Journal of Medicinal and Chemical Sciences

Journal homepage: http://www.jmchemsci.com/

Review Article

Citrullus lanatus, a Potential Source of Medicinal Products: A Review

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ARTICLE INFO

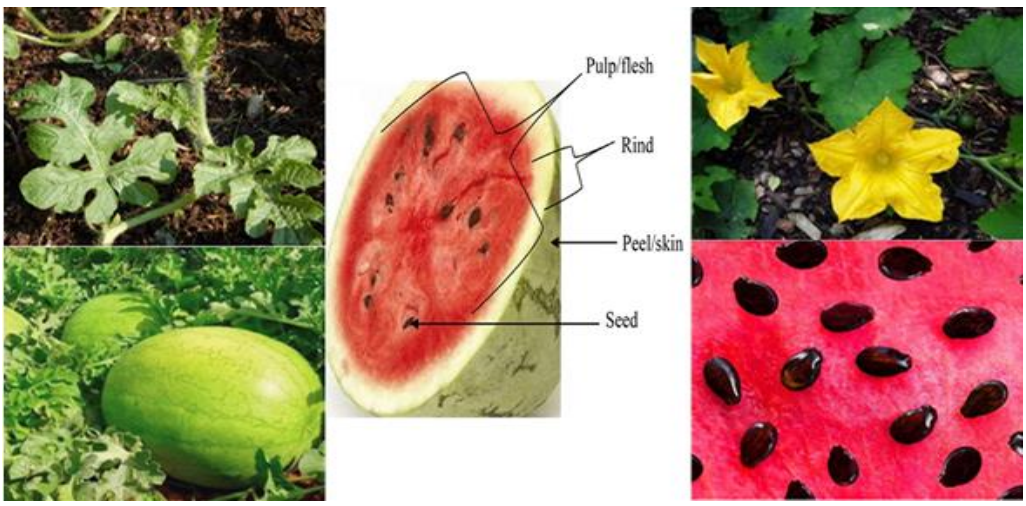
Article history
Received: 2022-02-06
Received in revised: 2022-02-11
Accepted: 2022-02-13
Manuscript ID: JMCS-2202-1415
Checked for Plagiarism: **Yes**
Language Editor:
Ermia Aghaie
Editor who approved publication:
Dr. Zeinab Arzehgar
DOI:10.26655/JMCHEMSCI.2022.4.16

KEYWORDS
Citrullus lanatus
Phytochemicals
Anti-Hypertensive
Anti-Diabetic
Antibacterial
Neuroprotective
Anti-Ulcer

ABSTRACT

Citrullus lanatus is a fruit that is eaten and carries many by-products like rind and seeds that are abandoned and fed to animals. Numerous studies have demonstrated the bio-medical properties of *Citrullus lanatus* by-products, making it a superior choice of natural source for medicinal products. *Citrullus lanatus* by-products' medical properties are due to their pharmacological significance, related to the availability of essential phytochemicals such as saponin, alkaloids, fatty acids, phenolic, citrulline, lycopene, coumarin, minerals, and other natural products. Gastrointestinal ulceration, diabetes, hypertension, cardiovascular disorders, and many kinds of malignancies have been treated with these by-products extract. The following review aimed to provide a thorough summary of the advantages of *Citrullus lanatus* by-products in the management of different ailments.

GRAPHICAL ABSTRACT



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Introduction

Natural products are well essential. They are a great source of potential medicines, and there has been a growing understanding that natural products are the very significance of medicinal herbs in the past years. Plant-based medicines are widely available, cheaper, safer, and more effective, with few adverse effects. The most obvious way to assess the current search for new, therapeutically effective drugs, such as anticancer therapies, is to look at plants that have been selected for medicinal use for thousands of years [1]. Flavonoids, terpenoids, tannins, carbohydrates, and alkaloids are chemical compounds found in natural products that have a pronounced physiological effect on the human body [2].

Citrullus lanatus (watermelon) is a harvested fruit that grows as a creeping herb that belongs to the family of plants known as Cucurbitaceae [3]. The "water" part of the name comes from the fact that the fruit yields roughly 90 percent water, and the "melon" part comes from the fact that the fruit is large, round, and sweet. *Citrullus lanatus*'s scientific name was derived from Latin and Greek roots. *Citrullus* is derived from the Greek word "citrus" which refers to the citrus fruit. The word *lanatus* comes from Latin and means "wooly" alluding to the plant's tiny hairs on the leaves and stems [4].

