2007).

Cauliflower (*Brassica oleraceae*), a cool-season crop originating from Asia, is primarily produced in China and India, with West Bengal being the largest producer in India, followed by Madhya Pradesh, Bihar, Haryana and Odisha (APEDA, 2018). In India, the annual production of cauliflower was recorded at 9,225 thousand metric tons, cultivated over an area of 473 thousand hectares (HSD, 2021). The edible part of cauliflower, known as the curd, is creamy white and compact, surrounded by large, inedible leaves. Approximately 45 to 60% of the vegetable's weight consists of this non-edible portion, which has the highest waste index among vegetables (Oberoi *et al.*, 2007). Although often discarded, the stalk and leaves are rich in protein, iron, calcium and β -carotene, making them valuable for producing various value-added products (Sharma and Prasad, 2018). Cauliflower leaves are particularly high in health-promoting compounds, including vitamins, minerals, carotenoids, flavonoids, phenols and glucosinolates (Campbell *et al.*, 2012). Research has shown that the leaves contain significant amounts of lysine and tryptophan, though they are deficient in cystine and methionine (Goel *et al.*, 2014). Additionally, dried cauliflower leaves provide essential fatty acids and are rich in antioxidant and antimicrobial properties (Sharmilan and Jaganathan, 2016).

Radish (*Raphanus sativus*), a widely cultivated and quick-growing cool-season crop from the Brassicaceae family, is either annual or biennial and originated in China (Wang and Hee, 2005). It flourishes in both tropical and temperate climates, with its main edible part being the swollen primary root. In India, its annual production is 3,263 thousand metric tonnes, cultivated over an area of 207 thousand hectares (HSD, 2021). Freshly harvested radishes have a shelf life of 2 to 3 days at room temperature. They are recommended for individuals with health issues like piles, liver troubles and jaundice and can be consumed raw in salads, cooked as vegetables, or

as juice for health benefits. Radish leaves are a good source of protein, containing all 22 amino acids and have a biological value of 76.6 with a digestibility coefficient of 73.5%. Due to their low-calorie content, radish leaves are suitable for diabetic patients. Additionally, the juice from fresh leaves acts as a diuretic and laxative (Ankita and Prasad, 2015). Radish leaves are rich in minerals such as iron, calcium, phosphorus, folic acid and vitamin C and radish leaf powder shows high antioxidant activity (87.04%) when dried at 40°C for 14 hours (Joshi *et al.*, 2019). However, the leaves are often excluded from diets due to their short shelf life and preparation inconvenience. Every year, 18% of India's fruit and vegetable production, valued at Rs. 13,300 crores, goes to waste. Due to inadequate cold storage facilities, around 30% of fruits and vegetables are lost at various stages of the supply chain, from harvesting and post-harvest handling to processing and consumption (Sharma *et al.*, 2024). Given the importance of developing convenient foods, there is a strong need to create instant soups that utilize the nutritional benefits of water chestnuts, cauliflower waste (including leaves and stalks) and radish leaves.

The selection of specific kitchen waste, such as radish leaves and cauliflower, is often based on factors like nutritional value, flavor balance, texture and usability in various applications. Radish leaves are rich in essential components, including iron, calcium and beta-carotene

(Table 2), making them a valuable addition to food preparations, composting and animal feed. Cauliflower leaves, on the other hand, are packed with fibre, minerals and beta-carotene (Table 2), contributing to both health benefits and sustainability efforts. These vegetable scraps are chosen because they blend well in soups, stews and other -culinary applications without introducing undesirable flavors or textures. Thus, selecting radish and cauliflower waste ensures a balance between nutritional benefits, ease of use and environmental sustainability.

MATERIALS AND METHODS

The raw material namely water-chestnut, radish and cauliflower along with leaves, peas, carrot, corn flour, common salt and powdered black pepper and cumin as required for the study were purchased from local market of Pantnagar whereas tomato powder, onion powder and garlic powder were purchased Haldwani market, Uttarakhand, India. All the reagents employed in the study were of Analytical grade. The investigation took place at the Department of Food Science and Technology, College of Agriculture, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.

