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REVIEW ARTICLE

Postharvest technology and value addition of watermelons (*Citrullus lanatus*): an overview

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ABSTRACT

This review article covers postharvest handling of red fleshed watermelons (*Citrullus lanatus*) as well as possible watermelon value-added products. The rate of biochemical and microbial reactions that take place after harvesting must be minimised so as to enhance the quality of watermelon products. In most cases the rind and the seeds of the watermelon are not utilised despite the fact that they contain some nutrients. The seeds and rind are thrown away after consumption of the pulp though in some African communities the seeds are used to make oil and often as a meat substitute and the rind is given animals as a feed. On a commercial scale the rind can be exploited to produce watermelon jam and a flour that can be an additive in baking. The watermelon seed flour can be incorporated in the formulation of weaning food. The watermelon pulp is used in the production of yoghurt, watermelon juice, wine and powder. All the components of the watermelon can be utilised to come up with value added products that are nutritious, some of which with health benefits.

Keywords: Watermelon, Postharvest, Value Addition, Quality, Food Security

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INTRODUCTION

Watermelon (*Citrullus lanatus*) is of the cucurbitaceae family. The watermelon fruit has a smooth thick rind and fleshy pulp and watery juice. The colours of the flesh vary from one variety to another. The different flesh colours of watermelons are attributed to carotenoids present. Examples of the watermelon flesh colours are white, orange, salmon yellow, pale yellow, canary yellow, crimson red, and scarlet red. Lycopene is the major pigment of red-fleshed watermelons (Zhao et al., 2013).

Watermelons are generally considered as refreshing fruit and consumed regularly as a dessert, fruit salad, breakfast food or even as a snack. Fresh watermelons have an approximate pH value of 5.2-5.6. Watermelon contains sugars that contribute to its sweetness (2.7g fructose,0.6g glucose and 2.8g sucrose per 100g of fruit). The rind of the watermelon constitutes about 44% by weight of the whole fruit (Sinha et al., 2012). Watermelons have vast nutrients, the nutrients are found in the pulp, the seeds as well as in the rind. Nutritional composition of watermelon has been described in Table 1.

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POSTHARVEST HANDLING

According to (Smith 2010; El-Ramady et al., 2015) it takes approximately 65,75 and 95 days for early variety, common type and late variety of watermelons respectively to reach market maturity from the planting stage under optimum conditions. Some of the watermelon harvest maturity indices that can be used is the flesh colour (75% red), and total soluble solids 10% (Kitinojo and Gorny 1998 as cited in El-Ramady et al., 2015).

Large quantities of watermelons are lost due to poor postharvest techniques. Microbial spoilage of watermelon juice is due to the activity of *Candida pseudotropicalis, Candida tropicallis, Saccharomyces cerevisiae, Trichosporan asashii, Serratia species and Staphylococcus saprophyticus* (Ugbogu, 2015). Water soaking appearance is associated with microbial spoilage of watermelons. Watermelon has been classified as a fruit that can be preserved using room cooling. It can be stored at an optimum temperature of 10-15°C and relative humidity of 90% with an expected storage life of between 14-21 days (Ahmad, and Siddiqui, 2015).

The washing of watermelons might not be necessary but the need arises when there is excess soil in which in such cases clean wash water is used. The grading of watermelons is based on the physical appearance of the watermelon. During handling, fruit scratching must be avoided and diseased fruits must be removed from other watermelons so as to avoid the spreading of diseases. The common fungal diseases that affect the rind in its postharvest life include fusarium, black rot, stem end rot and anthracnose, soft rot is the most common bacterial diseases that cause rind decay. The postharvest disorders affecting watermelons are mechanical injury, chilling injury and ethylene damage (Ministry of fisheries crops and livestock et al., 2003).

According to reports of the Asian Productivity Organisation (2004) seminar on reduction of postharvest losses of fruit and vegetables emphasis is now on harvest techniques that are modern such as aseptic packaging, cryogenic freezing, deep freezing, accelerated freeze drying, controlled and modified atmosphere storage, shrink wrapping are being used to extend the shelf life of fruits and vegetables (Rolle,2006).This reflects on the need for the advancement of postharvest techniques and studies related to watermelon storage and preservation.

