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Minor cucurbits from Africa: Horned melon (*Cucumis metuliferus* E. Mey. Ex Naudin)

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Abstract: Horned melon (*Cucumis metuliferus* E. Mey. Ex Naudin) (2n = 24) belongs to the family Cucurbitaceae and genus Cucumis. Horned melon is known by many names such as jelly melon (English), métulon (French), Kiwano® (in New Zealand), Melano® (in Israel), bitter wild cucumber (in South Africa), thorn melon (in Kenya), parachichi mwitu (Kiswahili in Kenya), African horned cucumber, orange spiky fruit, among others. Other members of the genus *Cucumis* are cucumber (*Cucumis sativus*) and melon (*Cucumis melo*). This review aims to present horned melon as a minor cucurbit that originated from Africa; its production, nutritive and nutraceutical values have been expounded. Horned melon originated from central and southern African region from where it spread to other regions as far north as Senegal, Nigeria, Ethiopia and Somalia. Horned melon is native to the dry Kalahari desert and it mostly grows in the dry or semi-arid places of the world. In many African countries, horned melon has generally been neglected by scientists as well as policy makers. It has been minimally exploited economically despite its high nutritive and medicinal value. The fruit has been introduced and is currently grown in other countries and continents. In Kenya, New Zealand, France, Australia, USA, and Israel, fruits of improved cultivars are commercially grown for export. Horned melon features in the international trade due to its high nutritional fruit value and as an ornament due to its interesting appearance and long shelf life. Horned melon fruit is more nutritious than cucumber. Its concentration of vitamins B complex, A and C is four times higher than in lemon. It is rich in antioxidants such as vitamin C, vitamin A, zinc, and lutein while the seeds are rich in antioxidants alpha-tocopherol and beta-tocopherol, both of which are organic forms of Vitamin E. The fruit also possess high mineral content particularly potassium, phosphorus, magnesium, calcium, iron, sodium, zinc, and copper. Consequently, it lowers the onset of heart diseases, high blood pressure, dementia and Alzheimer's disease, and promotes good eyesight, as well as healthy and strong bones, among others. Despite all the goodness of this fruit, it is rarely consumed especially by the urban population probably due to its unfavourable taste or lack of awareness of its nutritive value. The fruit should be promoted given that lifestyle diseases are a real menace especially among the urban population. In addition, breeding efforts should be enhanced to develop horned melon varieties that are more palatable.

Keywords: *Cucumis metuliferus*; Cucurbitaceae; Horned melon; Kiwano; Wild cucumber.

Introduction

Horned melon (*Cucumis metuliferus* E. Mey. Ex Naudin) (2n = 24) belongs to the genus *Cucumis* and species *metuliferus*. The genus *Cucumis* comprises about 25 Asian and Australian species and approximately 30 African species (Ghebretinsae et al., 2007; Schaefer, 2007). Horned melon is known by many names such as jelly melon (English), métulon (French), Kiwano® (in New Zealand), Melano® (in Israel), bitter wild cucumber (in South Africa), thorn melon (in Kenya), passion mwitu, parachichi mwitu (Kiswahili in Kenya), African horned cucumber, orange spiky fruit, Chitunguza in Zambia (Mwanza et al., 2023), gakachika in northern Zimbabwe (Mwanza et al., 2023) and many others (National Research Council, 2008; Marline et al., 2020). Horned melon considered as the wild or semi-wild relative of *Cucumis sativus* (cucumber) and *Cucumis melo* (melon), is an annual vine in the family Cucurbitaceae. Genetic distance analysis shows that horned melon is closer to melon than cucumber (Benzioni et al., 1991; Weng, 2010)

although the three belong to the genus *Cucumis*. The three are more closely related to the *Citrullus* (watermelon) and *Lagenaria* (bottle gourd) species than with species in genus *Cucurbita* (*C. maxima*, *C. pepo* and *C. argyrosperma*) (Ling et al., 2021). Horned melon fruit has horn-like spines hence the name "horned melon" (Wannang, 2011). Its fruits are small, 8-10 cm long and about 4.5 cm in diameter. The immature fruit is dark green with mottled light green spots; upon ripening, it turns golden or bright orange with very sharp spines. Inside, the flesh/pulp is succulent, green and translucent, and with many white seeds; each seed is inside a sac (Figure 1).