Development of instant soup mix powder

To prepare the instant soup mix from water chestnut and vegetable waste, the first step is to convert the water

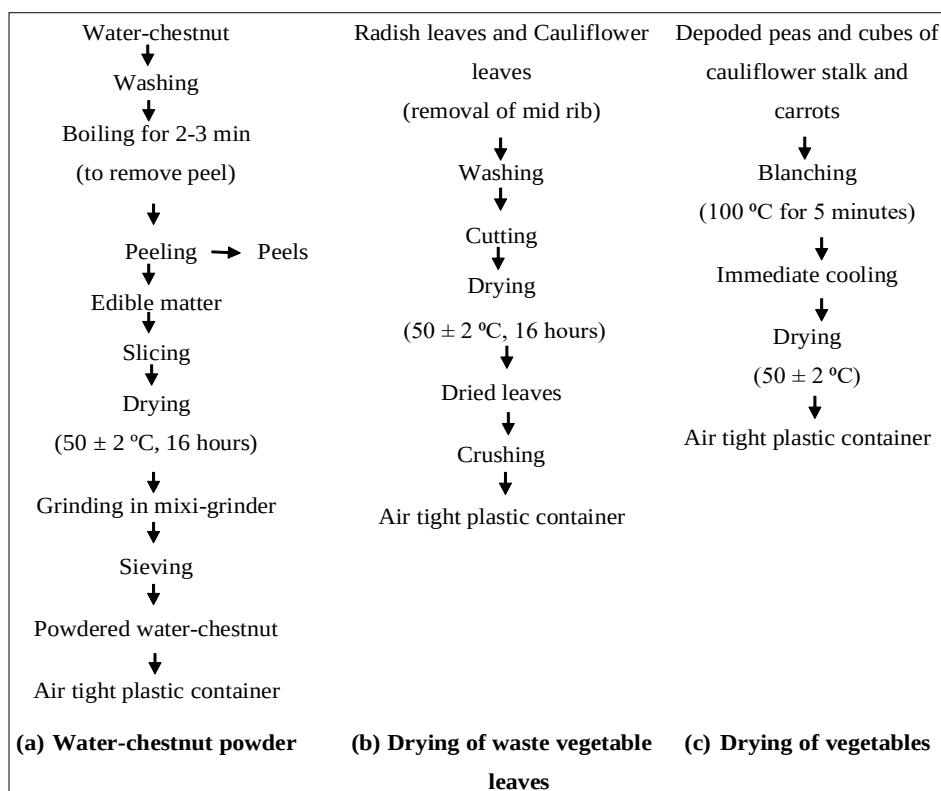


Fig 1: Preparation of dried powder from water-chestnut (a), cauliflower and radish leaves (b) and dried vegetables (c).

chestnut and vegetable waste into powder and dried the vegetable (pea and cubes of cauliflower stalk) as illustrated in (Fig 1). The instant soup mix powder was optimized by combining varying amounts of water chestnut powder (ranging from 5 to 50 g) with other ingredients, including corn flour, common salt, tomato powder, onion powder, garlic powder, black pepper powder, cumin powder and dried vegetables (cauliflower stalk: carrot: pea= 1:1:1).

Following the optimization of the water chestnut powder concentration based on physical and sensory parameters different levels (1 to 7 g) of cauliflower and radish leaves in ratio of 2:1 was also optimized.

The raw material and the optimized product were assessed for several physico-chemical characteristics (Table 1). A completely randomized design (CRD) was used for the analysis of variance concerning physical and

Table 1: Methods used for the analysis of physico-chemical and sensory parameters of raw material, treatments and optimized product.

