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Anti-Carcinogenic Factors of Water Melon Seed and Seed Oil: A Review

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ABSTRACT

The seeds of watermelon are generally considered as agro-waste and are thrown away out in spite of its high nutritional profile and therapeutic values. Watermelons seed is and unutilized by of oil contain essential fatty acids, vitamin-E, and minerals and are rich in anti-oxidants. Since watermelon seed contains high- quality proteins, the seed meal can be used as non-conventional protein source and functional ingredients during food formulations. watermelon seeds have beneficial health impact such as growth, cardio protective effect, anti-diabetic effect, anti-obesity, anti- arthritic effect and as well as anti-ulcerogenic effect. Adequate doses of watermelon seed extracts can increase sperm count. Watermelon seed oil and watermelon seed incorporated food products are available in many countries. There is an ample scope of research to explore the bioactive ingredients responsible for the positive health benefits of these and the use of value-added products from watermelon seeds.

1. Introduction

Watermelon (*Citrullus lanatus*) is a fruit crop, herbaceous creeping plant belonging to the family *cucurbitaceae*. It is mainly propagated by seeds and thrives best in warm areas. It is a tropical plant requires lot of sunshine and temperature of 25°C for optimum growth. Watermelon thrives best in a drained fertile soil of fairly acidic nature. Recently more attention has been focused to recover valuable components from neglected plant wastes, by-products or wasted by-products) and use them inside the food chain, in an economic and sustainable way. Fruits occupy a part of daily diet of the rich and rarely poor. But there are many parts of a fruit that are not considered to be edible and are thrown away.

One such fruit is watermelon, which is taken by all but the seeds of watermelon are thrown away and generally not included in regular diet. The juice or pulp from watermelon is considered as edible portion but rind and seeds are discarded as major solid wastes (Bawa e Bains, 1977). The fruit has numerous small black seeds embedded in the middle of the flesh. The embryo completely fills the seed. The seeds have sweet and nutritious kernels. Several studies have shown that seeds of *Cucurbitaceae* species are potential sources of nutrients such as protein, minerals and lipids as well as ingredients for native medicine.

2. Origin and Distribution

Watermelon is thought to have originated in southern Africa, as growing wild throughout the region, and showed maximum diversity. It has been cultivated in Africa for over 4,000 years. The citron (*Citrullus lanatus* subsp. *lanatus* var. *citroides.*) grows wild in sub-Sahara region of Africa and probable progenitor of watermelon. The natives knew about sweet as well as its bitter forms growing throughout southern Africa. One probable gene Centre is in the Kalahari Desert region

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where the species can still be found in the wild forms but its origin is in the Sahel Region in northern Africa. Watermelon spread from Africa to Asia about 800 AD and to Europe in 961 AD and was subsequently brought to America by Europeans in the 17th Century. Seeds are numerous, 6-10 mm long, pyriform, compressed, dark brown, or even black, pink, white or mottled. Seeds continue to mature as the fruit ripens and the rind lightens in color.

3. Plant Description

Watermelon is a flowering plant under the member of the family of cucumber (*cucurbitacea*). It is a drought tolerant crop which is cultivated chiefly in tropical, semi tropical and rigid regions of the world. Different varieties of watermelon are available and some of the popular varieties are: sugar baby, golden midget, star light, jubilee, yellow baby etc. They not only vary on their size but also in their shape and color of the flesh. It originates from west not southern Africa as previously believed. The type of specimen of the name *Citrullus lanatus*, prepared by the collector of southern Africa. Nuclear a plastid data further more revel that there are seven species of Citrullus, not four as assumed. They are as follows- *Citrullus naudinianus, C. colocynthis, C. rehmi, Citrullus amarus, with the synonyms C. caffer and C. lanatus var. citroides, C. ecirrhosus***.** (Guillaume Chomicki *et al.,* 2014). The species of watermelon which is widely available and eaten in Kolkata (India) was known as *Citrullus vulgaris*. It is round in shape, has dark green colored rind and red pulp which is sweet in taste.

