Cucurbita moschata: A Nutritional Powerhouse for Functional Food Development

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Abstract

Cucurbita moschata, commonly grown across the globe, is a nutrient-dense crop packed with carotenoids, vitamins, dietary fiber, minerals, and phenolic compounds. Beyond its nutritional value, it holds significant medicinal potential. some related researches have demonstrated its ability to support anti-obesity, anti-diabetic, antibacterial, and anticancer effects, sparking growing interest in medical research. The nutrients and bioactive compounds in Cucurbita moschata play a vital role in promoting human health. This article aims to review the physicochemical characteristics and nutritional profile of *Cucurbita moschata*, offering insights to guide future studies on its health benefits.

Keywords: *Cucurbita moschata*, Physicochemical characteristics, Nutritional profile, Bioactive compounds, Human health

Introduction

Cucurbita moschata, commonly known as pumpkin, has been grown in various countries since ancient times. This species is part of the *Cucurbitaceae* family and falls under the Cucurbitales order (Armesto et al., 2020). Interestingly, pumpkins have two distinct points of origin in the Americas. One is in Mexico and Central and South America, where you'll find varieties like *Cucurbita moschata, Cucurbita ficifolia, Cucurbita pepo, and Cucurbita mixta*. The other origin is located in South America, which is home to *Cucurbita maxima* (Armesto et al., 2020; Jacobo-Valenzuela et al., 2011b). *Cucurbita moschata* is an essential food crop

and plays a significant role in the diets of people in both rural and, to some degree, urban settings across the Americas (Lira and Montes, 1992). It's incredibly versatile in the kitchen, used as a vegetable or as an ingredient in various dishes—think bread, flour, soups, and pies (Doymaz, 2007; Guine´ et al., 2012).

This particular pumpkin thrives in warm, tropical climates and prefers areas with ample water. It's not fond of the cold, but it does manage to withstand drought and frost during its flowering season (Jacobo-Valenzuela et al., 2011b). The skin of the fruit is robust and durable, making it less prone to damage while being transported. Interestingly, it can be stored for over three months at room temperature, which not only makes it great for everyday meals but also for more extensive processing, leading to its popularity in the food industry.

In several countries—including the United States, Mexico, India, China, and Brazil—people have long used Cucurbita moschata for medicinal purposes (Jacobo-Valenzuela et al., 2011b; Yadav et al., 2010). This pumpkin is packed with nutrients, including vitamins A, B, and C, a variety of minerals, carotene, and eight essential amino acids. Plus, it contains trace elements such as phosphorus, potassium, calcium, magnesium, zinc, and silicon. Modern nutrition and medical studies have highlighted that Cucurbita moschata can help prevent conditions like hypertension, diabetes, and liver disease, while also boosting the immune system (Priori et al., 2017). The polysaccharides, dietary fiber, and pectin found in this pumpkin contribute significantly to its beneficial effects on the body (Jacobo-Valenzuela et al., 2011b).

Cucurbita moschata is quite versatile and is being explored in various fields. For instance, in food processing, researchers like Lee et al. (2002) have looked into the physical characteristics and sensory experiences of noodles made with Cucurbita moschata powder. Aziah and Komathi (2009) examined the differences between peeled and unpeeled Cucurbita moschata flour, comparing it to wheat flour. In the realm of medical research, Jun et al. (2006) extracted pectin polysaccharides from the peel and found they could foster the growth of beneficial gut bacteria. Additionally, Zaccari et al. (2007) studied how the beta-carotene content changes during the storage of Cucurbita moschata.

Despite the widespread cultivation and some research surrounding Cucurbita moschata, there's still a lot we don't know about this variety, which definitely deserves more investigation. The goal of this article is to provide a comprehensive overview of the physicochemical properties, nutritional components, and health benefits of Cucurbita

moschata. This will help people gain a deeper understanding of this pumpkin and lay the groundwork for future research.

Morphology of *Cucurbita moschata*

Cucurbita moschata has no regular shape, and the data show a wide range of physical and chemical characteristics (Jacobo-Valenzuela et al., 2011a). There is a great deal of variation in their sizes, shapes, and colours. There is a lot of short growth on the plant stems, and the flesh is rather thick (Ku et al., 2005). According to Wu et al. (2011) and Yildiz et al. (2013), the seed's length ranges from 8.00 to 22.41 mm, its width ranges from 1.00 to 14.10 mm, its thickness ranges from 1.58 to 4.52 mm, and its average weight falls between 0.063 and 0.190 g. Cucurbita moschata has a smooth exterior; the fruit will range in length from 13.21 to 91.99 cm, width from 9.46 to 55.40 cm, thickness from 0.58 to 6.95 cm, and weight from 0.59 to 8.75 kg. Colours of Cucurbita moschata include brown, orange, and more. According to Melendez Martınez et al. (2004), the variation in carotenoids in Cucurbita moschata contributes to the colour variation. The flesh of Cucurbita moschata, however, has a lower a and b colour value the longer it is stored (Gliemmo et al., 2009).