Origin and production of horned melon

Horned melon originated from central and south African region in South Africa, Namibia, Botswana, Zambia, Zimbabwe, Mozambique, and Angola. Population structure analysis suggests that horned melon originated in Zimbabwe, then spread to other south African regions where it likely underwent similar domestic selection as melon (Ling et al., 2021). The fruit grows naturally, usually wild and not abundantly, in the warmer parts of southern Africa, and sporadically as far north as Senegal, Nigeria, Ethiopia and Somalia and even eastward across the Red Sea in Yemen (David, 2016; Wilkins-Ellert, 2004). Horned melon has become naturalized in Australia and is reported as adventive in Croatia (David, 2016). It is a resilient plant, found clambering along roadsides and gully fringes as well as on fallowed and abandoned lands (National Research Council. 2008). In the fields, it is a vigorous colonizer and can quickly take over other crop species, classifying it as a weed in some parts of the world (Mwanza et al., 2023). Horned melon is native to the southern Africa's dry Kalahari Desert where it kept the local Khoisan people hydrated during dry seasons. It mostly grows in the dry or semi-arid places of the world. Generally, the wild specimens are not nearly as colorful or distinctive as the cultivated ones but they are nonetheless unmistakable. Fruits from wild-types are often bitter, unpalatable and are considered poisonous if taken by mouth (David, 2016); the toxicity can usually be neutralized by cooking the fruits (South African National Biodiversity Institute, 2009). In many African countries, horned melon has generally been neglected by scientists as well as policy makers; it has been minimally exploited economically despite its high nutritive and medicinal value. Not much has been documented about the African horned melon and it is little known especially by the urban population (Mwanza et al., 2023). Consequently, the fruit is grown, marketed and consumed locally with negligible processing. In most cases people cultivate horned melon in the backyard plots for subsistence use. The ripe fruit is sliced and added to tropical fruit salads (Wilkins-Ellert, 2004). The internal jelly-like pulp of the fruit can be scooped out and consumed as salad. When eaten on its own, some people sprinkle sugar or salt on the horned melon pulp and seeds to enhance flavour (Lim, 2012; Mwanza et al., 2023). The pulp and the seeds can also be blended in a food processor for making refreshments such as yoghurts and ice creams (April et al., 2018). The jelly can also be used as a substitute for vinegar in salad dressing (Mccormack, 2005). All parts of the horned melon fruit are edible including the rind (Marline et al., 2020; Mwanza et al., 2023) although most people eat only the inner parts (pulp and seeds) and throw away the rind (Šovljanski et al., 2022). The immature fruits can be relished like cucumber and its nutritional value is rated twice higher than that of cucumber (Lim, 2012). The fruits are also baked whole like pumpkin, especially across the Kalahari, and are also sliced and sun-dried for future use (Lim, 2012). According to Maundu et al. (2009), the unripe fruit of horned melon is poisonous, but edible and free of toxins when fully ripe. The bitter cucurbitacines and toxic triterpenoid substances present in the wild horned melon fruits have been reduced through breeding over time leading to development of safe non-bitter modern varieties. Young leaves can also be cooked and eaten as vegetables (Bester and Condy, 2013). The leaves contain saponin, an oily glycoside which can be toxic, but has many medicinal uses; saponin can be neutralized by cooking (Bester and Condy, 2013). The pounded dried root of horned melon is used to treat asthma in the Limpopo province of South Africa (Semenya and Maroyi, 2018) while the seeds are dried and ground into flour to prepare herbal medicine for eradicating tapeworms (Usman et al., 2015).