4. Germination of Watermelon Seed at Low Temperature

Watermelon (*Citrullus lanatus*) was formerly known as *Citrullus vulgaris*. The cultivars are classified as *Citrullus lanatus* and wild accession. Watermelon is grown throughout the world as a staple food (edible seed), a desert food (edible flesh), and for animal feed. Early planted watermelon often has difficulty with seed germination and emergence. Mostly cultivars selected for cold germination ability would provide grower with better stands for crop production. By testing the seed for germination in unfavorable environmental conditions. (Khan *et al.*, 1979) and (Thomas 1981) survived that seed after sowing is affected by physical, chemical, mechanical and biotic factors. Temperature, light, drought, flooding, and gaseous environments are physical factors which influence seeding emergences. Germination of watermelon seed was improved at 15°C after priming within organic osmotica water imbibed watermelon seeds provided faster crop establishment than dry seeds at below room temperature (Hall *et al.*, 1989). The study was conducted during 1970, lowering the water activity at particular temperature decreased the rate of germination. The effect of temperature on germination appears to be depends on the water activity of the medium. The watermelon cultivars used in this study were able to germinate at 14°C, but not at 10°C, during the 30 days used for the testing method. Some cultivars germinated rapidly, and with a high percentage at 14°C. If the trait is heritable, it could be transferred into elite cultivars to provide growers with more safety in early spring plantings. Improved cold germination ability may also provide better germination of triploid hybrids.

5. Nutrient Content of Watermelon Seeds

Watermelon seeds are one of the most nutrient-dense varieties of seeds. They are rich source of proteins, vitamins, omega 3 and omega 6 fatty acids, magnesium, zinc, copper, potassium. Watermelon seeds are easily available during summer season. Though it is not an oilseed but many researchers have reported that *C. vulgaris* seed kernels contain about 52.6% oil. It is a good source of energy (628k.cal) (Gopalan *et al.*, 1971). Gopalan has listed watermelon seed kernels under nuts and oilseeds. Charecteristics and compositions of *C. vulgaris*, pumpkin and paprika seed kernel oils and flours were evaluated by (Tarek. A, El-Adawy *et al.,* 2001). (Elezuo *et al.*, 2011) evaluated the nutrient composition of some unconventional feedstuffs. Whole seed of *C. vulgaris* was one among them (Elezuo *et al*., 2011).

5.1. Chemical Components

Watermelon seed are free from alkaloids and glucosides. Other than the fatty oil the press cake of watermelon seed contains soluble protein products, sugar and resinous material. From the resin there were isolated a very small amount of phytosterol a new alcohol. The shell of the seed was 48.7 percentage of the weight of the entire seed. In addition to other fatty acids a small amount of arachidic acid was isolated from the shell. Other constituent present in the shells were similar to that of the pressed cake. In order to ascertain whether the resin obtained from watermelon seed possesses any physiological activity. Some tests were conducted by (Ferderick et.al. 1910).

5.2. Physical Properties

Physical properties of watermelon seed include linear dimension, volume, sphericity, surface areas, true and bulk density, porosity, repose angle. These characteristics are important for the designing of equipment and machines for the transporting, sorting, handling, processing, drying and storing of watermelon seed. Physical properties of watermelon seed vary from variety to variety and seed moisture content are environment is important for the growth of watermelon seed.

Table 1. *Important Fatty Acids of Watermelon Seed*

NAME OF THE SPECIES	PALMITIC ACID (%)	STEARIC ACID (%)	OLEIC ACID (%)	LINOLEIC ACID (%)	LINOLENIC ACID (%)	NAME OF THE AUTHOR
Citrullus lanatus	15.47	12.61	20.53	50.78	0.14	(Azeem *et al.*, 2015)
	9.84	6.36	10.8	72.6	0.15	(Jorge *et al.*, 2015)
	10.57	8.333	13.65	62.14	5.293	(Essien e Eduok, 2013)
Sugar baby	15.0	11.2	21.2	51.1	-	**(Raziq *et al.*, 2012)**
QF-12	15.1	12.5	20.2	50.5	-	
DWH-21y	16.2	13.8	23.0	45.1	-	
Red circle-1885	14.3	12.3	20.2	51.2	-	
Citrullus lanatus White	13	18	11	68	-	(Sabahelkhier *et al.*, 2011)
Black	15	16	11	68	-	
	13.5	13.7	14.6	56.9	0.5	(Oluba *et al.*, 2008)
Citrullus vulgaris	14.42	9.01	0.33	76.25	-	(Onoriode *et al.*, 2015)
	10.64	6.33	15.65	64.32	5.14	(Azeem *et al.*, 2015)
	14.42	9.01	0.33	76.24	-	(Garba *et al.*, 2014)

