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Review on Watermelon Production and Nutritional Value in Ethiopia

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Abstract
There is a growing realization in Ethiopia for the need to enhance the production of xerophytic crops, including Watermelon, Citrullus lanatus L., in the face of climate change. It is adaptable to most of tropical and subtropical zone of Ethiopia, due to its low water requirement and has the potential to be a commercial crop. It is a newly introduced cash crop gaining a high level of economic importance in the generation of income and provision of nutritional value. Watermelon flesh contains high quantity of vitamins, minerals and other antioxidant compounds, which play important role in human metabolism. Antioxidant components help in preventing human disease by acting as oxygen radical scavenger. Watermelon rind and seed also have many health benefits due to the presence of important amino acids citrulline, fibres, minerals and phenolic compounds. Thus, the present review provides a comprehensive overview of the production status and challenges and nutritive values of watermelon in Ethiopia.
Keywords: Watermelon, Nutritive value, Lycopene; Xerophyte, Ethiopia
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1. Watermelon

Watermelon (*Citrullus lanatus*) is a xerophytic tropical fruit, belonging to a Cucurbitaceae family. It is native to tropical Africa, is a popular thirst-quencher fruit, and is mainly available during summer time [1]. Being low in calories and highly nutritious, it is enjoyed by many people across the world as a fresh-fruit [2]. Watermelon is highly cultivated around the world and has a huge economic importance [3]. The consumption of fresh-cut watermelon has increased at a rate of 20% to 30% annually [4]. The total estimated production of watermelon is approximately 79.2 thousand million tons in the world and China is the largest producer (56.6 thousand million tons) while United States ranked fifth in the world [5]. Watermelons are available in different forms, such as sliced, quarters, halves or chunks with rind, or as cubes in plastic containers without rind. Watermelon is rich in some of the major antioxidants, vitamin C, and a good source of lycopene that is responsible for the red color [6].

According to [1, 7], watermelon has one of the highest lycopene content among all fruits and vegetables. The lycopene content of watermelon has become very important for consumers, as recently lycopene has stimulated attention as a health-promoting antioxidant, associated with lowered risk of coronary heart disease [6]. It has been show that lycopene acts as a free radical scavenger and the highest single oxygen quenching. It also deactivates DNA-breaking agents related to some cancers [3]. According to [2], consuming fruits and vegetables rich in lycopene significantly decrease incidence of coronary heart disease and provides protection against prostate, kidney [2], breast, digestive-tract, and lung cancers [1, 8].

In addition to containing high levels of lycopene, watermelon is also an excellent source of vitamin C and a good source of vitamin A. A 100 g of watermelon provides 8.1 mg of vitamin C and 569 IU vitamin A, corresponding to 13.5% of the daily value for vitamin C and 11.38% of the daily value for vitamin A [1]. Additionally, it is also a good source of vitamins B, especially B1 and B6, as well as minerals such as potassium and magnesium. It is largely consumed as refreshing summer fruit, much appreciated because of its refreshing capability, attractive color, delicate taste and high water content to quench the summer thirst. Watermelon fruits yield about 55.3 % juice, 31.5 % rind and 10.4 % pomace [9]. The sweetness of watermelon is mainly due to a combination of sucrose, glucose, and fructose. Sucrose and glucose account for 20–40 % and fructose for 30–50 % of total sugars in a ripe watermelon [10].

The fruit is known to be a good source of lycopene and carotenoid. It helps quench the free radicals that contribute to conditions like asthma, atherosclerosis, diabetes, colon cancer and arthritis. It is also high in fiber and citrulline; an amino acid the body uses to make arginine [11]. Watermelon seeds are known to be highly nutritional; they are rich sources of protein, vitamins B, minerals (such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese and copper) and fat among others as well as phytochemicals [12]. The seeds of watermelons are known to have economic benefits especially in countries where cultivation is on the increase. The seeds are for instance used to prepare snacks, milled into flour and used for sauces. Oil from the seeds are used in cooking and incorporated into the production of cosmetics [13]. In spite of the various potential applications, the watermelon seeds are often discarded while the fruit is eaten. There is also limited literature on the effect of variety on the nutritional, phytochemical and antioxidant properties of the watermelon seeds.

Watermelon despite its enormous benefits, information on production, challenges and nutritive value was limited in Ethiopia. This is because of inadequate knowledge on its importance and how livelihoods of many

families will be affected by its production. Therefore, the objective of this paper was to review the production status, challenges, and nutritive values of pumpkin in Ethiopia.