Horned melon is grown and traded in most parts of the world due to its high nutritional fruit value and as an ornament due to its interesting appearance and long shelf life (Cantwell, 2011; Lim 2012; Vieira et al., 2021). Horned melon has a long shelf life and can store for 6 months at room temperature even in the tropics. It can be shipped without refrigeration, and at home in room temperature, it can store for months if left uncut. Benzioni et al. (1993;1996) found that horned melon could be kept for several months at 20^0 C and ethylene application few days before exportation induced color development in green or yellow fruits. Horned melon should be kept far away from cold as chilling makes it soft and susceptible to molds thereby decreasing its shelf life (National Research Council, 2008). In Africa, horned melon is primarily used as a fruit or food and rarely for decoration. In Europe and North America, horned melon is commercialized as a luxury fruit, being mostly appreciated for its spectacular appearance and extended storage life than for its flavour (Usman et al., 2015; Lim, 2012; David, 2016). Horned melon was introduced in New Zealand and Australia in the 1930s where it became extensively cultivated as a novel commercial fruit and ornamental cultivar. However, the aggressive nature of the vining plant led to it being labeled as an invasive weed because the melons eventually escaped cultivation and began colonizing native habitats. Over time, the horned melon has become naturalized in Australia where it is grown as a specialty fruit and it is popular for its long shelf life and unusual appearance. In New Zealand, horned melon is widely grown and is commercialized under the trade name "Kiwano" (Bacon, 2013). In most African countries such as Malawi, Zambia and Zimbabwe horned melon is grown for home consumption and for sale in the local markets (David, 2016); the fruit is commonly sold in markets in southern African countries such as Zimbabwe, Zambia, Mozambique, Malawi, and South Africa (Tefera, 2006). In Kenya, New Zealand, France, Australia, USA, and Israel, fruits of improved cultivars are commercially grown for export (David, 2016; Ling et al., 2021). The main producers of horned melon are New Zealand, Australia, and Africa, which export the fruit to Western Europe and North America (Bester and Condy, 2013). In Kenya, horned melon is one of the minor cucurbits whose high economic and nutritional value is yet to be fully exploited (Aliero and Gumi, 2012).

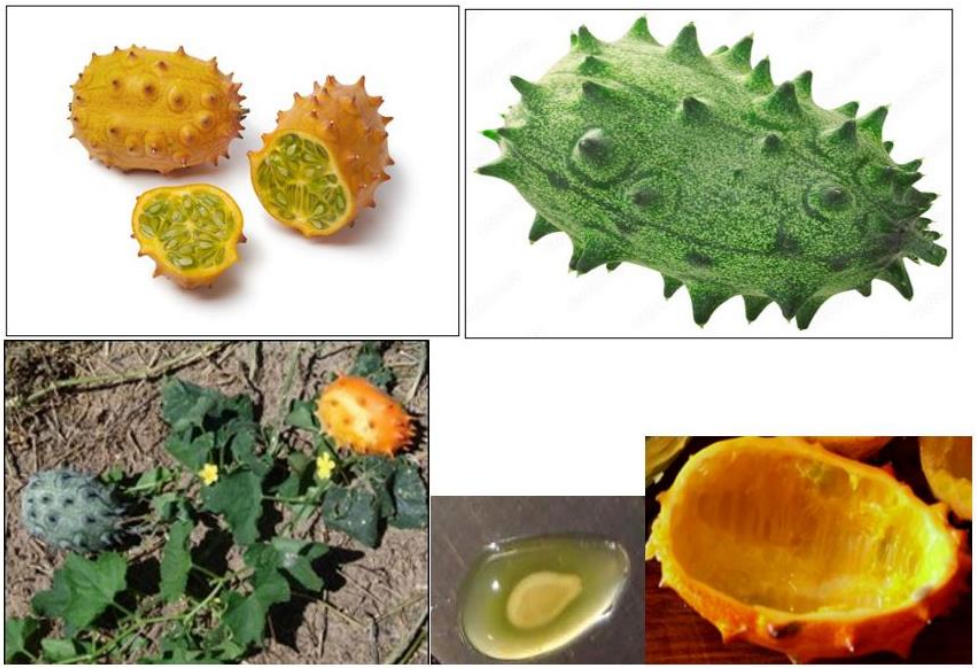

Figure 1. Horned melon (A) ripe fruit, (B) unripe fruit, (C) the plant, (D) the seed and (E) the peel.