According to Jacobo-Valenzuela et al. (2011b), Cucurbita moschata has four distinct shapes: "Ovalada," "Bule," "Buchona," and "Herradura." Of these, "Buchona" is the most prevalent morphology, while "Bule" is the least common. The peel has a colour range of 45.46 to 100.00 for the L value, - 9.83 to 24.51 for the a value, and - 21.12 to 54.05 for the b value (Jacobo-Valenzuela et al., 2011a). In the pulp of Cucurbita moschata, the colour parameters L, a, and b have been recorded to range between 40.30 and 100.00, - 13.14 and 33.09, and - 12.65 and 63.70, respectively.

Nutritional components of *Cucurbita moschata*

Cucurbita moschata fruit comes in a variety of shapes, colours, sizes, and seed kinds, according to Montes et al. (2004), who also analysed some of the plant's physical traits. The chemical composition (moisture, protein, fat, crude fibre, and crude ash) of a specific variety of Cucurbita moschata was assessed by Guine´ et al. (2012), Jacobo-Valenzuela et al. (2011b), and Roura et al. (2007). They determined that the shell's moisture content ranges from 80.04 to 88.47%, its protein content ranges from 2.59 to 4.45%, its fat content ranges from 0.31 to 0.49%, and its ash content ranges from 1.06 to 1.13% (Jacobo-Valenzuela et al., 2011a).

The pulp's moisture content ranges from 79.00 to 93.00%, its protein content ranges from 0.76 to 19.61%, its fat content ranges from 0.04 to 3.81%, and its ash content ranges from 0.57 to 13.45%, as indicated in Table 1. The physicochemical, chemical, and antioxidant characteristics of two pumpkin cultivars (Cucurbita moschata and Cucurbita maxima) were investigated by Indrianingsih et al. (2019). The antioxidant activity of Cucurbita moschata seeds is shown to be greater than that of Cucurbita maxima seeds. At the same time, Cucurbita moschata seeds had higher levels of fat and protein than Cucurbita maxima seeds, with respective contents of 28.49% and 19.23%. Compared to the pulp of Cucurbita maxima (69.51%), the pulp of Cucurbita moschata has a much greater carbohydrate content (up to 78.64%). Vitamins A, C, E, and dietary fibre are abundant in Cucurbita moschata. Additionally, it has high levels of potassium, magnesium, and manganese—all of which are vital for human health. Cucurbita moschata is also rich in pectin, mineral salts, carotene, vitamins, and other health-promoting compounds, according to Jun et al. (2006). It is particularly helpful for older, obese, and hypertensive individuals, and it is well suited for patients with hypertension, coronary heart disease, and high cholesterol levels.

Table1: Chemical composition of *Cucurbita moschata* Pulp

Parameters	Content	References
Moisture (%)	79–93	Armesto et al. (2020), Guine´ et al. (2012), Jacobo-Valenzuela et al. (2011a), Jacobo-Valenzuela et al. (2011b), Kulczyn´ski and Gramza-Michałowska (2019), Roura et al. (2007) and Usha et al. (2010)
Protein (%)	0.76–19.61	Armesto et al. (2020), Guine´ et al. (2012), Jacobo-Valenzuela et al. (2011a), Jacobo- Valenzuela et al. (2011b), Sim et al. (2020) and Usha et al. (2010)
Fat (%)	0.04–3.81	Armesto et al. (2020), Jacobo-Valenzuela et al. (2011a), Jacobo-Valenzuela et al. (2011b), Sim et al. (2020) and Usha et al. (2010)
Ash (%)	0.57–13.45	Armesto et al. (2020), Jacobo-Valenzuela et al. (2011a), Jacobo-Valenzuela et al. (2011b), Sim et al. (2020) and Usha et al. (2010)
Carbohydrates (%)	4.38–53.32	Armesto et al. (2020), Sim et al. (2020) and Usha et al. (2010)

Crude fiber (%)	0.51–2.97	Armesto et al. (2020), Jacobo-Valenzuela et al. (2011b) and Tamil selvi et al. (201
Vitamin C (mg/100 g)	10.84–83.05	Kulczyn´ski and Gramza-Michałowska (2019), Roura et al. (2004) and Roura et al. (2007)
Vitamin A (mg/g)	4.32–20	Evangelina et al. (2001), Jacobo-Valenzuela et al. (2011b)
Lutein (lg/g)	0.03–115.6	Bergantin et al. (2018), Evangelina et al. (2001), Jacobo-Valenzuela et al. (2011b) and Kulczyn´ski and Gramza-Michałowska (2019)
Dietary fiber (%)	14.78–30.02	Jacobo-Valenzuela et al. (2011a) and Lo´pez-Mejı´a et al. (2019)
b-carotene (lg/g)	0.006–2340	Armesto et al. (2020), Bergantin et al. (2018), Evangelina et al. (2001), Jacobo-Valenzuela et al. (2011b) and Kulczyn´ski and Gramza- Michałowska (2019)
a-carotene (lg/g)	6	Evangelina et al. (2001)
Zeaxanthin (lg/g)	5.2–21.2	Kulczyn´ski and Gramza-Michałowska (2019)
Total phenolic content (mg GAE/100 g)[1)]	476.6	Tamer et al. (2010)
Total phenolic content (mg CAE/100 g)[2)]	26.31–79.86	Priori et al. (2017)
Gallic acid (mg/100 g)	5.31–25.62	Kulczyn´ski and Gramza-Michałowska (2019)
Rutin (mg/100 g)	0.130–46.930	Enneb et al. (2020), Kulczyn´ski and Gramza-Michałowska (2019)
Quercetin (mg/100 g)	0.350–4.510	Enneb et al. (2020) and Kulczyn´ski and Gramza-Michałowska (2019)
Phenolics (mq C/g)[3)]	1.38	Jacobo-Valenzuela et al. (2011a)