According to Barth et al., 2009 fresh cut water melons have a normal shelf life of 2 days. However fresh cut watermelon can be preserved by ozone treatment. According to a study by Viet Man and Huy (2007), a blowing flux of 4.2mg/dm^3(30°C,1atm) of ozone concentration was applied for 3 minutes to fresh cut watermelons. The watermelon slices were then stored in polyethylene packaging. The shelf life was prolonged to 7 days at 4°C. This is due to reduction in microbial load as a result of ozone treatment.

Physiological changes after harvesting

The maturity of watermelons at harvest mainly affects the postharvest quality of the fruit. Watermelons do not have internal, sugar content or colour development after harvesting, thus watermelons must be harvested only when they have fully matured. Common postharvest disorders that can be observed on watermelons are mechanical injury which results mainly from postharvest handling, chilling injury due to storage below 10°C, ethylene damage due to exposure to ethylene and hollow heart which is of preharvest origin.

Microorganisms can be found on the external surface of uncut watermelons and the predominant are *Pseudomonas sp*, *E. coli* and *Enterobacter sp*. These microorganisms will be found on the surface of freshly cut watermelons and thus will cause

spoilage of the watermelon slices. Colour changes that is darkening of the surface of watermelons, flavour loss and loss in firmness are due to microbial activity (Abbey et al.,1988). Thus these losses due to pathogens need to be checked using non-chemical and biological approaches (Kumar et al., 2018).

Table 1. Nutritional composition of edible portion of watermelon

Nutrient	Unit	1 Value per 100 g
Proximate value		
Water	g	91.45
Energy	kcal	30
Protein	g	0.61
Total lipid (fat)	g	0.15
Carbohydrate, by difference	g	7.55
Fiber, total dietary	g	0.4
Sugars, total	g	6.2
Minerals		
Calcium, Ca	mg	7
Iron, Fe	mg	0.24
Magnesium, Mg	mg	10
Phosphorus, P	mg	11
Potassium, K	mg	112
Sodium, Na	mg	1
Zinc, Zn	mg	0.1
Vitamins		
Vitamin C, total ascorbic acid	mg	8.1
Thiamin	mg	0.033
Riboflavin	mg	0.021
Niacin	mg	0.178
Vitamin B-6	mg	0.045
Folate, DFE	µg	3
Vitamin A, RAE	µg	28
Vitamin A, IU	IU	569
Vitamin E (alpha-tocopherol)	mg	0.05

Vitamin K (phylloquinone)	µg	0.1
Lipids		
Fatty acids, total saturated	g	0.016
Fatty acids, total monounsaturated	g	0.037
Fatty acids, total polyunsaturated	g	0.05

United States Department of Agriculture (2016)

HEALTH BENEFITS

Watermelon fruit was determined to be rich in vitamin A and C with small amounts of vitamin B1, B2, B6, folate, and niacin. It is very rich in potassium and also contains other minerals like iron, calcium, magnesium and phosphorous in traces but free of fats and cholesterol, (Adejume et al., 2015). They are known to contain anti-carcinogenic properties and they contain relatively high levels of lycopene. There is a high ratio of lycopene to carotene (1:12) and this results in the good antioxidant capacity of watermelons which will in turn results in watermelon's potential to prevent various chronic ailments. (Naz et al., 2014). The red colour of water melons is attributed to lycopene. Red fleshed watermelons are the ones that contain a significant amount of lycopene as compared to yellow and orange fleshed types.

Different varieties of watermelon seeds e.g. Charleston gray, crimson sweet, black diamond contain phytochemicals like saponins, tannins, triterpenoids and glycosides and alkaloids. The tannins are effective against cancer because of their antimutagenic properties. alkaloids and glycosides (not cyanogenic glycosides) found in watermelon seeds all have health benefits. Alkaloids have analgesic effects and glycosides have anti-diarrhoeal properties (Tabiri et al., 2016).