Horned melon grows at an altitude range of 210 to 1800 meters above sea level (Bester and Condy, 2013). It prefers shallow or deep, well-drained, mostly alluvial sandy soil on river banks or flood plains although it has been found to grow in clay or loam soil and on rocky slopes (Usman et al., 2015). Horned melon tolerates a wide range of soil types throughout its natural distribution area (Robinson and Decker-Walters, 1997). It is a warm-season crop in both tropical and sub-tropical areas and cannot tolerate cold and mist conditions (Wilkins-Ellert, 2004). Optimum growing temperature ranges between 20 and 35^0 C (Aliero and Gumi, 2012; David, 2016). However, its growth is not greatly affected by temperatures as high as 40^0 C although flowering seems to be affected by temperatures over 30^0C and germination is greatly inhibited above 35^0C (Aliero and Gumi, 2012). Temperatures below 8^0C completely inhibits seed germination. Horned melon has high tolerance to drought and can do well with as little as 350 to 550 mm of rainfall per season; dry air is beneficial during the harvest period (Cantwell, 2011). Semi-arid climate and warm season rainfall enhances the fruit ripening stage, enabling the fruit to develop full flavour (Aliero and Gumi, 2012). The flowering season starts around 8 weeks after seeding, with male flowers appearing several days before female ones. Under field conditions, harvest occurs 3.5 months after sowing (Lim 2012; Bester and Condy, 2013). Fruits are eaten by a variety of birds when they ripen on the stems; birds are therefore largely responsible for the dispersal of seeds (Bester and Condy, 2013).

Pests and disease resistance

Horned melon has high resistance to pests and diseases. In southern Africa, horned melon plants are seldom affected by diseases or pests in their natural habitat. Horned melon has more plant disease resistance genes than other members of the genus *Cucumis*, and this explains why it is more resistant to several important plant pathogens such as rootknot nematode (*Meloidogyne incognita*) and some viruses than cucumber and melon (Ling et al., 2021). It has the largest number of resistance-related nucleotide-binding site leucine-rich repeat (NBS-LRR) genes in Cucurbitaceae (Ling et al., 2021). The resistance to some rootknot nematode species is associated with the suppression of larval development beyond the second stage, and cytoskeleton related genes are considered to play a role in the response against root-knot nematode (Ling et al., 2017). However, cucumber and melon are highly susceptible to southern root-knot nematode (*Meloidogyne incognita*) infections (Fassuliotis, 1967, 1979; Nugent and Dukes, 1997; Walters et al., 1993, 2006). Attempts to introgress pathogen resistance genes from horned melon into cucumber or melon through interspecific hybridization have been unsuccessful as no viable interspecific hybrids have been formed (Deakin et al., 1971; Guan and Zhao, 2014; Ling et al., 2021). Recent development in plant genomics is providing new avenues to explore useful genes in horned cucumber.

Horned melon also exhibits resistance to whitefly, papaya ringspot virus, musk melon yellow virus, and watermelon mosaic virus 1 (Provvidenti and Gonsalves, 1982; Provvidenti and Robinson, 1974). Resistant to watermelon mosaic virus 1 is due to a single completely dominant gene and hypersensitive-resistant to squash mosaic virus. Resistance to powdery mildew, melon aphid (*Aphis gossypii*), greenhouse white fly, and Fusarium wilt has been recorded in several horned melon accessions (Marsh 1993; Walters et al. 1993). The ubiquitous pumpkin fly (*Dacus bivitattus*), which ravages other cucurbit crops in southern Africa, does not attack horned melon. Consequently, horned melon can be a source of resistance genes against major diseases and pests that affect production and quality of cultivated cucumber and melon. In addition, it can be a potential rootstock for profitable production of

Table 1. Nutritional composition of fresh horned melon (in 100 grams fresh weight).