1)GAE = Gallic acid equivalents

2)CAE = Chlorogenic acid equivalents

3)mq = milliequivalents, C = Catechin

Table 2: Chemical composition of *Cucurbita moschata* shell and seed

Parameters	Content	References
Shell		
Moisture (%)	80.04–88.47	Jacobo-Valenzuela et al. (2011a); Jacobo-Valenzuela et al. (2011b)
Protein (%)	2.59–4.45	
Fat (%)	0.31–0.49	
Ash (%)	1.06–1.13	
Dietary fiber (%)	34.94–44.62%	
Lutein (lg/g)	10.7–12.7	
b-carotene (lg/g)	37.6–63.22	
Phenolics (mq C/g)	1.38	
Seed		
Moisture (%)	6.81–23.07	Yildiz et al. (2013)
Protein (%)	19.23	Indrianingsih et al. (2019)
Fat (%)	28.49	Indrianingsih et al. (2019)

Vitamins

Vitamin A

Vitamin A, primarily in the form of carotene, is mainly found in the pulp and juice of fruits. It supports healthy epidermal cell function and helps prevent night blindness and dry eyes. According to Evangelina et al. (2001), fresh pumpkin samples contain 432 µg RE/100 g of vitamin A, indicating that Cucurbita moschata is a significant source of this vitamin.

Vitamin C

The vitamin C concentration of Cucurbita moschata varies according to its maturation level, although it is considerable. Even when Cucurbita moschata is heated, a very high percentage of vitamin C is retained. Mature Cucurbita moschata pulp has 22.87 mg/100 g of vitamin C (Roura et al., 2007). Vegetables high in vitamin C have been shown by Del Caro et al. (2004) to lower the risk of diabetes, cancer, and disorders of the cardiovascular and neurological

systems. According to Roura et al. (2004), the vitamin C concentration of diced Cucurbita moschata that was ready to use at the beginning of the storage period was 15.7 mg/100 g, and after 15 days, it was 28.4 mg/100 g. According to Kulczyn´ski and Gramza-Michałowska's (2019) experiments, the ascorbic acid content of several Cucurbita moschata samples ranged from 41.98 to 83.05 mg/100 g (dry mass).

Dietary fiber

The phrase "dietary fibre" refers to macromolecules that are mostly made up of polysaccharides and that the body finds difficult to digest and absorb. Glycoprotein, cellulose, pectin, hemicellulose, and other materials make up this polymer. According to Lo´pez-Mejı´a et al. (2019), dehydrated pumpkin pulp had a dietary fibre value of 30.02%. Experimental studies were conducted on Cucurbita moschata peel and pulp by Jacobo-Valenzuela et al. (2011a). They discovered that the overall dietary fibre content of Cucurbita moschata ranged from 14.78 to 22.75% in the pulp and from 34.94 to 44.62% in the shell.

Based on their experimental findings, insoluble dietary fibre accounted for around 83% of the total dietary fibre. Apples and potatoes have a total dietary fibre content (dry mass) of 12.10 and 11.10 percent, respectively, according to Saura-Calixto et al. (2000). According to Table 3, the dietary fibre content of Cucurbita moschata pulp is higher than that of these fruits. The physiological benefits of dietary fibre have already been demonstrated in numerous studies. These benefits include lowering plasma cholesterol, preventing obesity, improving blood sugar production response, preventing gallstones, preventing breast cancer, preventing constipation, and preventing colon cancer (De Escalada Pla et al., 2007).

Pumpkin Polysaccharide

One major active component in Cucurbita moschata is pumpkin polysaccharide, which is also known to have hypoglycemic properties. In recent years, it has been discovered that pumpkin polysaccharides have not only clear hypoglycemic effects but also notable effects in lowering blood lipids and strengthening the immune, antioxidant, and antitumor systems, demonstrating their versatility (Caili et al., Caili et al., 2006). The varieties of monosaccharides found in pumpkin polysaccharides have been identified using paper chromatography. According to some research, the polysaccharides in pumpkin included glucuronic acid, galactose, glucose, arabinose, and xylose (Kong and Jiang, 1999; Maran et al., 2013). Monosaccharides such as glucose, glucuronic acid, galactose, pectinose, xylose,

and rhamnose were identified using high-performance capillary electrophoresis (Yang et al., 2007).