Citrullus lanatus peels and seeds are rich in nutrients because they contain many carbohydrates, fats, and proteins. Also, include a variety of beneficial cations such as calcium, potassium, and magnesium, and phytochemicals such as flavonoids, polyphenols, saponins, and alkaloids [5]. These by-products have antibacterial and antiviral properties, making them useful in preventing and treating various illnesses. In addition, these by-products isolate compounds offer anti-hypertension, anti-diabetes, anti-cardiovascular diseases, and anticancer properties [6, 7].

Plant Description

As shown in Figure 1, with its coarse, fluffy leaves and yellow flowers, *Citrullus lanatus* is a substantial sprawling annual plant. It's grown for the fruit, which is edible. The rind of the *Citrullus lanatus* fruit is thick, smooth, and deep green, with gray or light green vertical stripes. The inside of the fruit is red, with different amounts of black seeds implanted in the central third [8].

Citrullus lanatus is a seasonal vegetable that is primarily grown in warm climates. Long steam (up to 10 m/32.8 feet), curled tendrils, and huge hairy leaves are seen on the ground. The leaves have 3-5 lobes and are tough on both sides. Male and female flowers are seen on the same plant, and the flower stalks are hairy and lengthy. The fruit is 1.5-20 cm in diameter, malty, greenish, sub-globosely, dark green, and has a 50 mm long fruit stem in its wild form. The pulp is yellow or green in color and dark crimson. The seeds are oval, flattened, and range from yellow to dull brown or black (rarely white) 9-12×5-7 mm [9].

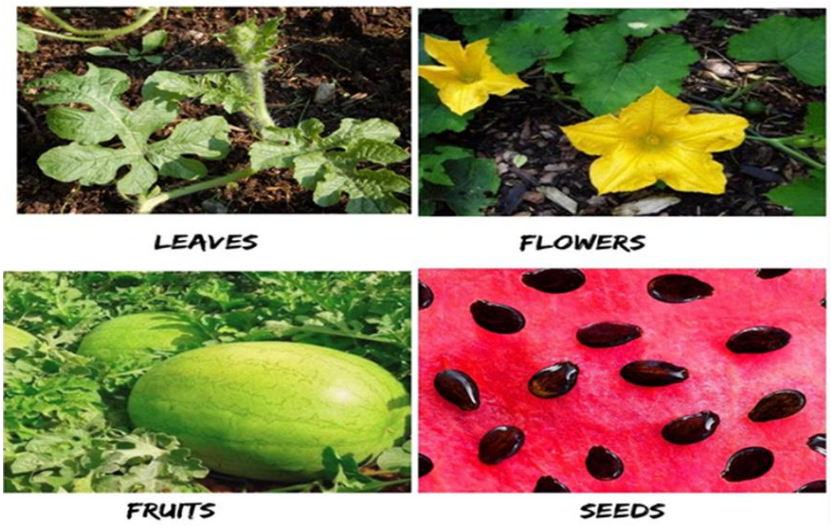

Figure 1: *Citrullus lanatus* plant description

Agriculture

Citrullus lanatus plants are grown in loose, loamy soil rich in organic matter with a pH between 6.5 and 7.5 [10]. Melon is specially grown in hot, arid subtropical climates and is a warm-season fruit. Vine growth is best at temperatures between 24-27°C. The accumulation of sugars in the fruit had favored by cool nights and warm days. Temperatures over 20°C are ideal for seed germination. When there is a lot of humidity during vegetative growth, the crop is more susceptible to fungal infections [10].

Photochemistry of Medical Plants

Photochemistry studies phytochemicals, which are plant compounds, mainly secondary metabolites that have evolved as a defensive mechanism against ultraviolet radiation, herbivores, diseases, pests, insects, and other environmental threats [11].

Citrullus lanatus Rind (WMR)

Thick white layer that located between the exterior green shell and the interior red core. It makes up about 1/3 of the total fruit mass and is usually thrown. Although it is fit for human consumption; nonetheless, WMR is usually avoided due to its disagreeable flavor, but it is considered a rich source of significant phytochemicals. Table 1 summarizes the nutritional content of WMR [12].

Table 1: Nutritional composition of the WMR

Components	Value in WMR
Humidity	9–17%
Raw protein	6–21%
Lipid	0.66–15%
Raw fiber	12–23%
Dust	12–20%
Carbo-hydrates	42–65%

Furthermore, WMR is made of pectin, lignin, celluloses, and hemicellulose with entrapped sugars, carotenoids, polyphenolics, lycopene, citrulline, and proteins [13]. Figure 2 summarizes the phytochemicals found in WMR [14].