Source	Pulp	Peel	Seed	
Moisture	89–96.0 g	18.4 g	7.31 g	
Carbohydrates	7.56 g	54.80 g	50.2 g	
Fibre	4–4.20 g	11.30 g	19.2 g	
Lipids	0.03–1.26 g	8.89 g	15.4 g	23.8g
Calories	22–44 kcal	-	386 kcal	
Proteins	1.78–1.80g	2.95 g	2.63g	23.2g
Source	USDA, 2015	Ezekaibeya et al., 2020	Achikanu et al., 2020	Sadou et al., 2007

Source: Adapted from Šeregelj et al., 2022.

Table 2. Vitamin and mineral contents of horned melon pulp, peel, and seed.

		Pulp		Peel	Seed	
Source	Ferrara, 2018	USDA, 2015	Romero et al., 1992	Ezekaibeya et al., 2020	Achikanu et al., 2020	Sadou et al., 2007
Vitamins (mg/g fresh weight)						
Thiamin (B1)	0.025	-	-	1.69	-	2.2
Riboflavin (B2)	0.015	-	-	1.74	-	1.72
Niacin (B3)	0.565	-	-	-	-	-
Pantothenic acid (B5)	0.183	-	-	-	-	-
Pyridoxine (B6)	0.063	-	-	-	-	-
Folic acid (B9)	0.003	-	-	1.93	-	2.1
Vitamin C	5.3	0.5	0.6	3.44	-	1.72
Vitamin A	0.007	-	-	1.85	-	2.22
Vitamin D	-	-	-	2.28	-	1.86
Vitamin E	-	-	-	2.92	-	2.05
Vitamin K	-	-	-	1.69	-	2.58
Minerals (mg/100 g fresh weight)						
Sodium	2	5.6	2.3	-	247	-
Calcium	13	17	16	-	247	-
Iron	1.3	0.5	0.5	-	10.9	-
Magnesium	40	23	16.2	-	289	-
Phosphorus	37	50	50	-	44.7	-
Potassium	143	266	302	-	1174	-
Zinc	0.48	0.2	0.2	-	1.7	-
Copper	-	0.1	-	-	5.4	-
Manganese	0.039	0.2	0.1	-	-	-

Source: Šeregelj et al. 2022.

cucumber, melon and other members of the cucurbitaceae family (Lim, 2012). In a previous study, specialty melons grafted onto horned melon exhibited less root galling and lower root-knot nematode population densities in the rhizosphere than those for non-grafted and self-grafted melons (Guan et al., 2014). Future breeding efforts may be directed to developing more vigorous horned melon rootstocks with greater potential for yield enhancement in grafted melon production.

Horned melon is susceptible to cucumber mosaic virus, tobacco ringspot virus, tomato ringspot virus, watermelon mosaic virus 2, and a severe strain of bean yellow mosaic virus. Some accessions are also susceptible to Fusarium wilt (*Fusarium oxysporum*) (Wilkins-Ellert, 2004; David, 2016). In Israel, horned melon was affected by several viruses (notably, zucchini virus), and perhaps bacteria causing watery spots on the fruit; fungi can also be a problem in wetter conditions (National Research Council. 2008). Plants were affected by powdery mildew (*Sphaerotheca fuliginea*) and squash mosaic virus. In Spain, plants in the greenhouse with high temperatures and humidity, were affected by powdery mildew (*Erysiphe cichoracearum*) and the greenhouse white fly (*Trialeurodes vaporariorum*) while the field plants were unaffected (Wilkins-Ellert, 2004; David, 2016).

Nutritive value and other health benefits of horned melon fruit

Horned melon fruit is rich in various phytochemical components that can alleviate malnutrition or provide phytochemicals to the food and pharmaceutical industries (Ferrara, 2018; Mwanza et al., 2023). The nutritional composition of horned melon is affected by the degree of fruit maturity (Ferrara, 2018). In general, horned melon is more nutritious than cucumber and have notably higher values for most nutrients (Šeregelj et al., 2022; Lim 2012). The concentration of vitamins B complex, A and C in horned melon is four times higher than in lemon (Usman et al., 2015). Fresh horned melon pulp has a high-water content (89–96.0 g/100g) and low levels of calories (22–44 kcal/100g), carbohydrates (7.56 g/100g), fiber (4–4.20 g/100g), lipids (0.03–1.26 g/100g), and

Table 3. Phytochemical composition of horned melon pulp, peel, and seed. dw—dry weight. fw-fresh weight.