Carotenoids

Evangelina et al. (2001) reported that *Cucurbita moschata* contains high levels of β-carotene and lutein, along with notable amounts of α-carotene and φ-carotene. Once absorbed by the human body, β-carotene is converted into vitamin A, which plays a crucial role in maintaining healthy vision and preventing night blindness. Additionally, β-carotene acts as an antioxidant by neutralizing free radicals. According to studies by Bergantin et al. (2018), Evangelina et al. (2001), Jacobo-Valenzuela et al. (2011b), and Kulczyński and Gramza-Michałowska (2019), the lutein content in various *Cucurbita moschata* varieties ranges from approximately 0.03 to 115.6 µg/g, while β-carotene levels vary from about 0.006 to 2340.000 µg/g. Carotenoids, such as these, function as antioxidants that boost immune defense and help lower the risk of cancer, chronic illnesses, and vascular disorders. Research by Evangelina et al. (2001) and Rodriguez-Amaya (2003) indicates that carotenoid-rich diets can strengthen the immune system and help lower the risk of chronic illnesses such as cancer, cardiovascular conditions, and atherosclerosis. Similarly, Lee et al. (2002) found that carotenoids may act as scavengers of free radicals, suggesting their potential role in cancer prevention. In another study, Kim et al. (2016) treated mouse splenocytes and RAW 264.7 macrophage cells with both steamed and baked *Cucurbita moschata* as well as β-carotene. Their findings revealed that these treatments may stimulate the production of Th1 cytokines by spleen cells and macrophages, thereby boosting immune function.

Total phenolic compounds

The health-promoting effects of phenolic compounds are largely attributed to their antioxidant potential. These compounds can bind with metal ions, inhibit lipoxygenase activity, and neutralize free radicals, as demonstrated by Martínez-Valverde et al. (2000) and Yen et al. (1993). In addition to their antioxidant properties, phenolics contribute to plant development and reproduction, enhancing resistance to pathogens and influencing the pigmentation of fruits and vegetables (Acunha, 2013).

According to Priori et al. (2017), the phenolic content in ten varieties of *Cucurbita moschata* ranged from 26.31 to 79.86 mg per 100 grams of fresh weight. Enneb et al. (2020) extracted quercetin and rutin from the pulp, fiber, and seeds of *Cucurbita moschata* using four solvents—methanol, ethyl acetate, hexane, and chloroform—and identified these compounds

in the methanol and ethyl acetate extracts using a Shimadzu UFLC XR system. The quercetin concentrations were 0.533 mg/100 g and 0.350 mg/100 g, while rutin levels were 0.250 mg/100 g and 0.130 mg/100 g, respectively.

Kulczyński and Gramza-Michałowska (2019) analyzed six *Cucurbita moschata* cultivars and reported that the 'Butternut' variety had the highest concentrations of quercetin and rutin, with values of 4.51 mg/100 g and 46.93 mg/100 g (on a dry weight basis), respectively. Quercetin derivatives, commonly found in plant-based foods, exhibit various biological functions, including protection against cancer, neurodegenerative conditions, and cardiovascular diseases (David et al., 2016). Rutin, another bioactive compound, has been recognized for its pharmacological effects and its ability to prevent conditions such as neuroinflammation, depression, stroke, and other disorders (Ganeshpurkar & Saluja, 2017).

Jacobo-Valenzuela et al. (2011a) reported that the mean phenolic content in *Cucurbita moschata* flesh was 1.38 mg C/g, whereas the peel contained an average of 5.14 mg C/g (dry weight). Que et al. (2008) compared hot-air and freeze-drying methods for *Cucurbita moschata*, revealing that hot-air drying led to a significantly greater antioxidant activity, possibly due to heat-induced increases in total polyphenol content, as supported by Piga et al. (2003). Furthermore, Tamer et al. (2010) measured the total phenolic content in fresh *Cucurbita moschata* and reported a value of 476.63 ± 0.91 mg GAE/100 g.

Mineral elements

Minerals are abundant in nature and have vital functions in human anatomy. While certain minerals are obtained through the human diet, inadequate intake nonetheless happens often (Sichieri et al., 2000). Eating a sufficient amount of veggies is crucial since some of them contain significant levels of minerals. Pumpkins were fertilised by Paulauskiene et al. (2018) using four different types of fertilisers: compost and complex fertiliser combinations, humic substances fertiliser, complex fertilisers, and humic substances fertiliser. The results demonstrated an increase in zinc, calcium, sodium, manganese, and iron in the pumpkin fruits of every fertilisation experimental group.