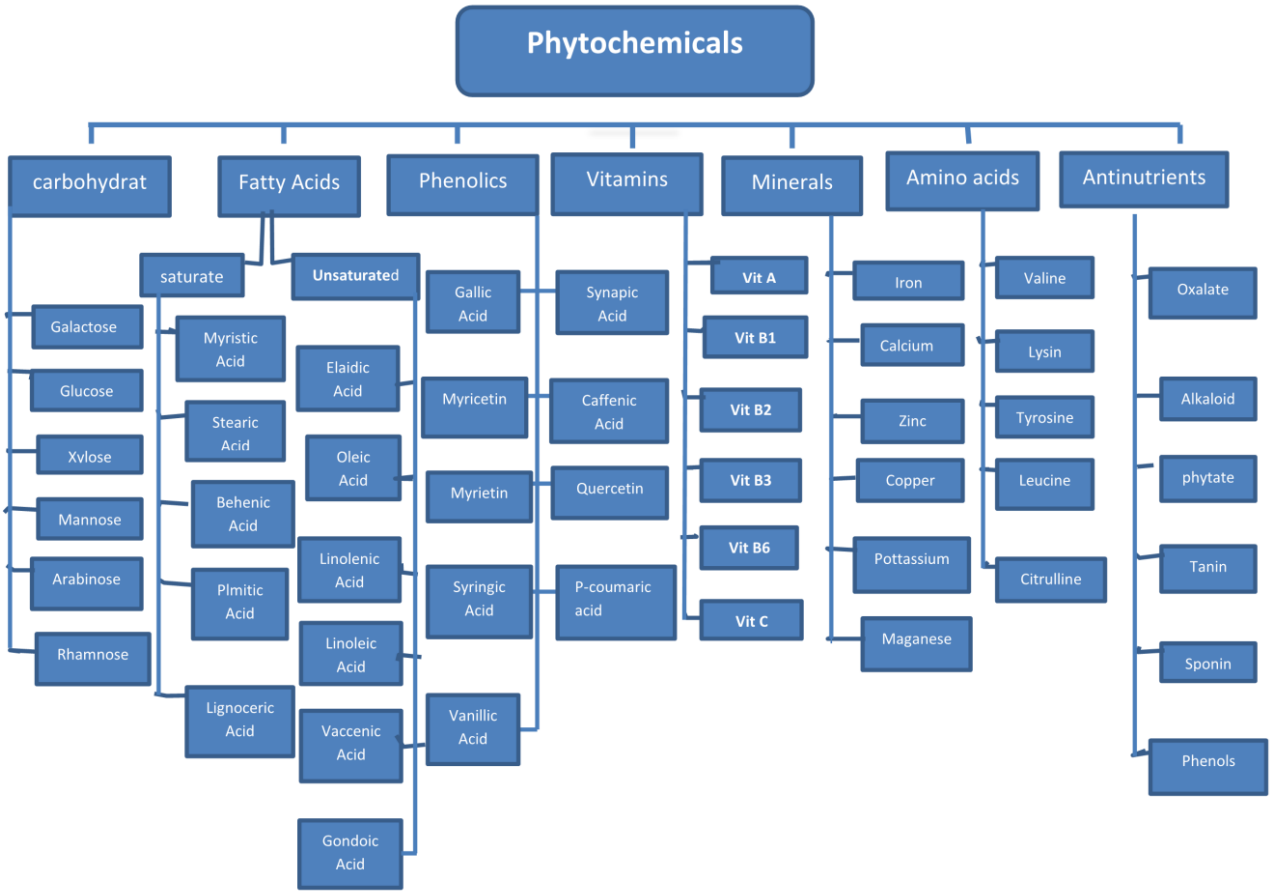

Figure 2: Biochemicals found in WMR

Citrullus lanatus Seeds (WMSs)

Bioactive phytochemicals like oxalate, phytates, steroids, phenols, cardiac and cyanogenic

glycosides, flavonoids, phytosterols, tannins, saponin, alkaloids, and terpenoids were found in WMSs, according to qualitative and quantitative examination [15]. Figure 3 summarizes the phytochemicals found in WMSs [14]. In addition, WMSs are also rich in vitamins involving vitamins C, B, and A [16].