A study carried out to investigate the radioprotective effect of watermelon on mice revealed that 50% watermelon juice supplementation can result in modulation of oxidative damage that would have been caused by low dose X-Ray exposure (Mohammad, 2014). Watermelon juice from red flesh watermelons has possibilities/potential use as a natural product that has significant diuretic effects thus it can work better than known diuretic agents. (Gul et al., 2012).

VALUE ADDITION

Infant feed

Functional and physiochemical properties of watermelon seed were studied in terms of their oil and water absorption capacities, foaming capacity and stability and emulsion stability and the results indicated the feasibility of utilising watermelon seed flour as food by incorporating it in infant food formulation rather than throwing it away (Oyeleke et al., 2012).

Flour prepared from watermelon seeds have high values of protein, fibre, minerals were noted making the seeds a good source of food constituents. The functional properties also reflect on the possibilities of the seed flour to be used in other food products for example the bulk density content is good for weaning food (Otutu et al., 2015).

Watermelon seed oil

Watermelon seeds are rich in oil and protein according to Fila et al., 2013. Watermelon seed oil contains high amounts of unsaturated fatty acids with linoleic and oleic acids as the major acids, (Xiaonan Sui et al., 2011). The test for feasibility and

safety of watermelon seed oils was conducted and the results revealed that the white and black seed oil contains 68% linoleic acid and can be used safely for human consumption. The oil was extracted from sun dried seeds. White watermelon seeds had a yield of 40% whilst the black seeds had an oil yield of 35% (Sabahelkhier et al., 2011).The seeds and rind can be consumed safely though they might be thrown away on the speculation of toxicity. It has been proven that the watermelon rind,seed and pulp's concentrations of antinutritional components is tolerable (Egbuonu, 2015; Johnson et al., 2012).

Watermelon jam

Watermelon rind that is a by-product of watermelon juice processing can be used in the production of watermelon jam. The jam can be without flavour or with different flavours that is vanilla, pineapple, strawberry, and lemon. The watermelon rinds are stored immediately after juice extraction at 4°C to avoid further degradation. Equal quantities of rind and sugar (250g each) are mixed and kept for 45 minutes before boiling. Citric acid is then added and flavours can also be added to improve sensory perceptible properties. Packaging is done in sterilised glass bottles whilst the product is still hot for preservative purposes. Storage is between 25°C and 32°C (Souad et al., 2012). The use of watermelon rind in value addition is an advantage in that instead of throwing away the nutritious rind, individuals can benefit from it. The watermelon raw peel contains more ash and crude fibre as compared to the watermelon pulp (Morais et al., 2017).

Watermelon wine

Watermelon juice can be used in the formulation of a watermelon wine with antioxidizing properties (Darman, 2010). The antioxidizing properties are due to the presence of polyphenols. A mixed fruit wine can be made with watermelon being one of the constituent fruit juice, for example a combination of watermelon and pawpaw or banana and watermelon can be fermented using Saccharomyces cerevisiae isolated from palm wine to produce a mixed fruit wine (Ogodo et al., 2015). This has a bearing in reducing postharvest losses in that the overripe fruits that might face rejection in the fresh produce market can be utilised to come up with an acceptable safe product.

A similar study was also conducted by Adedeji and Oluwalana (2013), a watermelon pawpaw wine blend was produced using different ratios of pawpaw to watermelon. The physiochemical properties and sensory characteristics were analysed and results indicated wine with a formulation of pawpaw to watermelon ratio of 60:40 had the highest quality with a storage life of 6 months at 30±2°C.

Watermelon antistaling agent and baking additive

Watermelon rind powder if used with the sharyln melon peel powder can retard the staling of cakes by inhibiting oxidation of lipids and the formation of free fatty acid during storage. This effect is attributed to the presence of phenolic compounds which are significantly higher in watermelon rind powder than sharyln melon powder (Al-Sayed and Ahmed, 2013).