Table 3: Minerals content in Cucurbita moschata

Minerals	Content (mg/ 100 g)	References
Pulp		
Manganese (Mn)	0.051–162.68	Armesto et al. (2020), Jacobo-

Magnesium (Mg)	17.47–492.718	Valenzuela et al. (2011a), Kulczyn´ski and Gramza-Michałowska (2019) and Priori et al. (2017)
Iron (Fe)	0.18–8.409	
Potassium (K)	3.39–7386.90	
Calcium (Ca)	23.00–985.433	
Copper (Cu)	0.14–1.042	
Zinc (Zn)	0.39–4.02	
Sodium (Na)	47.24–346.92	
Shell		
Manganese (Mn)	0.235–1.48	Jacobo-Valenzuela et al. (2011a)
Magnesium (Mg)	251.887–492.718	Jacobo-Valenzuela et al. (2011a)
Iron (Fe)	5.318–8.409	Jacobo-Valenzuela et al. (2011a)
Potassium (K)	1786.027–3076.58	Jacobo-Valenzuela et al. (2011a)
Calcium (Ca)	435.013–686.578	Jacobo-Valenzuela et al. (2011a)
Copper (Cu)	0.278–0.815	Jacobo-Valenzuela et al. (2011a)
Zinc (Zn)	1.882–4.901	Jacobo-Valenzuela et al. (2011a)
Sodium (Na)	61.667–77.232	Jacobo-Valenzuela et al. (2011a)

Calcium

A deficiency in calcium is strongly associated with bone deformities and irregular blood pressure. Calcium is essential for various physiological functions, including the development of bones and teeth, blood clotting, and the transmission of nerve signals. *Cucurbita moschata* is recognized for its relatively high calcium content. According to Priori et al. (2017), the calcium levels in ten different varieties of *Cucurbita moschata* ranged from 2.26 g/kg to 7.49 g/kg on a dry weight basis. Jacobo-Valenzuela et al. (2011a) reported that calcium concentrations in the pulp of *Cucurbita moschata* varied from 311.337 to 985.433 mg per 100 grams, while the shell contained between 435.013 and 686.578 mg/100 g. In another study, Armesto et al. (2020) measured calcium content in *Cucurbita moschata* and found it to range from 26.66 to 31.16 mg/100 g. Kulczyński and Gramza-Michałowska (2019) analyzed six different cultivars and found calcium levels between 152.34 and 281.23 mg/100 g (dry matter). The variation in these results may stem from differences in the plant varieties tested or the analytical methods used across the studies.

Manganese

Manganese is a vital trace mineral required by the human body, as it is a component of various enzymes that perform critical physiological roles. In *Cucurbita moschata*, the manganese concentration is comparatively low (see Table 3). Jacobo-Valenzuela et al. (2011a) reported that manganese levels in the pulp of *Cucurbita moschata* ranged from 0.51 to 6.90 mg/kg, while the shell contained between 2.35 and 14.80 mg/kg. Similarly, Priori et al. (2017) observed that manganese content in different varieties varied from 2.33 to 13.94 mg/kg on a dry weight basis.

Potassium

Potassium is a vital mineral that plays a key role in maintaining acid–base balance and regulating body fluids. It is essential for the proper function of the heart, kidneys, muscles, nerves, and digestive system. Adequate potassium intake is linked to a reduced risk of several health issues, including hypokalemia, osteoporosis, high blood pressure, stroke, kidney stones, and asthma (Larsson et al., 2008; Swain et al., 2008). Among all the minerals found in *Cucurbita moschata*, potassium is the most prevalent.

Priori et al. (2017) reported that the potassium levels in ten different *Cucurbita moschata* varieties ranged from 33.9 to 94.6 g/kg on a dry weight basis. According to Jacobo-Valenzuela et al. (2011a), the potassium content in the pulp was between 3017.013 and 4941.67 mg/100 g, while the shell contained between 1786.027 and 3076.580 mg/100 g. In a separate study, Armesto et al. (2020) measured potassium concentrations between 244.67 and 294.61 mg/100 g. Additionally, Kulczyński and Gramza-Michałowska (2019) analyzed six varieties and found potassium levels ranging from 4104.30 to 7386.90 mg/100 g (dry matter). These significant differences in potassium content may be attributed to variations in the plant varieties used, their maturity stages, and the methods applied for measurement.

Magnesium

Magnesium, a key mineral found predominantly in green leafy vegetables, whole grains, and nuts, plays a crucial role in numerous cellular processes. As the primary cation within human cells, it is essential for a wide range of biochemical reactions. Magnesium is particularly important for maintaining proper neuromuscular function and supporting blood glucose metabolism (De Baaij et al., 2015).

In terms of its presence in *Cucurbita moschata*, Priori et al. (2017) reported that the magnesium content across ten varieties ranged from 0.8 to 2.9 g/kg on a dry weight basis. Jacobo-Valenzuela et al. (2011a) found that the pulp of *Cucurbita moschata* contained

between 121.401 and 161.507 mg of magnesium per 100 grams, while the shell had significantly higher levels, ranging from 251.887 to 492.718 mg/100 g. In a separate study, Armesto et al. (2020) observed lower values, with magnesium concentrations ranging from 17.47 to 25.54 mg/100 g. Similarly, research by Kulczyński and Gramza-Michałowska (2019) on six different varieties showed magnesium levels ranging from 81.15 to 135.54 mg/100 g (dry weight). These variations are likely due to differences in cultivar types, plant maturity, and the methodologies used for analysis.