Parameters	References/equipment/method
Physical parameters	
Bulk density (g/cc)	Sarkar <i>et al.</i> , 2019
True density (g/cc)	Deshpande and Poshadri, 2011
Porosity (%)	Singh, 2002
Solubility (%)	Sarkar <i>et al.</i> , 2019
Chemical parameters	
Moisture (%)	AOAC, 1984
Crude protein (%)	AOAC, 1984
Crude fat (%)	AOAC, 1984
Ash (%)	AOAC, 1984
Crude fibre (%)	Ranganna, 1986
Carbohydrate (%)	By difference, Ranganna, 1986
Calcium and Iron (mg/100 g)	Atomic absorption spectroscopy by Ranganna, 1986
β -carotene (mg/100 g)	UV-V spectrophotometer by Ranganna, 1986
Calorific value	James, 1995
*Sensory evaluation	Panel of semi-trained members on 9-point Hedonic Rating Scale (Islam, 2018)

* Boil 600 ml of potable water, add the instant soup mix (50 g) made from water chestnut and vegetable waste and simmer until it reaches the desired consistency (4-5 min). Serve hot for organoleptic evaluation by the sensory panel.

Table 2: Chemical characteristics of water-chestnut kernel, cauliflower waste and radish leaves.

Chemical characteristics	Water-chestnut	Cauliflower waste		Radish leaves
		Leaves	Stalks	
Moisture (%)	75.43 $\pm$ 0.13 ^a (24.57 $\pm$ 0.13) ^b	83.66 $\pm$ 2.45 (16.34 $\pm$ 2.45)	90.40 $\pm$ 0.10 (9.6 $\pm$ 0.10)	90.15 $\pm$ 0.58 (9.20 $\pm$ 0.53)
Crude protein (%)	1.82 $\pm$ 0.28 (7.44 $\pm$ 1.57)	2.88 $\pm$ 0.13 (17.80 $\pm$ 0.73)	1.86 $\pm$ 0.04 (19.26 $\pm$ 0.44)	2.08 $\pm$ 0.07 (22.55 $\pm$ 0.83)
Crude fat (%)	0.36 $\pm$ 0.21 (1.5 $\pm$ 0.95)	0.63 $\pm$ 0.22 (3.91 $\pm$ 1.34)	0.50 $\pm$ 0.02 (5.20 $\pm$ 0.26)	0.09 $\pm$ 0.01 (1.01 $\pm$ 0.12)
Ash (%)	0.94 $\pm$ 0.65 (3.86 $\pm$ 1.35)	1.69 $\pm$ 0.06 (10.38 $\pm$ 0.39)	0.59 $\pm$ 0.07 (6.19 $\pm$ 0.74)	1.62 $\pm$ 0.07 (13.39 $\pm$ 0.77)
Crude fibre (%)	0.72 $\pm$ 0.47 (2.93 $\pm$ 0.75)	2.36 $\pm$ 0.38 (14.48 $\pm$ 2.91)	1.04 $\pm$ 0.07 (10.80 $\pm$ 0.78)	1.40 $\pm$ 0.13 (15.31 $\pm$ 1.44)
Carbohydrate (%)	21.45 $\pm$ 0.04 (62.63 $\pm$ 1.21)	11.14 $\pm$ 2.20 (51.57 $\pm$ 1.03)	6.65 $\pm$ 0.20 (59.75 $\pm$ 1.39)	6.06 $\pm$ 0.71 (53.85 $\pm$ 0.21)
Calcium (mg/100 g)	34.53 $\pm$ 0.50 (104.33 $\pm$ 2.08)	58.26 $\pm$ 0.95 (631 $\pm$ 3.78)	3.6 $\pm$ 1.57 (37.50 $\pm$ 1.35)	2.27 $\pm$ 1.76 (35.56 $\pm$ 1.76)
Iron (mg/100 g)	1.56 $\pm$ 0.15 (3.63 $\pm$ 0.11)	12.43 $\pm$ 0.49 (58.33 $\pm$ 0.36)	0.63 $\pm$ 2.83 (6.56 $\pm$ 2.44)	4.80 $\pm$ 0.62 (52.17 $\pm$ 0.62)
β -carotene (mg/100 g)	-	6.97 $\pm$ 0.50 (38.15 $\pm$ 6.15)	-	4.11 $\pm$ 0.18 (28.85 $\pm$ 1.90)

^aAverage values $\pm$ Standard deviation.