Table 2. *Physicochemical Characteristics of Watermelon Seed*

NAME OF THE SPECIES	SPECIFIC GRAVITY	REFRAC-TIVE INDEX	ACID VALUE	SAPONI- FICATION VALUE	IODINE VALUE	PER- OXIDE VALUE	NAME OF THE AUTHOR
Citrullus lanatus		1.466 (40^0C)	5.05 mg KOH/ g	212.6 mgKOH/g	128.8 g/100g	3.40 meq/kg	(Jorge *et al.*, 2015)
		1.468 (40^0C)		198 mgKOH/g	107.51 g/100g	1.31 meq/kg	(Azeem *et al.*, 2015)
	0.87 (25^0C)		6.10 mg KOH/ g	205.3 mgKOH/g	28.51 g/100g	2.80 meq/kg	(Egbuonu *et al.*, 2015)
	0.85	1.47	2.37 mg NaOH/ g	183.13 mgNaOH/g	121.51 Wijs		(Adebanjo e Kehinde, 2013)
	0.9129	1.35	7.09 mg KOH/ g	220.19 mgKOH/g	114.94 g/100g	20.0 meq/kg	(Essien e Eduok, 2013)
Sugar baby		1.4665 (40^0C)		1.99.81 mgKOH/g	97.10 g/100g	2.90 meq O_2/kg	(Raziq *et al.*, 2012)
QF-12		1.4668 (40^0C)		205.57 mgKOH/g	103.25 g/100g	5.06 meq O_2/kg	
DWH-21y		1.4667 (40^0C)		196.84 mgKOH/g	116.32 g/100g	3.30 meq O_2/kg	
Red circle-1885		1.4670 (40^0C)		190.20 mgKOH/g	114.00 g/100g	4.62 meq O_2/kg	
White	0.898 g/cm^3	1.468	16 %	609 mgKOH/g	85 mg/g	12 meq O_2/kg	(Sabahelkhier *et al.*, 2011)
Black	0.894 g/cm^3	1.467	32 %	625 mgKOH/g	80 mg/g	9 meq O_2/kg	
Oven dried (30^0C)	0.86 g/ml	1.459	13.40 mg NaOH/g	117.81 mgKOH/g	59.69 g/100g	18.75 %	(Oluwadare *et al.*, 2008)
Sun - dried	0.86 g/ml	1.458	8.98 mg NaOH/ g	115.94 mgKOH/g	58.42 g/100g	18.75 %	
	0.93	1.45	3.5 mg KOH/ g	192.0 mgKOH/g	110.0 mg/g	8.3	(Oluba *et al.*, 2008)

Table 3. *Comparison of Some Major Nutrient Content of Seed of Watermelon Seed According to Few Researches (Per 100 Gm)*

S. NO	Nutrients	Watermelon seed ***Citrullus lanatus*** (C. Gopalan *et al.,* 171)	Watermelon seed Sugar baby (Tarek A.El- Adawy, 2001)
1	Protein	34.1 gm	35.66 g
2	Fat	52.6 gm	50.10 g
3	Arginine	900 mg/g of N	1161.25 mg/g of N
4	Calcium	100 mg	150 mg
5	Phosphorous	937 mg	1279 mg
6	Zinc	-	10.6 mg

5.3. Protein

Watermelon seeds are very high in protein One cup of dried seeds contains 30.6g which is 61% of the daily recommended value. The protein of watermelon seed consists of several amino acid, one of which is arginine. Some of the health benefits of arginine include regulating blood pressure and treating coronary heart diseases. Other amino acids make up the protein in watermelon seeds, containing tryptophan, glutamic acid and lysine (Traci, 2013).