Iron

Iron deficiency poses a significant threat to public health and is recognized by the World Health Organization as one of the most widespread nutritional concerns globally. An individual's iron requirement can vary depending on factors such as age, gender, and dietary habits. In *Cucurbita moschata*, the iron content is generally low (Table 3).

According to Priori et al. (2017), the iron concentration across ten varieties of *Cucurbita moschata* ranged from 1.8 to 5.9 mg/kg on a dry weight basis. Jacobo-Valenzuela et al. (2011a) reported that the iron content in the pulp was between 2.969 and 3.348 mg/100 g, while the shell showed higher levels, ranging from 5.318 to 8.409 mg/100 g. In another study, Armesto et al. (2020) found that the iron levels ranged from 0.80 to 1.63 mg/100 g. Similarly, Kulczyński and Gramza-Michałowska (2019) analyzed six different varieties and observed iron concentrations ranging from 1.24 to 2.59 mg/100 g (dry mass). The variation in these findings can likely be attributed to differences in the specific cultivars studied, their stages of maturity, and whether the measurements were based on fresh or dried samples.

Copper

Cucurbita moschata contained 0.140–1.042 mg/100 g of copper (Table 3). Cucurbita moschata had a copper level ranging from 5.78 to 8.93 mg/kg (dry mass), according to Priori et al. (2017). Six different types of Cucurbita moschata were tested by Kulczyn´ski and Gramza-Michałowska (2019), who discovered that the copper content ranged from 0.26 to 0.53 mg/100 g (dry mass). The copper content of the shell ranged from 0.278 to 0.815 mg/100 g, according to Jacobo-Valenzuela et al. (2011a).

Zinc

Humans, animals, plants, and microbes all require zinc as a trace element. About 2 billion individuals suffer from zinc deficiency, which can lead to a variety of illnesses (Prakash et al., 2015; Prasad, 2003). Jacobo-Valenzuela et al. (2011a) discovered that the pulp's zinc

content ranged from 1.868 to 2.692 mg/100 g. According to Armesto et al. (2020), Cucurbita moschata contains 0.39 to 0.45 mg of zinc per 100 g.

Sodium

While a low salt consumption can lower blood pressure and raise the risk of linked noncommunicable diseases, an excessive sodium intake can induce some noncommunicable diseases, including high blood pressure, cardiovascular disease, stroke, etc. (He and MacGregor, 2009). The sodium concentration in Cucurbita moschata pulp ranged from 53.211 to 78.591 mg/100 g, whereas the shell's sodium content ranged from 61.667 to 77.232 mg/100 g, according to Jacobo-Valenzuela et al. (2011a) (Table 3). Cucurbita moschata's salt concentration ranged from 47.24 to 63.26 mg/100 g, according to Armesto et al. (2020). Using six different types of Cucurbita moschata, Kulczyn´ski and Gramza-Michałowska (2019) discovered that the sodium content ranged from 219.05 to 346.92 mg/100 g (dry mass).

Food Applications

Pumpkin is grown worldwide and serves multiple purposes, including use as a vegetable, medicinal ingredient, and as a source for various food products such as syrups, jams, jellies, and purees (see Table 4). Pumpkin seeds are widely incorporated into a variety of foods like snacks, bread, crackers, cookies, cakes, muffins, cereal bars, and traditional sweets like chikki, as well as other baked goods. Additionally, pumpkin seed powder is used to enhance the flavor of gravies, soups, and baked items, while also improving their nutritional value.

Fermented pumpkin products contribute distinct aromas and flavors to soups and condiments. In Nigeria, edible seeds from the fluted pumpkin are utilized to produce ogiri, a fermented condiment commonly used to season soups. Due to its high protein content, ogiri is a nutritious food product that can be particularly beneficial for individuals with protein deficiencies. The preparation of ogiri remains a traditional process, often involving packaging in leaves, which preserves its cultural authenticity (Chika et al., 2013).