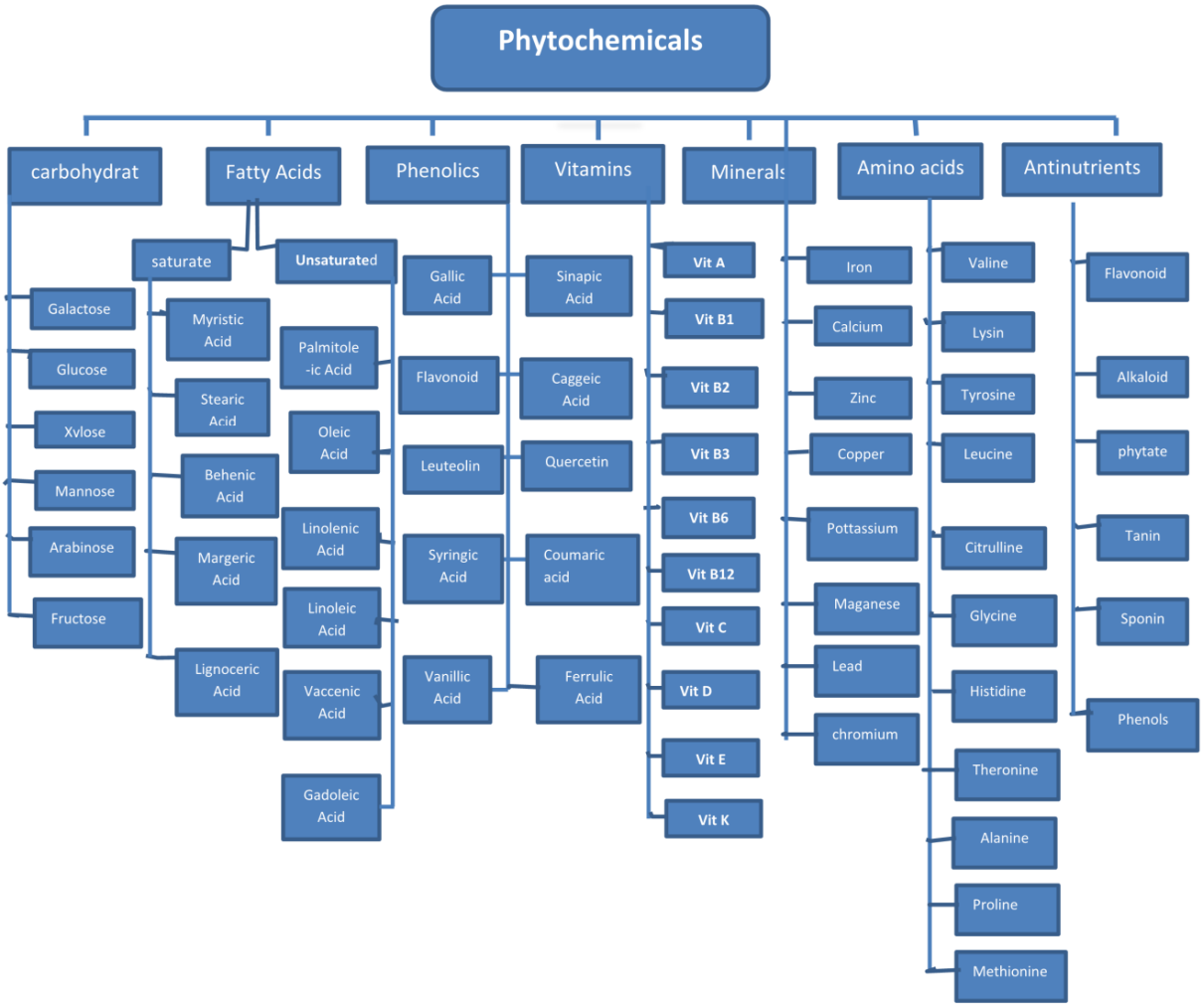

Figure 3: Biochemicals found in WMSs

Furthermore, Table 2 shows the nutritional value per 100 grams of dry WMSs [17]. All of these phytochemicals are essential for energy generation [17]. Besides, they can be helpful to improve the nutritional value of various food products, helping to meet nutrition requirements and combat various degenerative diseases [18].

