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RESEARCH ARTICLE

A COMPREHENSIVE REVIEW ON WATERMELON SEED – THE SPITTED ONE

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ABSTRACT

The seeds of watermelon are generally considered as agro-waste and are spitted out inspite of having its high nutritional value as well as therapeutic benefits. Cucurbitaceae species are potential sources of nutrients such as protein, minerals and lipids as well as ingredients for native medicine. Watermelon seeds are a good source of low-molecular-weight polypeptides i.e. globulin, glutenin and albumin. Seeds are also rich in aspartic acid, glutamic acid and serine. Since watermelon seeds contain high- quality proteins, the seed meal can be used as a non- conventional protein source as well as functional ingredients during food formulations. It has already been found that watermelon seeds has positive impact on growth, cardioprotective effect, anti-diabetic effect, anti-obesity , anti-arthritic effect and as well as anti-ulcerogenic effect and it has also been revealed that adequate doses of watermelon seed extracts can increase sperm count. Watermelon seeds may indeed represent an appropriate tool for the treatment of various ailments without any obvious undesirable side effects especially in those countries in which more classical therapeutic approach is not easily available for all. Watermelon seed oil and watermelon seed incorporated food products are already available and used in many countries. Still there is an ample scope of research to expose unknown bioactive ingredients responsible for the positive health benefits of these seeds.

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INTRODUCTION

Recently more attention has been focused to recover valuable components from neglected food parts (food "losses", "wastes", "by-products" or "wasted by-products") and recycle them inside the food chain, in an economic and sustainable way. Fruits occupy a part of daily diet of the rich and rarely the 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 the edible portion but rind and seeds are discarded as major solid wastes (Bawa and 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.

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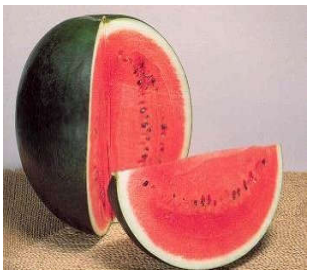
"Charmagaz" which is familiar in the sub continental region as a therapeutic agent, is derived from the seed kernels of cucurbit fruits and vegetables such as melon, watermelon, cucumber and gourd.

Plant description

Watermelon, a vine-like flowering plant, is a 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 varieties are: sugar baby, golden midget, star light, jubilee, yellow baby etc. They not only vary on their size (large or small) but also in their shape (oval, round or oblong) and colour of the flesh (red, orange and yellow). Sweet watermelon originates from West, not southern Africa, as previously believed, and the South African citron melon has been independently domesticated. The type specimen of the name Citrullus lanatus, prepared by a Linnaean collector in South Africa in 1773, is not the species now known as watermelon. Instead, it is a representative of another species that is sister to C. ecirrhosus**,** a tendril-less South African endemic. The closest relative of the watermelon is a West African species. Nuclear and plastid data furthermore reveal 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, Susanne S. Renner 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.

***C. vulgaris* plant**



***C. vulgaris* fruit**

According to Armen Takhtajan, the accepted name of this plant is given below-

Table 1. Taxonomical classification (Armen Takhtajan, 2009)

Citrullus lanatus (Thunb.) Matsum. & Nakai. syn. *Citrullus vulgaris* Schrad.

Family	: Cucurbitaceae
Order	: Cucurbitales
Superorder	: Violane
Subclass	: Dilleniidae

AIMS AND OBJECTIVES

- To study the scientific literature of different species of watermelon.
- To compile the physicochemical properties, nutritional components and bioactive phytochemicals present in watermelon seeds of different species.
- To map out the information regarding the therapeutic benefits and the physiological effects of watermelon seeds.

REVIEW OF LITERATURE

In-vitro analysis of watermelon seeds

Nutritional analysis

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, so these are good source of energy (628k.cal) (C. Gopalan *et al*., 1971). C. 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*. (Tarek. A, El-Adawy *et al.,* 2001). Elezuo et.al in the year 2011 evaluated the nutrient composition of some unconventional feedstuffs. Whole seed of *C. vulgaris* was one among them (Elezuo *et al*., 2011).