Table 4: Applications of *Cucurbita moschata* in food products

Food product	Use	References
Gluten-free pasta	Gluten-free pasta was prepared by adding pumpkin flour, and the version containing 25% pumpkin flour showed	Mirhosseini et al. (2015)

	the most favorable outcomes.	
Weaning mix	A weaning mix enriched with vitamin A was developed, demonstrating increased levels of β-carotene, lutein, and cryptoxanthin.	Usha et al. (2010)
Bakery products	Adding pumpkin flour to bakery products enhances their nutritional value by increasing carotenoid content. However, when the pumpkin flour concentration reached its highest level of 3.263 grams, the biscuits' crispiness, breakability, and hardness deteriorated significantly.	Kulkarni and Joshi (2013)
	Crackers high in fiber were produced using pumpkin combined with various composite flours, and their taste and crispiness remained comparable to those of commercially available crackers.	Rachtanapun et al. (2010)
	Cookies fortified with pumpkin powder, particularly those containing 30% pumpkin powder, were well received and showed increased levels of ash, moisture, fat, protein, fiber, and vitamin C.	Kumar et al. (2015)
	Bread made with 5-10% pumpkin seed flour exhibited higher protein content compared to bread made solely with wheat flour.	Giami (2003)
Spread	Hull-less pumpkin seed flour was utilized to create a low-fat functional spread. All rheological properties were influenced by the gel concentration, except for yield stress.	Radocaj et al. (2011)
Puree	Pumpkin puree was made to boost carotenoids and shelf life (180 days); despite notable xanthophyll loss, provitamin A (α-carotene, all-trans-β-carotene) retention remained high, up to 75%.	Lemmens et al. (2010)
Corn grits	A study on producing pumpkin flour corn grits through extrusion revealed that the texture became firmer, while a fine bubble structure and low bulk density of the pumpkin flour contributed to better sensory acceptance	Nor et al. (2013)
Cereal bars	Pumpkin seed powder was incorporated at 12.5% and	Santana et al.

	25% levels to enhance the nutritional value of the product, resulting in increased protein and fat content along with good acceptability.	(2014)
Whey cheese with pumpkin jam	A study was conducted to develop a jam combining pumpkin and whey cheese, which received high acceptability for attributes like aroma, salty flavor, sweetness, texture, and granule presence.	Guiné (2012)
Yoghurt	A study was conducted to improve the nutritional quality and taste of yogurt by adding pumpkin, resulting in increased viscosity and positive sensory evaluation as a flavor enhancer.	El Samh et al. (2013)
Cake	Adding pumpkin powder to cake increased moisture, fiber, ash, and β-carotene but decreased protein, fat, and carbs; during storage, moisture and carbs rose while other nutrients fell. Pumpkin seed flour (33–100%) enhanced firmness and moisture retention.	Bhat and Anju (2013)
Muffins	Muffins were made with varying amounts of pumpkin seed flour (0-50%), which improved their nutritional value. Among them, muffins containing 33% seed flour received the highest sensory ratings compared to the others.	Bialek et al. (2016)
	Pumpkin pulp flour was added at varying levels of 10%, 20%, 40%, 60%, and 80% for fortification.	Sathiya Mala et al., 2018)
Chikki	Adding 25% pumpkin seed to chikki led to higher protein and fat content, along with improved acceptability.	Sathiya et al. (2015)
Fruit bar	Pumpkin pulp flour was incorporated at various levels, including 5%, 10%, 17.5%, and 20%.	Bemfeito et al., (2021)

Health Benefits of *Cucurbita moschata*

Essential nutrients are abundant in Cucurbita moschata. Numerous researchers have examined Cucurbita moschata over the past few decades and discovered that it has a wide range of medical uses, including anti-diabetic, antibacterial, anti-cancer, and anti-obesity

qualities (Caili et al., 2006; Jacobo-Valenzuela et al., 2011b). As pumpkin farming has become more widespread, this type has progressively come into the public eye, particularly in traditional medicine. Researchers have concentrated on this plant because of its abundance of bioactive compounds and therapeutic potential. Numerous epidemiological research have been conducted in the study of bioactive compounds, which has prompted several animal models, cell culture investigations, and clinical trials intended to evaluate their pharmacological activities (Caili et al., 2006).

Anti-obesity

Hossain et al. (2018) investigated the anti-obesity potential of fermented Cucurbita moschata extract and found that it suppressed the mRNA expression of fat-related genes in mice. They suggested that fermented Cucurbita moschata might serve as a promising treatment for obesity. Additionally, Lee et al. (2012) isolated dehydrodiconiferyl alcohol (DHCA) from a water-soluble extract of Cucurbita moschata and studied its effects on mitotic clonal expansion and lipogenic gene expression.

Anti-diabetic

In recent years, numerous studies have highlighted the various health benefits of Cucurbita moschata, with particular focus on its impact on diabetes. Both the pulp and seeds of Cucurbita moschata have demonstrated blood sugar-lowering effects in normal animals as well as in diabetic rats induced by tetraoxopyrine. Researchers isolated two new tetrasaccharide glyceroglycolipids, QGMG-3 and QGMG-2, from Cucurbita moschata, which were found to significantly reduce blood glucose levels in diabetic mice. These compounds show promise as potential treatments for type II diabetes (Jiang and Du, 2011).

Anticancer activity

Treating cancer remains extremely challenging, as most types are not yet fully curable due to cancer cells' ability to replicate indefinitely and spread throughout the body. This characteristic presents significant obstacles for both researchers and healthcare professionals. Studies have indicated that increasing the consumption of fruits and vegetables may help lower the risk of developing cancer (Craig, 1997).