Table 2: Nutritional value per 100 g of dried WMSs

Components	Nutritive Value
Protein	28.3 g
Lipid	47.4 g
Water	5.1 g
Energy	2340 kJ (557kcal)
Carbohydrate	15.3 g
Calcium	54 mg
Phosphorous	755 mg
Iron	7.3 mg
Vitamin B1	0.19 mg
Vitamin B2	0.15 mg
Vitamin B3	3.55 mg
Folate	58 µg

Biomedical Features of Citrullus lanatus

Anti-Hypertensive Property

High blood pressure is a major cause of cerebrovascular accidents, heart attacks, and cardiac arrest, all associated with reduced life expectancy. Pre-hypertension is a condition in which a systolic blood pressure (SBP) greater than 120 mmHg and diastolic blood pressure (DBP) greater than 80 mmHg. While hypertension is a condition in which a systolic blood pressure greater than 140 mmHg and diastolic blood pressure greater than 90 mmHg. Anxiety, sedentary lifestyle, weight gain, potassium insufficiency, kidney failure, increased renin level, and other factors increase the risk of developing high blood pressure [19]. Isolated *Citrullus lanatus* compounds can lower blood pressure by releasing two primary amino acids (L-citrulline and arginine) found in the fruit's flesh, seeds, and peels. These two amino acids are converted to nitric oxide in the body and stimulate the dilation of blood vessels, an essential process for regulating blood pressure [20]. Also, isolated polysaccharides from WMR have been shown to have a striking inhibitory effect on ACE (angiotensin-converting enzyme) (93.93 ± 0.68% at 1 mg/L). They can be offered as an alternative, natural and affordable inhibitor for treating and preventing high blood pressure [21].

Phytochemicals such as flavonoids, polyphenols, saponins, and alkaloids can lower blood pressure through various mechanisms, including vasodilation and antioxidant potential via nitric oxide production, suppression of ACE, calcium channel stoppage, and depression of sympathetic transmission of impulses [22, 23]. As a result of their phytochemical composition, *Citrullus lanatus* seeds were believed to be useful verse hypertension.

Anti-Diabetic Property

Diabetes is a metabolic disorder that affects the metabolism of carbohydrates, fats, and proteins [24,25]. In white female mice with explorative type 2 diabetes, the beneficial action of consuming fresh *Citrullus lanatus* juice on correcting blood glucose level and structural improvement in pancreatic cells was observed [26]. Besides increasing absorption of blood glucose into different body tissues and organs and potentiating pancreatic secretions of insulin from B-cells [27]. Consumption of *Citrullus lanatus* drinks increased plasma L-arginine concentrations, which acts as a substrate and convert to nitro-oxide dependent tetrahydrobiopterin synthetase. Consequently, nitro-oxide production and concentration increase have an essential role in stimulating the secretion of certain hormones such as insulin [28].

Antibacterial Property

Mixing WMR isolates with polyvinyl alcohol (PVA) results in approximately 1.2 times greater antibacterial activity than pure WMR isolates. WMR/PVA had an effective surface area in suppressing *S. aureus* and *E. coli* at 94 ± 0.8 percent and 83.5±0.09 %, respectively [29].

While flavonoids, phenols, lactones, steroids, tannins, triterpenes, diterpenes glycosides, alkaloids, and saponins discovered in WMSs samples have significant antimicrobial activity against several co-resistant organisms like *Klebsiella pneumonia*, *Pseudomonas*, *E. coli*, and *Neisseria sicca* [29-31]. In addition, the WMSs ethanolic isolate has strong antibacterial properties also can be utilized as a convenient naturalist source of antimicrobial compounds [32]. Furthermore, *B. subtilis*, *B. cereus*, *S. typhi*, *E. coli*, *P. fluorescence*, *P. aeruginosa*, and *S. aureus* can be treated with watery and methanolic isolates of WMSs powders [33, 34].

The antibacterial properties of raw ethanol, hexane, and chloroform isolates of *Citrullus lanatus* seeds, stems, fruits, and leaves were tested versus microorganisms, including bacteria and fungi [35]. Diffusion technologies such as cup-plate diffusion as well as disc diffusion were utilized. After analyzing the results, discovered that the chloroform isolate of the fruits had the highest antibacterial effect (against *P. aerguinosa*: 19 mm, P*. Vulgaris*: 23 mm, *E. coli*: 37 mm, *B. subtilis*: 38 mm, and *S. aureus*: 36 mm). The findings were compared to two common antimicrobials drugs: gentamicin and clotrimazole. According to the findings, *Citrullus*

lanatus exhibits antibacterial action that is equally effective as typical antimicrobial medicines against certain microbes [35].

Anti-Ulcer Property

Hydro-ethanolic isolates of WMR equivalent to 500 mg/kg had a significant positive therapeutic effect ($p<0.05$) on NSAID-induced gastrointestinal ulceration in the intestines of albino Wistar rats. The levels of malondialdehyde, reactive-oxygen species, and lipid peroxidation are also reduced [36].