2. Physical Characteristics

It is a large, sprawling annual plant with coarse, hairy pinnately lobed leaves and yellow flowers.
It is grown for its edible fruit, which is a special kind of berry botanically called a pepo. The watermelon fruit has deep green smooth thick exterior rind with grey or light green vertical stripes. Inside the fruit is red in color with small black seeds embedded in the middle third of the flesh [14]. Watermelons range in shape from round to oblong. Rind colors can be light to dark green, with or without stripes. Flesh colors can be dark red, red or yellow.

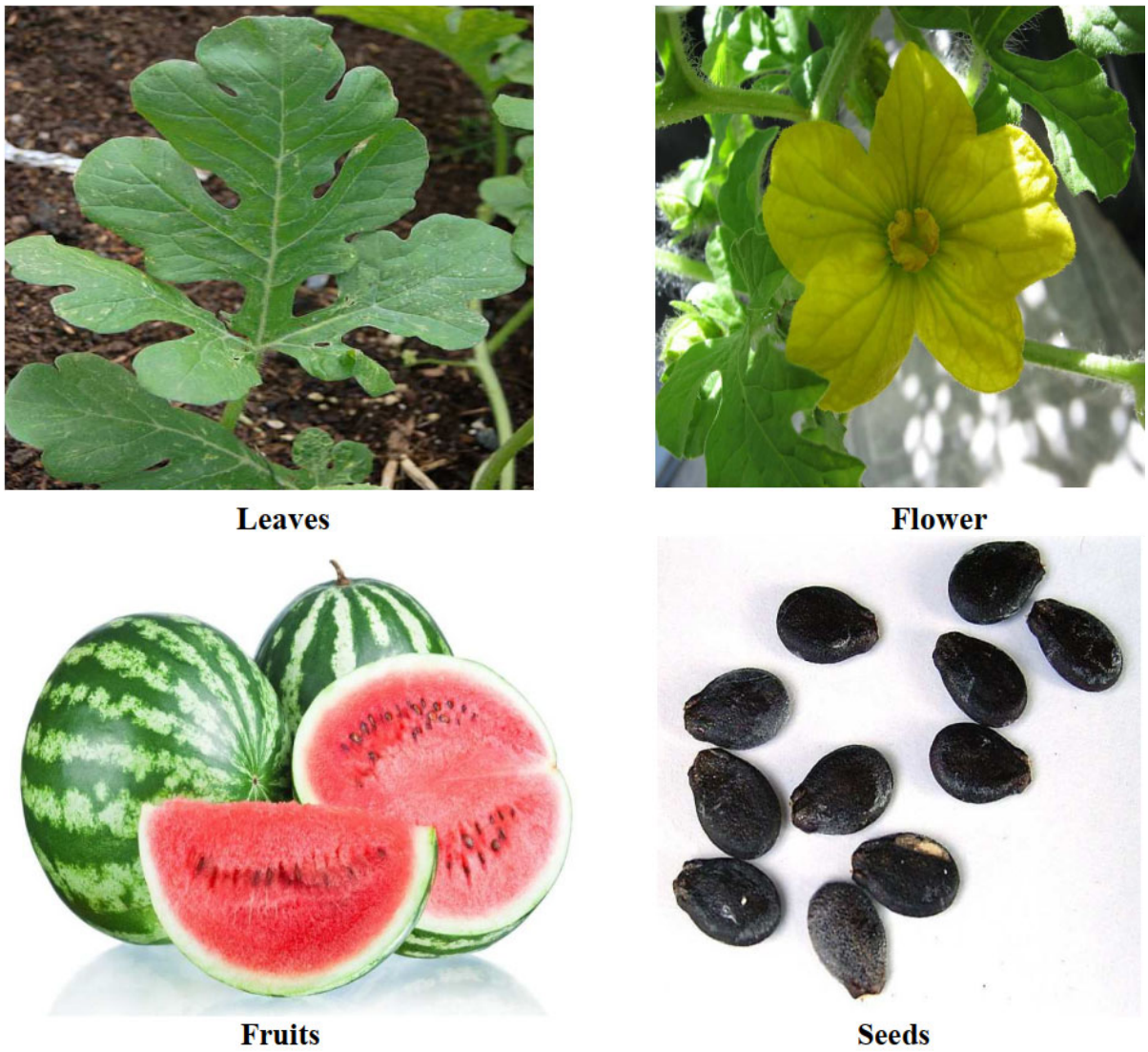

Figure 1: *Citrullus lanatus* leaves, flower, fruit and seeds

3. Watermelon Production

Watermelon not only tolerates hot weather but also for best growth requires more heat than any other vegetables. Watermelon seeds germinate well and plants thrive at 25°C - 30°C. Fruits mature best at 30°C. Watermelon requires dry weather and plenty of sunshine. Continuous rain or cloudy will not only stunt the plant growth but also reduce the flowering and fruit setting. If watermelons mature in rainy season, the sugar content will be significantly reduced. Watermelons grow best on sandy loam soils, with good drainage and a slightly acidic pH [15]. When planted in very heavy soils, the plants develop slowly and fruit size and quality are usually inferior. Fine sands produce the highest quality melons when adequate fertilizer and water are provided. Windbreaks are advisable on sandy soils to reduce sand blast damage and stunting of young seedlings caused by winds. Wind may also cause plants grown on plastic mulch to spin, which can damage the crown of the plant. To reduce the risk of diseases, it is not advisable to plant on land where vine crops have grown during the past three years. Highly experienced growers often prefer an even longer rotation period [16].

3.1 Optimal Ecological Requirements for Watermelon Production

Altitude	0 – 1500 meters above sea level
Rainfall	500 – 600mm of rainfall annually
Growing temperature	22 – 28 ^{0}C (day)
Soils	• Sandy loam • Well drained and slightly acidic • pH range 6.0 – 6.8

Source: [17]

3.2 Planting and transplanting

Watermelon can be direct seeded in the field or grown as transplants seedling in pots and then transplanted to the field. Before sowing seeds are soaked in warm water for 12 hours. Normally 3.5 kg of seed of watermelon is required for planting one ha area. The hills are usually spaced 1 to 1.5 meters apart in the rows also 2 to 2.5 meters apart. A variation of spacing hills 4meters apart in the rows 1.5 meters apart are also commonly used in the tropics. Apply FYM 20 t/ha, P 55 kg and K 55 kg as basal and N 55 kg/ha 30 days after sowing [18].

3.3 Weeds and insect control

Depending upon the season about 2-3, weeding operations is required. The first weeding should be done 20-25 days after sowing while subsequent weeding is done at an interval of one month. The biggest watermelon pest is the leaf-eating beetles, they damage the flowers. The other main problem with growing watermelons is mildew, a fungus that makes the leaves look as if they were coated with white powder [18].