Early investigations into crude extracts and purified substances like proteins and polysaccharides from Cucurbita moschata have revealed potential anticancer properties against cancers such as melanoma and leukemia. However, findings are inconsistent; some studies suggest that boiled pumpkin juice can significantly suppress cancer cell growth, while

others report that fresh pumpkin juice might actually promote it (Caili et al., 2006; Xia et al., 2003). Case studies and hospital comparisons have suggested that regularly consuming pumpkin, combined with consistent physical activity, may reduce the risk of stomach, intestinal, lung, and breast cancers (Huang et al., 2004).

Xia et al. (2003) identified and purified a novel ribosome-inactivating protein called Moschatin from mature seeds of Cucurbita moschata. This type 1 RIP was found to effectively inhibit the proliferation of M21 melanoma cells. Additionally, increasing the intake of compounds such as lycopene, α-carotene, β-carotene, β-cryptoxanthin, lutein, and zeaxanthin—found in foods like tomatoes, pumpkin, spinach, watermelon, and citrus fruits—has been associated with a reduced risk of prostate cancer (Jian et al., 2005).

Antibacterial activity

Bacteria, viruses, fungi, and other parasites are responsible for many diseases and can also hinder economic growth. Researchers isolated a novel antifungal peptide weighing 8 kDa from Cucurbita moschata seeds, which at a dose of 375 μg effectively inhibited the growth of Botrytis cinerea, Fusarium oxysporum, and Mycosphaerella oxysporum. It also suppressed protein synthesis in cell-free rabbit reticulocyte systems with an IC50 value of 1.2 μM (Wang and Ng, 2003). Additionally, three basic proteins from Cucurbita moschata seeds—MAP2 (2,249 Da), MAP4 (4,650 Da), and MAP11 (11,696 Da)—showed yeast growth inhibition, with MAP11 being the most potent. However, MAP2 and MAP4 did not affect Escherichia coli growth (Caili et al., 2006; Vassiliou et al., 1998).

Given these findings, promoting pumpkin consumption in developing countries could help prevent infectious diseases due to its bioactive components. Qian (2014) extracted a water-soluble polysaccharide from Cucurbita moschata, which demonstrated strong antibacterial activity against Bacillus subtilis, Staphylococcus aureus, and Escherichia coli. Wang et al. (2017) isolated a protein-bound polysaccharide (PSP-I) from the seeds using hot water extraction and ethanol precipitation and tested its antibacterial effects on four common bacteria. The minimal inhibitory concentrations (MICs) of PSP-I were 62.5, 7.8, 125.0, and 15.6 μg/mL for Bacillus subtilis, Staphylococcus aureus, Pichia fermentans, and Escherichia coli, respectively, suggesting PSP-I as a promising new antibacterial agent. Moreover, peptides from Cucurbita moschata seeds effectively inhibited Acinetobacter baumannii, with a lethal concentration of 122.9 ± 3.2 μg/mL, indicating their potential use as antibacterial components in nutritious foods and food systems (Dash and Ghosh, 2018).

Some other benefits

Two different extracts were obtained from the pulp of Cucurbita moschata using chloroform and ethyl acetate, both demonstrating notable anticomplement activity within the complement system (Yang et al., 2002). Suphakarn et al. (1987) reported that children who consumed pumpkin seeds at a dose of 60 mg/kg body weight daily experienced a lower incidence of bladder stones. An ethanol extract from Cucurbita moschata was found to decrease plasma lactate and ammonia levels as well as reduce creatine kinase activity. This effect is linked to increased energy storage (as glycogen) and release (as blood glucose), alongside reduced levels of plasma lactic acid, ammonia, and creatine kinase, suggesting that the extract may have anti-fatigue properties (Wang et al., 2012). Furthermore, the seeds of *Cucurbita moschata* are rich in omega-3 fatty acids, which might contribute to lowering blood pressure to some extent (Kamarubahrin et al., 2018). Bahramsoltani et al. (2017) investigated the wound healing potential of *Cucurbita moschata* peel extract on burns and found that its high mucus content and strong antioxidant properties make it effective for burn treatment.

Conclusion

Cucurbita moschata, is a nutrient-rich crop widely cultivated for its versatile culinary and medicinal uses. Originating from Central and South America, it thrives in warm climates and offers good storage stability, making it valuable for food processing. The pulp and seeds are rich in vitamins A, C, and E, dietary fiber, essential minerals like potassium and magnesium, and bioactive compounds including carotenoids, polysaccharides, and phenolics. These contribute to numerous health benefits such as anti-diabetic, anti-obesity, antioxidant, anti-inflammatory, anti-cancer, antibacterial, and cardiovascular protective effects. Pumpkin is also widely incorporated into various food products like bakery items, pasta, spreads, yogurts, and snacks, enhancing both nutritional value and sensory qualities. Its high fiber, antioxidant, and functional compound content make it particularly beneficial for managing chronic diseases and improving overall health.

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