	Horned melon		
Compound	Pulp (Busuioc et al., 2020)	Peel (Ezekaibeya et al., 2020)	Seed (Achikanu et al., 2020; Sadou et al., 2007)
Flavonoids	Rutin, quercetin, quercetin-3-d-galactoside, kampferol-3-glucoside, and kamferol	1.71 mg/g dw	0.97 mg/g dw
Phenolics	Gallic acid, catechin, epicatechin, neochlorogenic acid, caffeic acid, p-coumaric acid, oleanolic acid, and ursolic acid	1.54 mg/g dw	1.20 mg/g dw
Tannins	-	1.38 mg/g dw	2.93 mg/g dw
Alkaloids	-	1.06 mg/g dw	2.54 mg/g dw
Steroids	-	0.93 mg/g dw	2.62 mg/g dw
Carotenoids	β-carotene: 0.88 µg /g fw (USDA, 2015)	-	1.56 mg/g dw; 130 mg/g dw
Glycosides	-	2.19 mg/g dw	-
Saponins	-	0.72 mg/g dw	1.41 mg/g dw
Fatty acids	-	-	C14:0, C16:0, C18:0, C20:0, C16:1n-9, C18:1n-9, C18:1n-7 C8:2n-6, C18:3n-3
Tocopherols	-	-	α-tocopherol, γ-tocopherol

Source: Šeregelj et al., 2022.

proteins (1.78–1.80g/100g) (USDA, 2015). The higher water content is good for hydrating the body while the low calorie is ideal for people who are aiming to lose weight. The high dietary fiber improves the digestion process. Fresh peels were reported to have high levels of carbohydrates (54.80 g/100 g); the other proximate composition values were fiber (11.30 g/100 g); moisture (18.4 g/100 g), lipids (8.89 g/100 g), and proteins (2.95 g/100 g) (Ezekaibeya et al., 2020; Table1).

The peel of the horned melon contains essential nutrients, organic compounds, vitamins, and minerals. The high vitamin E improves brain function and slows down neurological disorders such as Alzheimer's disease and dementia while vitamin C helps in the production of collagen and repair of damaged skin and organ tissues (Mwanza et al., 2023). The pulp also contains high levels of vitamins; high concentrations were noted for vitamin B complex and vitamin C, while a lower level was determined for vitamin A (USDA, 2015; Table 2). The seeds have been reported to possess high mineral content particularly potassium, phosphorus, magnesium, calcium, iron, sodium, zinc, and copper (Table 2).

The minerals help in the development and growth of bones; due to its high calcium storage capability, horned melon helps to treat bone-related conditions, such as osteoporosis. Zinc is required for insulin discharge and normal carbohydrate metabolism (Mwanza et al., 2023) among others, while magnesium helps in the management of blood sugar, reduces blood pressure and lowers the risk of heart problems and stroke.

Horned melon pulp, peel and seeds have been reported to have high antioxidant potential (Mwanza et al., 2023). The antioxidants (α-tocopherol and γ-tocopherol) keep the blood vessels and nerves healthy; they neutralize the free radicals in the body and flush out carcinogenic substances from the body (Mwanza et al., 2023). The high level of tocopherol boosts the cognitive function and keeps the mind fresh. Vitamins C and E are essential antioxidants that protect cells from oxidative stress-induced cellular damage by scavenging on reactive oxygen species (Traber and Stevens, 2011) while fat-soluble vitamins, D, E, K, and A, are important in lipid metabolism (NRC, 1989). Vitamins K, thiamine, folic acid, and riboflavin concentrations in the peel (Ezekaibeya et al., 2020; Table 2) are higher than the recommended daily allowance (RDA) for an adult. Thiamine and folic acid serve as coenzymes in synthetic and metabolic processes, while riboflavin is an essential vitamin for oxidative phosphorylation (Achikanu et al., 2020). In the seed, the fat-soluble vitamins (D, E, K, and A) and vitamin complex B (thiamin, folic acid, and riboflavin) are present in higher concentrations than water-soluble vitamin C (Table 2). These vitamins act as potent antioxidants for the management of free radical-related diseases such as cardiovascular diseases, Parkinson's and Alzheimer's diseases, and diabetes (Usman et al., 2015). Vitamins A and C and other compounds with antioxidant properties are known to slow down cellular aging. In particular, they are known to protect the integrity of the skin and to reduce the appearance of wrinkles and stains typical of old age.