Whole seeds of *C. vulgaris*

Seed kerenels of *C. vulgaris*

Table 2. Comparison of some major nutrient content of seed kernels of *C. vulgaris* according to few researches (per 100gm)

S. No.	Nutrients	Seed kernel (C.Gopalan *et al*., 1971)	Seed kernel (Tarek A.El-Adawy, 2001)
1	Protein	34.1gm	35.66g
2	Fat	52.6gm	50.10g
3	Arginine	900mg/g of N	1161.25 mg/g of N
4	Calcium	100mg	150mg
5	Phosphorus	937mg	1279mg
6	Zinc	-	10.6mg

After studying the comparative analysis of some major nutrient content of *C. vulgaris* seed kernel, difference of the nutrient content have been observed within the two studies which might be due to the ecological and environmental variation of the two countries. Amount of crude protein, oil, fiber, total ash and minerals present in *Citrullus lanatus* (Thunb.) Mansf seeds at 6.0% dry basis were determined by Mustafa Paksoy et. al for the watermelon seeds of South Eastern Turkey. (Mustafa Paksoy *et al*., 2010**)** Ali AbasWani *et al.* showed that watermelon (*Citrullus lanatus*) seeds were a good source of low-molecular-weight polypeptides i.e. globulin, *glutenin and albumin*. Seeds were also rich in aspartic acid, glutamic acid and serine. Since watermelon seeds contain high- quality proteins, the seed meal can be used as a non- conventional protein source as well as functional ingredients during food formulations (Ali AbasWani *et al.*, 2010).

Chemical components

Watermelon seeds were free from alkaloids and glucoside. Other than the fatty oil the press cake of watermelon (*Cucurbita citrullus*) seeds contain soluble protein products, sugar and *resinous material*. From the resin there were isolated a very small amount of a phytosterol, and a new alcohol, designated *cucurbitol* ($C_{24}H_{40}O_4$). The shells of the seeds were 48.7 per cent 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 constituents 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 Dr. H. H. Dale (Frederick B. Power and Arthur H. Saltvas, 1910).

Physical properties

Some physical properties of watermelon (*Citrullus vulgaris*) seed of three major local Iranian varieties, Sarakhsi, Kolaleh and Red along with linear dimensions, volume, sphericity, surface areas, true and bulk densities, porosity, repose angle, static coefficient of friction were explored by Razavi and Milani as a function of moisture content, variety as well as environmental and growth conditions.

Anti-nutritional factors

Table 3. Identification of anti-nutritional factors from watermelon seeds

Species	Properties
Citrullus vulgaris	the amino acid sequences of two *trypsin inhibitors* which were isolated from the seeds and investigated as a source of proteinase inhibitors. Both inhibitors contained Arg5-Ile6 bond at their reactive site.(Jack Oilewske *et al*., 1987)
Citrullus vulgaris	Among all other anti-nutritional factors, *phytic acid and trypsin inhibitor* were found in considerable amount in the seed kernel flour. (El-Adawy *et al*., 2001)

These characteristics were important for the designing of equipments and machines for the transporting, sorting, handling, processing, drying, and storing watermelon seeds. It was concluded that the physical properties of watermelon seeds varied from variety to variety and it was also a function of the seed moisture content, environmental and growth conditions (Seyed M. A. Razavi and Elnaz Milani, 2006). The physical properties of three common Iranian varieties of *Cucumis melo* seeds had been evaluated as a function of seed moisture content of Ghermez(Red), Kolaleh and Sarakhsi, respectively by A. Koocheki *et al*.

Ghermez **Kolaleh**

Sarakshi

Results obtained were nearly same as obtained by Razavi and Milani by analyzing *C. vulgaris species* (A. Koocheki *et al*., 2007). Some physical properties that were important for the design of equipments for sowing, harvesting, processing, transportation, sorting, separation and packaging of *Citrullus lanatus* seeds grown in South Eastern Turkey were determined as functions of moisture content in the moisture range from 6 to 28% dry basis (d.b.) and the physical properties of the watermelon seeds were varied (Mustafa Paksoy *et al.,* 2010).