5.4. B Vitamins

Watermelon seeds are also rich in B vitamins. The American Cancer Society reports that B vitamins are necessary for converting food into energy and other important bodily functions. The most prevalent B vitamins in watermelon seeds in niacin, with one cup of dried watermelon seed containing 3.8mg, which is 19%of the daily value. Niacin is important for maintaining the nervous system, digestive system and skin health. Other B vitamin in watermelon seeds include folate, thiamine, riboflavin, vitamin B6 and pantothenic acid (Traci, 2013).

5.5. Minerals

Minerals are aboundant in watermelon seed. Magnesium is the most abundant mineral, weighing in with 556mg, or 139% of the recommended daily value, cup of dried seeds. According to the National Institute of Health, magnesium helps to regulate blood pressure and the metabolism of carbohydrates, which has a beneficial effect in blood sugar as well. Other important minerals in watermelon seed are phosphorous, iron, potassium, sodium, copper, manganese and zinc (Traci, 2013).

5.6. Fats

The most surprising thing in watermelon seed is the amount fat. One cup of dried seed, contains 51g of fat among which 10g is saturated fat. Other fats are monosaturated, poly saturated and omega 6 fatty acids. American Heart Association reported that mono saturated and poly saturated fats and the omega 6 fatty acids can help in reducing high blood pressure (Traci, 2013).

6. Anti-Nutritional, Phytochemical and Antioxidant Activity of Watermelon Seed

Presence of saponins, tannins, triterpenoids, glycosides as well as alkaloids whilst flavonoids, anthracene glycosides and cyanogenic glycosides are absent. In watermelon seeds, Tannins which is a major plant polyphenol isolated from edible or non-edible plants have shown strong biological activity in the form of anti-tumour, anti-mutagenic, anti-diabetic, anti-proliferative, anti-bacteria and anti-mycotic properties (Arapitsas, 2012). The treatment of sore throat, haemorrhage and wound healing has also been linked to tannins (Abdul-Mumeen, 2013). But if ingested in excessive quantities, tannins inhibit the absorption of minerals such as iron and calcium which may lead to aneamia or osteoporosis if prolonged (Varadharajan *et al.*, 2012). Glycosides which were present in the seeds of watermelon are known to have anti-diarrhoeal(Tiwari *et al.*, 2011). Alkaloids are known to be ranked the most efficient therapeutically important plant secondary metabolite and are widely used worldwide as a basic agent for analgestic, antisplasmodic and bacterial effects (Oseni and Okoye, 2013)..

Cyanogenic glycosides are considered to be toxic. Cyanogenic glycosides when enzymatically hydrolysed, release cyanohydric acids known as prussic acid. This acid is extremely toxic due to its ability of linking with metals such as Fe^{2+}, Mn^{2+} and Cu^{2+} which are functional groups of many enzymes thereby inhibiting processes like reduction of oxygen in the cytochrome respiratory chain, electron transport in the photosynthesis, and the activity of enzymes like catalase, oxidase (Francisco and Pinotti, 2000). Therefore, its absence is preferred. (Braide *et al.*, 2012) reported the presence of cyonogenic glycosides in the seeds of watermelon but at a very low percentage of 0.0023. They observed the presence of saponins, alkaloids, flavonoids, oxalate and tannins in the seeds were observed.

6.1 Antioxidant activity

DPPH free radical scavenging ability 56.93% was found in watermelon seed. This was similar to the percentage free radical scavenging ability of the seeds of the Charleston gray variety. (Acar *et al.*, 2012). Lower percentage radical scavenging ability of dehulled watermelon seeds with a range of 1.31-13.90% is reported.

Antioxidants are known to quench free radicals, thus are essential components of anti-ageing formulations. Antioxidants also offer protection against damage to tissues due to the detrimental effects of environmental and other agents and encourage collagen growth by combating harmful effects of free radicals (Rodriguez *et al.*, 2006). Consumption of the seeds may reduce the chances of getting cardiovascular diseases and cancers due to the appreciable amount of total phenols found in the seeds and its antioxidant activity.