The watermelon rind powder can be used for the fortification of pan bread, by substituting the wheat flour by 12% watermelon rind powder. The sensory perceptible properties will be enhanced by the watermelon rind powder (El-Badrv et al., 2014). According to Hoque and Iqbal (2015) watermelon rind flour 10% in combination with wheat flour can be used to produce an acceptable cake with more preference in terms of the sensory characteristics as compared to the wheat cake. Therefore, the watermelon rind can be used in the formulation of cake and bread recipes to improve sensory perceptible properties and nutritional values of baked products.

Watermelon yoghurt

Watermelon juice can be utilised in the production of fruit yoghurt. Watermelon juice is mixed with reconstituted dried powdered milk and homogenised. The mixture is inoculated with 2% of a mixed strain starter (*Lactobacillus delbrueckii* subs *bulgaricus* and *Streptococcus thermophilus*, 2:1 v/v) and incubated for 6 hours at 37°C (Sengupt et al., 2014). The sensory quality of yoghurt can be improved by the addition of watermelon juice depending on the formulation used.

Watermelon fruit pulp's use in making fruit yoghurt has also been demonstrated. Fresh whole milk was filtered and boiled (with the addition of 10% sugar). The milk was cooled down to 42-43°C and watermelon fruit pulp was added separately at 55%,10% and 15%. A starter culture was inoculated (1.5%) at 41°C and the mixture was incubated at 37°C for 8-12 hours. A plain yoghurt was also made using the same formulation as a control. The yoghurt was analysed for sensory test, moisture, ash, protein, fat, pH, acidity, total soluble solids and syneresis. The results indicated that watermelon yoghurt had better nutritional and sensory perceptible properties as compared to the control (Roy et al., 2016). In this regard, the nutritional quality of yoghurt can be improved by the incorporation of watermelon pulp into the yoghurt formulation.

Incorporation of 25% watermelon juice can lead to an increase in vitamin C content as compared to plain yoghurt. Improvements can also be noted in terms of colour, appearance, odour and overall acceptability (Warakaulle et al., 2014).

Watermelon powder

The feasibility of producing watermelon powder was demonstrated by Quek et al.,2007 using a minispray dryer. The sugar baby variety was used in the experiment. Spray drying of the watermelon juice was carried out at a feed temperature of 20°C, pressure of 4.5bars, aspirator rate of 60% and flow rate of 600h/l.Four inlet temperature of 145°C,155°C,165°C and 175°C were used and maltodextrin of 3% or 5% was added to reduce fouling of the product. With further studies being carried out watermelon drying parameters and conditions can be improved to minimise nutritional loss as well as a decrease in sensory perceptible properties. The powder can be used as a food additive or it can be reconstituted.

Watermelon juice

Watermelon juice can be extracted from the pulp. Watermelon juice can be blended with pineapple juice in order to improve the sensory perceptible properties. The juice blend produced can have a shelf life of at least 5 weeks (Okwori et al., 2017: Akande and Ojekemi, 2013). Watermelon juice can be blended with beetroot in the ratio of 75:25 by volume respectively. The blending improves the total soluble solids value and vitamin C content (Ankush et al., 2015). According to Okwori et al., 2017 the shelf life of natural watermelon juice can be increased by refrigeration. Fresh watermelon juice with sugar added to it has a longer shelf life as compared to watermelon juice (Ogunbanwo et al., 2013). According to Alam et al., (2013) 0.1% sodium benzoate and 0.1% potassium sorbate can be added to fresh pasteurised, sweetened (with 20% sucrose) watermelon juice to improve on its shelf life. The product can be stored under refrigeration (4°C -15°C) for best results that is an expected shelf life of three months.

CONCLUSION

A variety of products can be made from watermelon. There is need to intensify studies on every possible water melon value-added product. This will in turn assist in the stable production of consistent supplies of value added nutritious watermelon products. The production of watermelon value added products will minimise postharvest loses due to the utilisation of even the components that might be regarded as waste to produce an acceptable and safe product.

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