Horned melon pulp has been reported to contain a wide range of total phenolics (47.2–200 mg GAE/100 g dry weight) depending on the type of extract used (water, ethanol, or their mixture) (Arrieta et al., 2020; Mester et al., 2019). The pulp also contains low levels of flavonol aglycones (myricetin and quercetin) and high amounts of flavonol glycosides (rutin) (Ferrara, 2018). Busuioc et al. (2020) found that horned melon juice contains a large number of triterpenes and significant amounts of both polyphenols and flavonoids. The main metabolites were catechin (928.74 mg/kg), followed by oleanolic (347.67 mg/kg) and ursolic acids (193.92 mg/kg). Catechin is a flavonoid that presents a high antioxidant activity in living systems, while ursolic acid is known for its activity against HIV-1 protease. Other phytochemicals occurring in horned melon juice were rutin (33.78 mg/kg), kampferol-3-glucoside (19.61 mg/kg), epicatechin (17.66 mg/kg), p-coumaric acid (6.99 mg/kg), quercetin (5.96 mg/kg), gallic acid (5.76 mg/kg), caffeic acid (5.56 mg/kg), neochlorogenic acid (4.68 mg/kg), kampferol (4.32 mg/kg), and quercetin-3-d-galactoside (2.35 mg/kg) (Busuioc et al., 2020). Carotenoids are less

abundant in horned melon pulp (88 µg β-carotene/100 g dw)(USDA, 2015). In contrast, peels of horned melon have more total polyphenol content (TPC) (500 mg GAE/100 g of dry weight) than pulp (200 mg GAE/100 g of dry weight) (Matsusaka and Kawabata, 2010). Ezekaibeya et al. (2020) found that flavonoids (171 mg/100 g) and tannins (138 mg/100 g) are the major bioactive compounds in the peels. Beside polyphenols, the peels are also a source of alkaloids (106 mg/100 g), steroids (93 mg/100 g), and glycosides (219 mg/100 g). In seeds, polyphenols are highly abundant (400 mg GAE/100 g dry weight) (Matsusaka and Kawabata, 2010). Similar to peels, tannins (293 mg/100 g dry weight) are the major class of polyphenols in seeds, while alkaloids (254 mg/100 g) and steroids (262 mg/100 g) are even more abundant than in peels (Achikanu et al., 2020). The seeds are also a better source of carotenoids (156–13000 mg βecarotene/100 g dry weight) compared to fruit pulp (Achikanu et al., 2020; Sadou et al., 2007; Table 3).