7. Health Benefits of Watermelon Seed

Low calorie, watermelon seed contains approximately 158 calories. Several minerals are found in watermelon seeds like magnesium, iron, Folate etc.

7.1 Effect on Growth

(Reetapa Biswas *et al.,* 2015) watermelon seed full-fat (WMSF) and watermelon seed meal (WMSM) samples were analyzed for proximate composition and then incorporated in broiler chicks' diets at increasing levels up to 20%. WMSF caused increased weight gain ($P< 0.01$) weight gain and PER (Protein Efficiency Ratio) than the control group of rats fed with the stock diet.

7.2. Anti-Diabetic Effect

(Benariba *et al.*, 2009) study was conducted a study to find out the anti-hyperglycemic effect of Citrullus colocynthis seed aqueous extracts in streptozotocin induced diabetic rats. Results of the study revealed that Citrullus colocynthis seed aqueous extracts had glucose homeostasis and body weight maintenance ability by improving fasting glucose level, oral glucose tolerance test, body weight and food and fluid intake. The efficacy of methanolic extract of Citrullus lanatus seeds on blood glucose concentration and electrolyte parameters (Na+, K+, HCO3-, Cl-) of fifteen female Wistar rats had been shown by Magdalene(Omigie e Agoreyo, 2014) . The co- treated rats were made diabetic by i.p injection of streptozotocin (60 mg/kg) and after one-week oral administration methanolic extract of seeds was provided (200 mg/ kg body weight) as a protection for 21days. There was a significant decrease in plasma glucose concentration at week 2 and 4 but no such significant effect was observed in the electrolyte's concentration. The decrease in the plasma glucose concentration had been occurred either due to the stimulation of insulin release from the β-cells of the pancreas or increase in hepatic glycogen synthesis(Omigie e Agoreyo, 2014).

7.3 Anti-ulcerogenic effect

Among various therapeutic properties, *Citrullus lanatus* also has anti-ulcerogenic property. When the crude methanolic extract of *Citrullus lanatus* seeds (300 mg/kg body weight, for 7 days) was applied orally to the two different ulcer models i.e. pyloric ligation (PL, 4h ligation) and water immersion (WS, 25^0C for 3 h) in albino Wistar rats, it showed significant decrease in ulcer index in both pyloric ligated and water immersion stress induced rats. In case of pyloric ligation model, it also showed gastric volume, free acidity and total acidity lowering effect. The ulcer protective potentiality might be due to the presence of triterpenoids and the phenolic compounds in the methanolic extract of the *Citrullus lanatus* seeds which provided anti-secretory and proton pump inhibitory activity (Bhardwaj *et al.*, 2012).

7.4 Anti-Obesity and Anti-Arthritic Effect

A study conducted in Rajiv Gandhi University of Health Sciences, Bengaluru, Karnataka, by J. Manoj evaluated the anti-obesity and anti-arthritic activities of seed extracts of *C. vulgaris* (Cucurbitaceae) in rats. No mortality or behavioural abnormality recorded in mice at the highest dose level of 2000mg/kg with both alcoholic (ALSCV) and aqueous (AQSCV) extract of the seed, tested for LD50 studies. Three different doses like low (100mg/kg), medium (200mg/kg), high (400mg/kg) with both the extracts were selected for the study. Standard reference *Sibutramine* produced a significant anti-obesity activity in cafeteria (CD) and atherogenic (AD) diet induced obese rats. Both the seed extracts with medium and high doses exhibited a significant anti-obesity activity by reducing the body weight, food intake, organ and fat pads weight and serum glucose, cholesterol, triglyceride, LDL and VLDL cholesterol levels with an increased HDL levels in CD and AD induced obese rats. Indomethacin the standard reference exhibited a significant anti-arthritic activity in formaldehyde and freunds adjuvant (FA) induced arthritis. Both the seed extracts with medium and high doses exhibited a significant anti-arthritic activity by reducing arthritic index in formaldehyde and FA induced arthritis in rats and reducing serum biochemical parameters like BUN, Calcium, ALP, Protein, SGOT, SGPT levels with an increase in the Albumin levels in FA induced arthritis model of rats.