^bValues in parenthesis are on dry basis.

chemical treatments, while a randomized block design (RBD) was utilized for the sensory evaluation. The standardization experiment was replicated three times.

RESULTS AND DISCUSSION

Chemical characteristics of water-chestnut and vegetable waste

Table 2 represents chemical composition of raw water-chestnut and vegetable waste i.e. leaves and stalk of cauliflower and radish leaves. The proximate composition revealed that water-chestnut, leaves and stalk of cauliflower and radish leaves contains considerable amount of protein, fibre, calcium and iron. Additionally, the leaves of cauliflower and radish are good sources of beta-carotene. Previous research has reported similar values and highlighted the significant impact of nutrient availability on the final product (Singh *et al.*, 2010; Alfasane *et al.*, 2011; Walde and Misra 2016; Chakraborty *et al.*, 2015; Longvah *et al.*, 2017; Wani and Kaul, 2011; Abul-Fadl, 2012; Sharma and Prasad, 2018; Ankita and Prasad, 2015).

Effect of water-chestnut flour on physical and sensory attributes of instant soup mix

The effect of incorporation of different concentration of water-chestnut flour into the instant soup mix on physical and sensory attributes is flourished in Table 3. It is evident from the data that all the physical parameters were gradually decrease as the concentration of water-chestnut flour increases into the soup mix. Statistical analysis of the data indicates that increasing the level of water-chestnut flour in making instant soup mix did not influence its bulk density and true density significantly. However, porosity was influenced significantly and it might be due to different values of bulk density and true density of the instant soup mix

powder. Solubility of all prepared samples exhibited decreasing trend with the rise in concentration of water-chestnut flour. This may be due to hindering effect on solubilization of the substances in water by increasing the level of water-chestnut flour on account of increasing level of native starch.

Table 3 also shows that the soup premix containing 35 g of water-chestnut flour achieved the highest sensory score among all treatments, except for consistency. Water-chestnut flour has a neutral taste and mild aroma. As the amount of water-chestnut flour increased, it replaced the spice mix powder, which impacted the taste and odor of the product. Additionally, the consistency of the prepared samples gradually increased with higher concentrations of water-chestnut flour. This is likely due to the significant starch content in water-chestnut, which acts as a thickening agent and influences the product's consistency (Hallale and Jadhao, 2016).

Effect of different concentration of dried leaves on physical and sensory attributes of instant soup mix

As shown in Table 4, increasing the concentration of dried leaves in the soup premix significantly reduced the true density, porosity and solubility. This may be because the dried leaves are lightweight and occupy more volume. The observed decrease in solubility could be attributed to the dried and crushed leaves absorbing more water in the soup, which reduces the amount of water available to dissolve other ingredients. Additionally, dried leaves are generally insoluble in nature, further contributing to the reduction in solubility. It can also be observed that the instant soup mix containing 3 g of leaves received the highest sensory scores, while the addition of more leaves beyond this amount resulted in a decrease in sensory scores (Table 4).

Table 3: Effect of different levels of water-chestnut flour on physical and sensory characteristics of instant soup mix.

Recipe	Level of water chestnut (g) + other constant ingredients*	Physical characteristics				Organoleptic scores				
		Bulk density (g/cc)	True density (g/cc)	Porosity (%)	Solubility (%)	Appearance	Odour	Taste	Consistency	Overall acceptability
1	5	0.660	3.30	80.00	28.51	6.40	6.13	5.00	5.23	5.17
2	10	0.690	3.30	80.00	27.25	6.30	6.33	5.40	5.47	5.37
3	15	0.710	3.30	79.00	26.15	6.47	6.33	5.93	5.57	6.10
4	20	0.717	2.50	72.03	25.20	6.57	6.33	5.93	5.93	6.23
5	25	0.714	2.50	72.03	24.44	6.93	6.76	6.57	6.27	6.20
6	30	0.714	2.50	72.00	23.56	6.73	6.83	7.67	6.67	7.53
7	35	0.714	2.00	65.00	22.93	7.37	7.76	8.33	7.77	8.17
8	40	0.714	2.00	66.00	22.16	6.50	7.27	7.43	7.83	6.93
9	45	0.760	2.00	62.00	21.70	6.63	6.73	6.07	7.90	6.23
10	50	0.760	2.00	62.00	21.17	6.47	6.700	4.90	7.93	5.83
	C.D at 5 %	NS	NS	0.04	0.035	NS	0.63	0.62	0.72	0.58
	SE (m) ±	0.001	0.001	0.014	0.012	0.30	0.21	0.20	0.24	0.19