3.4 Harvesting and storage

The crop is ready for harvest in about 75-100 days after sowing. For local market, harvesting should be done at full maturity while for transporting to distant markets, it is done slightly earlier. Watermelons can be stored for 14 days at 15°C. Watermelons should not be stored with apples, bananas as the ethylene produced during storage from these fruits hastens softening and development of off flavor to watermelons [18].

4. Challenges

Fruit quality is an important attribute in the production of watermelons for a specific market [19]. Generally, the market prefers red as opposed to yellow-fleshed fruit primarily due to lack of yellow-fleshed cultivars with high-quality fruit and consumer resistance. Other cultivars are prone to physiological problems such as cracking, hollow-heart, mealy textures, or a lack of uniformity in fruit shape [20]. The most important watermelon pests are leaf-chewing beetles and sucking insects, which damage leaves, flowers, and root-knot nematodes that affect water and nutrient uptake [21]. Diseases of economic importance include mildew, fusarium wilt, mosaic viruses, and bacterial rind necrosis [22]. It is important to note that watermelon is produced with minimal fertilizer and pesticide inputs in Africa as well as Ethiopia and is usually grown as an intercrop; thus, it is not considered a priority when allocating land for agricultural production. This implies that some pests, though not of great concern in other production systems, are of significance in Ethiopia.

5. Opportunities

Watermelons have evolved several gene expression patterns, biochemical pathways and physiological mechanisms not present in most crops that allow them to adapt to drought and high light stress [23]. Ethiopia as it is an African country, has ideal temperatures, long warm growing seasons, and soils for commercial watermelon production. Watermelons grow best on sandy loam soils, with good drainage and which are slightly acid pH [24]. As countries in Africa are often affected by drought, adapted watermelon cultivars will be ideal given they require minimum moisture and have high returns on the market compared to other drought hardy crops. Watermelon growth is more rapid during the dry season (under irrigation) than during the wet season (rainfall period) due to erratic precipitation patterns [25]. Excess water during maturity can cause fruits to crack which reduces yield and fruit quality [26]. In Ethiopia, like other African countries, watermelon cultivation is prevalent in drought-prone, semi-arid, areas with an annual rainfall below 650 mm. Most watermelon landraces provide important traits for drought and heat tolerance, such as higher biomass, which would greatly improve crop adaptation to climate change worldwide [22].