Antioxidants present

Table 4. Estimation of polyphenols and flavonoid content from watermelon seeds

Species	Properties
Citrullus vulgaris	Methanolic extract of the seeds showed high antioxidant activity and had high contents of polyphenols and flavonoids (Omar M. Atrooz, 2009).
Citrullus lanatus	The n-hexane extract of *Citrullus lanatus* seeds showed the highest antioxidant activity and total phenolic content whereas the ethanol extract had highest total flavanoid content (Habibur Rahaman *et al*, 2013).

In-vivo activity of watermelon seeds

Effect on growth

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 ($P<0.05$), feed intake, protein consumption, protein efficiency ratio and improved feed conversion ratio. A positive linear effect was observed for weight gain, protein consumption and protein efficiency ratio in birds fed WMSF. Feed intake was linearly increased with increasing the level of WMSM. However, no similar response was noted for weight gain, protein consumption, protein efficiency ratio and feed conversion ratio in chicks given increasing levels of WMSM. The study indicated that WMSF and WMSM might be used as feed ingredients in broiler chick diets at up to 20% (Shazali *et al.,* 2013). Reetapa Biswas *et al* observed that the treated group of male albino rats fed with a modified diet containing *Citrullus vulgaris* seeds had significantly higher ($p < 0.01$) weight gain and PER (Protein Efficiency Ratio) than the control group of rats fed with the stock diet (Reetapa Biswas *et al.,* 2015).

Anti-diabetic effect

A study was conducted by Nabila Benariba et.al 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. (Nabila Benariba *et al*., 2009). 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 *et al.* 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 electrolytes 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 IO *et al.* 2014).

Cardioprotective 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 ($P<0.05$) (Adesanya A. Olamide *et al.,* 2011). Administration of hydro alcoholic watermelon seed (*Citrullus Vulgaris)* extract to the experimental male Wistar rats at the dose of 55mg/kg body weight/day for 28 days has not only improved the sperm population but also increased the sperm motility and viability significantly. So it was concluded that the seed extract could be used in phytotherapy as a regimen of male infertility. (Arash Khaki *et al.,* 2013). Administration of *Citrullus vulgaris* seeds extract to the streptozotocin (55mg/kg) induced diabetic male Wistar rats for 28 days had improved the sperm parameters significantly as well as sperm population. So it could be assumed that use of this extract would be beneficial for infertile diabetic patients (Arash Khaki *et al.,* 2013). The hydro alcoholic extract of *Citrullus lanatus* seeds had a beneficial effect on improving sperm quality and serum testosterone level which was reflected by enhanced fertility rate in male. (Arash Khaki *et al.,* 2014).

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.

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 (Alok Bhardwaj *et al.,* 2012).

Food formulation

It has already been established that the seeds of melon fruits are rich in oil and protein. In Nigeria, oil was produced from these seeds (Akoh C.C and C.V. 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 (*Citrullus vulgaris*) 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 objectives to find out the sensory acceptability, the nutrient content and cost of three products such as “Biscuits”, “Mathri” and “Laddoo” prepared by incorporation of amaranth seeds, watermelon seeds and their flour in different proportions. On the basis of sensory evaluation using 9point hedonic scale, results were obtained and it revealed that amaranth seeds, watermelon seeds and their flour can be successfully incorporated in “Biscuits”, “Mathri” and “Laddoo”. Nutritive value of the prepared products indicate that protein, fat, carbohydrate, calcium and iron content increased in enriched “Biscuits”, , “Mathri” and “Laddoo”. Cost of the three products increased significantly as the ratio of amaranth seeds, watermelon seeds and their flour increased (Virginia Paul *et al.,* 2014).

CONCLUSIONS AND RECOMMENDATIONS

Worldwide studies have been done to make use of herbal medicine. Based on that, a sizeable quantum of information is available as regards to the beneficial effects of watermelon seeds. 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. Still there is an ample scope of research to expose hitherto unknown bioactive ingredients responsible for the positive health benefits of these seeds. 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.

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