* Other constant ingredients (65 g) include Corn flour (15 g), common salt (15 g), tomato powder (8 g), onion powder (5 g), garlic powder (3 g), black pepper powder (5 g), cumin powder (2 g) and dried vegetables (12 g).

Nutritional characteristics of optimized instant soup mix

The nutritional composition of the optimized instant soup mix, as presented in Table 5, demonstrates a balanced nutritional profile with $8.8 \pm 0.3\%$ moisture, $1.39 \pm 0.04\%$ crude fat, $4.73 \pm 1.76\%$ crude protein, $2.24 \pm 0.034\%$ crude fiber, $2.18 \pm 0.53\%$ ash and $82.90 \pm 2.45\%$ carbohydrates. Additionally, the soup is a good source of essential minerals, providing 53.00 ± 2.45 mg/100 g of calcium and 3.80 ± 1.38 mg/100 g of iron. The β -carotene content is 0.46 ± 0.58 mg/100 g. With a high caloric value of 363.03 ± 2.71 Kcal, the optimized instant soup mix offers a nutritious and energy-dense food option.

The high carbohydrate content ($82.90 \pm 2.45\%$) of water chestnut soup mix makes it an excellent energy booster, providing quick replenishment, especially for athletes and individuals with high energy demands. Water chestnut flour primarily consists of starch, which is easily digestible and ensures a sustained release of energy. Beyond its carbohydrate content, the mix is nutritionally rich, containing essential minerals like calcium, iron, potassium and phosphorus, which play crucial roles in muscle function, nerve signaling and bone health. It may also include fiber (2.24 ± 0.34), which promotes digestive health and aids in regulating blood sugar levels. Furthermore, the soup mix may also be exhibits strong antioxidant activity due to the presence of polyphenolic compounds present in water chestnut flour and spices used for the preparation of soup mix.

The expected shelf life of water chestnut soup mix typically ranges from 6 to 12 months based on the moisture content (8.8%) and this also depends on storage conditions, packaging and ingredient composition. Properly sealed and stored in a cool, dry place can help maintain its quality and freshness for an extended period. Adding natural preservatives such as rosemary extract, ascorbic acid (Vitamin C) and tocopherols (Vitamin E) can enhance antioxidant stability and prevent rancidity, thereby extending the shelf life of the water chestnut soup mix. In addition to natural options, small amounts of synthetic

preservatives like sodium benzoate or potassium sorbate can be used to effectively inhibit microbial growth while ensuring safety within regulatory limits. Furthermore, incorporating spices such as turmeric, cloves and cinnamon not only enhances the flavor profile but also provides antimicrobial and antioxidant properties, contributing to the overall preservation and longevity of the product.

The moisture content of 8.8% in water chestnut soup mix is within an optimal range to ensure product stability while preventing microbial growth. Lower moisture content helps to inhibit the growth of bacteria, yeast and mold, which thrive in high-moisture environments. This controlled moisture level enhances the shelf life of the product by reducing the risk of spoilage and maintaining its sensory and nutritional quality over time. Regarding microbial quality, a properly processed and packaged soup mix with 8.8% moisture content is expected to have low microbial load, as the reduced water activity makes it less favourable for microbial proliferation.