In addition, the principal fatty acids in the horned melon seed oil are linoleic acid (56.21%) and oleic acid (18.6%), followed by palmitic acid (16.2%) and stearic acid (7.65%) (Sadou et al., 2007). These fatty acids have high potential in reducing blood cholesterol levels (LDL), lowering blood pressure and preventing both heart attacks and strokes thereby providing cardiovascular protection (Frenoux et al., 2001; Usman et al., 2015). The linoleic acid strengthens the heart muscles and helps improve the overall cardiovascular health (Mwanza et al., 2023). High contents of α and γ-tocopherols (79.9 and 517 g/100 g, respectively) were reported in the horned melon seed oil (Sadou et al., 2007). Consumption of these two tocopherols prevents cardiovascular diseases, cancer, inflammatory processes and keeps the blood vessels and nerves healthy as well as neutralizes the free radicals in the body (Mwanza et al., 2023). Beta carotene also is beneficial against atherosclerosis and vascular diseases. Like tocopherols, beta carotene would increase the low-density lipoproteins' (LDL) resistance against oxidation (Sadou et al., 2007). Health benefits of horned melon result from the presence of bioactive antioxidants which protect the cells and their structures against oxidative damage. Diets rich in polyphenols, carotenoids, ascorbic acid, tocopherols, and other antioxidants contribute to the inhibition of oxidation processes. The antioxidant potential is strongly correlated with the reduction in the risk of various human diseases, which is not only due to the effect of individual antioxidants but also may be the result of their synergy (Šeregelj et al., 2021). The seeds are rich in nutrients and phytochemicals with high radical scavenging potential (Bolek, 2020). Matsusaka and Kawabata (2010) found that horned melon and pawpaw peels have a strong ferrous ion-chelating capacity, although they did not have a high phenolic content. In addition, horned melon peel exhibited DPPH and ABTS radical scavenging activities as well.

Some limitations in utilization of horned melon

Fruit quality in horned melon is measured by colour, size, taste, acidity and aroma. One of the major limitations to consumption of horned melon as a fruit is its unfavourable taste. The taste of horned melon is influenced by the sugar content (reflected by total soluble solids), acidity, and aroma (Benzioni et al., 1993; 1996). Some people liken its taste to that of lime, others to cucumber, and yet others to a ripe banana/green-banana cross, or even pomegranate or papaya (Bacon, 2013; Paquin, 2009; Mwanza et al., 2023). Many improved horned melon cultivars have no hint of cucurbit bitterness, and there are good opportunities for improving the overall flavour. The sugar content in some selections has already been doubled. But the primary allure for buyers is still its appearance, both as a whole-fruit decoration or as a beautiful garnish when sliced or diced. In the past, some cultivars were improved in view of decreasing the bitterness while increasing the sweetness and overall flavor (National Research Council. 2008). In Africa, Zimbabwe, Botswana, and South Africa already grow sweeter selections (Wilkins-Ellert, 2004). A great tasting horned melon might become a major crop to join its cousins, the melon and watermelon.

Spikes on the rind makes fruit handling a problem. Anyone who harvests and packs horned melon fruit must wear gloves because the leaves have needle-like hairs and the fruits have piercing horns making them hard to handle. After harvest, traders use nylon brushes or sand paper to quickly and easily grind down the sharp spikes to rounded nubs, so people can then handle the fruits without stabbing themselves (National Research Council. 2008; Wilkins-Ellert, 2004). Fruits should not be stacked without protective covering; the sharp spines easily puncture the skin of other fruits causing wounds. The fruits are best preserved without touching each other because the ground-down spikes can still easily spear adjacent fruits unless there is space or a barrier between them (Ferrara, 2018). This increases the size of packaging containers and hence freight costs during exportation. Some specimens totally lacking spiny protuberances, have been observed both in the wild and under semi-cultivated conditions in Zimbabwe (Wilkins-Ellert, 2004). The high seed content in horned melon can make eating the fruit less convenient than many common fruits (Mwanza et al., 2023). Need seedless or fewer seeds for more juice production. Seedless forms have been created. These are small but nonetheless promising. They change the fruit from "a bag of seeds" to a glob of green jelly that is unique. Indeed, researchers in both France and Israel are growing the crop in winter under glass to produce seedless (i.e., parthenocarpic) fruit.

Conclusions

Horned melon is a highly nutritious fruit which should be consumed. It is rich in vitamins, minerals and antioxidants. Consequently, it lowers the onset of heart diseases, high blood pressure, dementia and Alzheimer's disease, and promotes good eyesight, as well as healthy and strong bones, among others. More awareness should be created on its nutritive value and more palatable varieties should be developed.

Authors contributions

The first author conceived the research idea and made a draft manuscript. Bo the first and second author improved on the manuscript.

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