6. Production of Watermelon in Ethiopia

The horticultural sector in Ethiopia is growing strongly. Ethiopia is an extraordinarily rich agrobiodiversity resulting from its geography, climatic differences, ethnic diversity and strong food culture. Unique is the great variation in climates, due to the great variation in altitude ranging from sea level up to 4500 meters [27]. The variation in climate also makes it possible to grow all types of fruits and vegetables. Both in Europe and the Middle East growing interest exists for products from Ethiopia. Presently, the main export products are fresh beans,

strawberries, grapes, tomatoes, courgettes, peppers and fresh herbs. Potential almost all types of fruits &vegetables can be grown in Ethiopia [28]. The production of watermelon to Ethiopia is limited to some area. Little research on watermelon production has been done in Ethiopia compared to cereals and legumes. Farmers use a range of production methods, which demonstrate the diversity under which the crop is grown and different niches the crop occupies in farmer livelihood. Smallholder farmers grow most watermelons for consumption. The quality of watermelon that has been produced by Ethiopian farmers is very low compared to the world average. Its average total soluble solids content (TSS) is less than 6% while a minimum TSS shall not be lower than 9 % in world standard.

There is crop variety registering book that is annually issued by ministry of agriculture in Ethiopia within their description of agronomic and morphological characterization; in 2014, five type watermelon crop varieties were registered. Among the five varieties, only four types of varieties were cultivated and namely indicated as Lahat, Augusta, Ria and Candy.

a) Ria b) Candy c) Lahat d) Augusta

Figure 2. Four varieties of watermelon fruit

7. Nutritional Value of Fresh Watermelon

It is one of the commonly consumed fruits in many countries. Watermelon contains more than 91% water and up to 7% of carbohydrates. It is a rich source of lycopene and citrulline. Watermelon rind contains more amounts of citrulline then flesh. Additionally, watermelon has a number of essential micronutrients and vitamins.

Table 1: Nutritional value per 100 g of Watermelon, raw

Components	**Nutrient Value**	**Daily recommended allowance (%)**
Energy	30Kcal	1.5
Carbohydrates	7.55g	6
Sugars	6.2g	≤10
Proteins	0.61g	1
Fats	0.15g	0.5
Dietary fiber	0.4g	1
Vitamins		
Vitamin A	28 µg	4
Thiamine (B1)	0.033mg	3
Riboflavin (B2)	0.021mg	2
Niacin (B3)	0.178mg	1
Pantothenic acid (B5)	0.221mg	4
Vitamin B6	0.045mg	3
Choline	4.1mg	1
Vitamin C	8.1mg	13.5
Minerals		
Calcium	7mg	1
Iron	0.24mg	2
Magnesium	10mg	3
Manganese	0.038mg	2
Phosphorus	11mg	2
Potassium	112mg	2

Components	Nutrient Value	Daily recommended allowance (%)
Sodium	1mg	0
Zinc	0.1mg	1
Phyto-nutrients		
Beta-carotene	303 µg	3
Lycopene	4532 µg	---
Other constituents		
Water	91.45g	------

Source: USDA National Nutrient Database

8. Health Benefits of Watermelons

Despite popular belief that it is made up of only water and sugar, watermelon is actually considered a nutrient dense food, a food that provides a high amount of vitamins, minerals and antioxidants for a low amount of calories. Many studies have suggested that increasing consumption of plant foods like watermelon decreases the risk of obesity and overall mortality, diabetes, heart disease and promotes a healthy complexion and hair, increased energy, overall lower weight.

8.1 Cardiovascular & Bone Health

The lycopene in watermelon is especially important for our cardiovascular health and is now being recognized as an important factor in promoting bone health. Consuming large amounts of watermelon has also been correlated with improved cardiovascular function because it improves blood flow via vasodilation (relaxation of blood pressure). Dietary lycopene (from foods like watermelon or tomatoes) reduces oxidative stress, which normally reduces the activity of osteoblasts and osteoclasts (the two major bone cells involved in the pathogenesis of osteoporosis) - this means stronger bones for those consuming lycopene-rich foods. Watermelon is also rich in potassium, which helps to retain calcium in your body, resulting in stronger bones and joints.

8.2 Reduces Body Fat

The citrulline in watermelon has been shown to reduce the accumulation of fat in our fat cells. Citrulline is an amino acid, which converts into arginine with help from the kidneys. When our bodies absorb citrulline it can take the step of converting into arginine if so required. Citrulline, when consumed, has the ability to (through a series of steps) block the activity of TNAP (tissue-nonspecific alkaline phosphatase) which makes our fat cells create less fat, and thus helps prevent over-accumulation of body fat.