Comparison of water chestnut soup mix and commercial instant soup mix

The water chestnut soup mix stands out as a superior alternative to commercial instant soups due to its lower moisture content ($8.8 \pm 0.3\%$), which enhances shelf life and prevents microbial growth compared to the higher moisture levels (10-12%) found in commercial varieties. It also contains significantly less fat ($1.39 \pm 0.04\%$), making it a healthier choice that reduces the risk of obesity and heart disease, whereas commercial soup mixes often contain 5-15% fat. The water chestnut soup mix offers a naturally sourced protein content ($4.73 \pm 1.76\%$), comparable to commercial instant soups but without artificial enhancers. Its high fiber content ($2.24 \pm 0.034\%$) supports digestion, promotes gut health and helps regulate blood sugar levels, making it a superior choice over commercial soups, which often contain less than 1% fiber. The ash content ($2.18 \pm 0.53\%$) indicates a richer mineral composition, enhancing its overall nutritional density. With an

Table 4: Effect of different levels of leaves on physical and sensory characteristics of instant soup mix.

Process	Level of leaves (g)	Physical characteristics				Sensory characteristics				
		Bulk density (g/cc)	True density (g/cc)	Porosity (%)	Solubility (%)	Appearance	Odour	Taste	Consistency	Overall acceptability
Control	0	0.714	2.00	65.00	22.93	7.90	7.76	8.36	8.00	7.80
1	1	0.72	2.00	63.80	23.89	8.00	7.93	8.36	7.83	8.00
2	2	0.76	2.00	61.53	23.02	8.00	7.90	8.43	7.83	8.00
3	3	0.73	1.64	55.16	22.17	8.33	7.96	8.60	7.80	8.16
4	4	0.73	1.64	55.20	21.92	7.40	6.83	7.50	7.73	7.16
5	5	0.81	1.66	50.70	21.82	6.83	6.66	6.66	7.70	6.33
6	6	0.81	1.42	42.40	21.62	6.33	6.16	4.66	7.67	6.00
7	7	0.83	1.42	41.40	21.44	6.33	6.03	4.00	7.66	4.00
	C.D. at 5 %	NS	0.03	0.04	0.003	0.85	0.65	0.88	NS	0.46
	SE (m) $\pm$	0.001	0.01	0.013	0.001	0.27	0.21	0.29	0.21	0.15

Table 5: Nutritional characteristics of optimized instant soup mix (on dry weight basis).

Nutritional characteristics*	Average $\pm$ SD*
Moisture (%)	8.8 $\pm$ 0.3
Crude fat (%)	1.39 $\pm$ 0.04
Crude protein (%)	4.73 $\pm$ 1.76
Crude fibre (%)	2.24 $\pm$ 0.34
Ash (%)	2.18 $\pm$ 0.53
Carbohydrate (%)	82.90 $\pm$ 2.45
Calorific value (Kcal)	363.03 $\pm$ 2.71
Calcium (mg/100 g)	53.00 $\pm$ 2.45
Iron (mg/100 g)	3.80 $\pm$ 1.38
β -carotene (mg/100 g)	0.46 $\pm$ 0.25

*Standard deviation.

exceptionally high carbohydrate content (82.90 $\pm$ 2.45%), the soup mix provides sustained energy, making it ideal for athletes and active individuals. While its caloric value (363.03 $\pm$ 2.71 Kcal/100 g) is comparable to commercial options, it delivers clean energy without artificial additives. Additionally, it is naturally rich in essential minerals, offering 53.00 $\pm$ 2.45 mg/100 g of calcium for bone health and 3.80 $\pm$ 1.38 mg/100 g of iron for oxygen transport-nutrients that are often lower in commercial soups, which rely on synthetic fortification. The presence of β -carotene (0.46 $\pm$ 0.58 mg/100 g) further enhances its health benefits by providing natural antioxidants that support immune function and eye health. Unlike many commercial soups that contain synthetic preservatives, MSG and artificial colors, the water chestnut soup mix is a clean-label product, making it a healthier and safer alternative.

CONCLUSION

It can be concluded that the underutilized water chestnut, rich in nutrients such as protein, fiber, calcium and iron, holds significant potential for broader use. Similarly, the leaves of cauliflower and radish, often discarded as waste, have higher nutritional value compared to their edible portions. These resources can be effectively utilized to develop a variety of value-added products.

Conflict of Interest

The authors have declared no conflict of interest for this article.

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