7.5. Cardio Protective Effect

Reetapa Biswas *et al.,* observed that serum triglyceride (TG) and VLDL-C of the treated group of male albino rats fed with a modified diet containing Citrullus vulgaris seeds were significantly decreased ($p < 0.05$ and $p < 0.05$ respectively) in comparison to the control group fed with the stock diet. Serum total cholesterol, LDL and AI (Atherogenic Index) were decreased whereas HDL was increased in the treated group (Reetapa Biswas *et al.,* 2015). Effect on reproductive system Adesanya A. Olamide et.al observed the effects of methanolic extract of Citrullus lanatus seed (MECLS) on experimentally induced benign prostate hyperplasia on adult male wistar rats.

Hormone treatment (testosterone and estradiol respectively on alternate days for three weeks) did not affect the body weight of the animals; however, it caused a significant decrease in the weight of the testes and rendered all the rats azoospermia. In addition, treatment with extracts caused a significant decrease in the enlarged prostate, seminal vesicle and testes sizes in a dose related manner ($P< 0.05$ and $p < 0.05$ respectively) in comparison to the control group fed with the stock diet. Serum total cholesterol, LDL and AI (Atherogenic Index) were decreased whereas HDL was increased in the treated group.

8. Functional food development using Watermelon seeds

It has already been established that the seeds of melon fruits are rich in oil and protein. The oil was produced from these seeds (Akoh e Nwosu, 1992) and in some Arabian countries, snacks were prepared by salting and roasting the watermelon seeds (T. A. El- Adawy and K.M. Taha, 2001). So, it can be said that watermelon seeds which are a byproduct can be used as a food product and biscuits can be prepared by using these seeds. High protein biscuits blends (HPBB) were prepared by using five biscuits formulas containing wheat flour, free fat watermelon seed kernels along with rice, corn and chick–pea. The nutritional value, physical and organoleptic properties along with thickness, weight index and dimensions of these types of biscuits were varied depending on the presence or absence of gluten, source of starch, and protein content. The biscuits prepared from 100% watermelon seed kernel flour had not only good nutritional and sensory properties but also those were gluten free and low in carbohydrate. So, it could be concluded that defatted watermelon seed kernel flour might be used to manufacture high protein biscuit. (40-50%) either with wheat flour or in mixture with other cereal like corn and rice and chickpea flours (Nasr S.I. Abu Foul, 2004). A study was carried out with the sensory acceptability, the nutrient content and cost of three products such as Biscuit, Mathr and Laddoo prepared by incorporation of amaranth seeds, watermelon seeds and their flour in different proportions. Nutritive value of the prepared products indicates that protein, fat, carbohydrate, calcium and iron content increased in the products.

9. Conclusion

Worldwide studies have been done to make use of herbal medicine. The watermelon seeds are rich source of protein, fat, fiber and minerals that are essential in the body system. Watermelon seeds may indeed represent an appropriate tool for the treatment of various ailments without any obvious undesirable side effect, especially in those countries in which more classical therapeutic approach is not easily available. According to most of the researches the values of the physicochemical characteristics of watermelon seed oil are within the recommended limits and therefore it could be a good source of cooking and frying oil. After going through its comprehensive toxicological investigation, nutritional and physiological benefit, as revealed from different animal studies, it may be recommended that watermelon seed oil must be commercially exploited to be used in different nutraceuticals and functional food commodities and also a potential antidote for fighting against various ailments. Still there is an ample scope of research to expose unknown bioactive ingredients responsible for the positive health benefits of these are phytoconstituents responsible for the positive health benefits of the seed and seed oil. After extensive literature survey it is known that citrulline, a key ingredient is present in watermelon seeds, so an integrated research should be performed to assess the amount of citrulline present in the seeds of different species of watermelon. These watermelon seeds may provide considerable medicinal, health and economic benefits if freshly consumed or utilized in food products.

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