8.3 Anti-inflammatory & Antioxidant Support

Watermelon is rich in phenolic compounds like flavonoids, carotenoids, and triterpenoids. The carotenoid lycopene in watermelon is particularly beneficial in reducing inflammation and neutralizing free radicals. The tripterpenoid cucurbitacin E is also present in watermelon, which provides anti-inflammatory support by blocking activity of cyclo-oxygenase enzymes, which normally lead to increased inflammatory support. Make sure you pick ripe watermelons, because they contain higher amounts of these beneficial phenolic compounds.

8.4 Diuretic & Kidney Support

Watermelon is a natural diuretic that helps increase the flow of urine, but does not strain the kidneys (unlike alcohol and caffeine). Watermelons helps the liver process ammonia (waste from protein digestion) which causes strain on the kidneys while getting rid of excess fluids.

8.5 Muscle & Nerve Support

Since watermelon is rich in potassium, it is a great natural electrolyte and thus helps regulate the action of nerves and muscles in our body. Potassium determines the degree and frequency with which our muscles contract, and controls the excitation of nerves in our body.

8. 6 Alkaline-forming

Watermelons have an alkaline-forming effect in the body when fully ripe. Eating many alkaline-forming foods (fresh, ripe, fruit and vegetables) can help reduce your risk of developing disease and illness caused by a high-acid diet (namely, meat, eggs and dairy).

8.7 Improves Eye Health

Watermelon is a wonderful source of beta-carotene (that rich red hue of watermelon = beta-carotene) which is converted in the body to vitamin A. It helps produce the pigments in the retina of the eye and protects against age-related macular degeneration as well as prevents night blindness. Vitamin A also maintains healthy skin, teeth,

skeletal and soft tissue, and mucus membranes.

8.8 Immune Support, Wound Healing & Prevents Cell Damage

The vitamin C content in watermelon is astoundingly high. Vitamin C is great at improving our immune system by maintaining the redox integrity of cells and thereby protecting them from reactive oxygen species (which damages our cells and DNA). The role of vitamin C in healing wounds has also been observed in numerous studies because it is essential to the formation of new connective tissue. The enzymes involved in forming collagen (the main component of wound healing) cannot function without vitamin C. If you are suffering from any slow-healing wounds, up your intake of vitamin C heavy fruit.

Source: [29].

9. Uses of Watermelons

9.1 Food Uses

Watermelons are collected from the wild for local use, notably as a source of water in the Kalahari region of southern Africa. The flesh comprises about 65% of the whole fruit and contains over 90% water. Watermelon contains carotenes and vitamin C. One particularly useful species is watermelon, *Citrullus lanatus*. An important source of water in the Kalahari region over the dry season, it also provides food and medicines. Watermelons are cultivated commercially for their refreshing, sweet fruits.

They are mostly consumed as fresh fruit, alone or as part of fruit salads or other desserts. In some African cuisines the fruit and leaves are cooked as a vegetable. Watermelon rinds are also edible, but most people avoid eating them due to their unappealing flavor. They are used for making pickles, and sometimes used as a vegetable. The rind is stir-fried, stewed or more often pickled, which is sometimes eaten in the Southern US. Small, white-fleshed cultivars are used in the production of preserves. Watermelon fruits are made into syrup in Eastern Europe. The rind may be consumed in pickled or candied form.

9.2 Traditional medicine

Watermelon fruit pulp, juice and seeds have been used as a diuretic. Fruit pulp has been used as a purgative, particularly that from bitter-forms. A preparation of watermelon seed has been used to lower blood pressure. Watermelon seeds have been used to expel intestinal worms in Senegal.

9.3 Other Uses

Bitter forms of watermelon and the cake left over after expressing the seed oil are used as cattle-feed. The leaves and fruit provide grazing for stock. Watermelon has been used as ingredient in sun-lotions and other cosmetics. The amino acid citrulline is produced in water rind. Watermelon pulps contains carotenoids, including lycopene.

Source: [30].

10. Conclusion and Recommendations

Watermelons are very good source of important nutritive components and contained a very high concentration of nutrients for human consumption. It also contains different components of medicinal values. Therefore, it would be \more effective in healthcare management. Additionally, watermelon rind and seed is a rich source of an important amino acid and minerals. These exceptional qualities of watermelon and its products warrant us to use it for health benefits. Watermelon despite its enormous benefits, information on production, challenges and nutritive value was limited in Ethiopia. This is because of inadequate knowledge on its importance and how livelihoods of many families will be affected by its production. Therefore based on the above conclusion watermelon production in different part of Ethiopia must be studied in detail, various component of watermelon must be isolated, characterized and evaluated from different parts.

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