Neuroprotective Property

The neuroprotective ability of WMSs extract products in maintaining cortical cells in male rats' brains was demonstrated by attenuating $HgCl_2$ intoxication at a dose of 0.2 g/kg [37]. Also, ethanolic WMSs isolates effectively improve learning ability in Wistar rats by increasing the immune-reactivity of antibody signaling to pathway proteins ($p < 0.05$) [38].

Anti-Prostatic Hyperplasia Property

The effect of Citrullus lanatus seeds methanolic isolated products (WSMIP) was explored in twenty male Wistar rats weighing approximately 135–180 g. These rats were randomly assigned to four families of five rats, each of them on induced benign prostatic hyperplasia, as shown in Table 3 [39].

Table 3: The procedure for evaluating the activity of isolated Citrullus lanatus seeds in the management of benign prostatic hyperplasia

Group	Acted as	Material Taken	Dose and Duration
R0	Control	Corn oil as placebo	1 gram per kilogram
R1	Hormone treated control	Testosterone(**T**) and estradiol (**E2**)	For three weeks, rats have taken a continuous dose of 300 µ (**T**) and 80 µ (**E2**) subcutaneously in the umbilicus on separate days. (induction of prostate enlargement)
R2	Extract-treated	(**T**) and (**E2**)	After successful induction of prostate enlargement, the mice were given 2g/kg of **WSMIP** orally for 28 days.
R3	Extract-treated	(**T**) and (**E2**)	After successful induction of prostate enlargement, the mice were given 4g/kg of **WSMIP** orally for 28 days.

Several mice were soon randomly selected and slaughtered for comprehensive screening for prostatic hyperplasia and assessment of sperm count [39]. These steps were repeated for 28 days of treatment with the extract WSMIP. According to the findings, parts of the prostate were removed and treated with paraffin embedding and hematoxylin-eosin staining. The rats' body mass was unaffected by hormonal therapy but, it did produce a considerable decline in the weight of the testicles, rendering all the animals' azoospermia. Furthermore, extract administration reduced the size of the enlarged prostate, seminal vesicles, and testicles in a dose-dependent way ($P<0.05$) when contrasted to the hormone-treated control group [39].

Gastric Antacid Property

In experimental studies in rats with NSAID-induced ulcers, the effects of juice made from Citrullus lanatus on gastric acid release and pH were studied. The study involves pre-treating four groups of mice for one month with distilled water (control group), 25%, 50%, and 100% Citrullus lanatus juice in contrast. The incidence of gastric ulcers was significantly decreased in rats pre-treated with the juice ($P < 0.05$), in addition, the ulcerative efficacy in the treatment groups was significantly lower compared to the control group ($P < 0.05$). This juice has been appearing to have a considerable gastro-protective impact in NSADs-induced gastric ulceration, according to the findings [40].

Laxative Property

The potential laxative impact of watery Citrullus lanatus fruits pulp isolate was investigated in experimental rats. The experimental rats were classified into five groups, each with six animals, as shown in Table 4 [41]. The weight of the stool particles was utilized to determine the efficiency of the laxative. Watery fruit pulp isolates given orally at three various doses had a considerable laxative effect and decreased loperamide-induced constipation in a dose-dependent fashion.

Table 4: Indicated laxative activity is the procedure for assessing the activity of Citrullus lanatus pulp isolate in management

Groups	Acted as	Material Taken	Dose
R0	Control	Distal water	----------
R1	Standard	Sodium Pico sulfate (reference medication)	5 mg/kg orally
R2	Treated	Watery pulp isolate	250 mg/kg orally
R3	Treated	Watery pulp isolate	500 mg/kg orally
R4	Treated	Watery pulp isolate	1000 mg/kg orally

In comparison to castor oil (2 ml), the identical doses of the extract (500 and 1000 mg/kg, orally) resulted in a substantial improvement ($p<0.05$) in intestinal transit. The findings revealed that the watery fruit pulp of *Citrullus lanatus* isolate has a substantial laxative effect [41].

Antioxidant Property

Individual body cells and other organs go through a range of biochemical reactions regularly. As a natural by-product of ongoing metabolic activity, highly reactive free radicals have been formed in the body [42]. These free radicals have a proclivity for reacting with macro-biological components, such as lipids, proteins, and DNA molecules, disrupting their basic physiological functioning [43-45]. On the other hand, antioxidant-rich foods can help avoid oxidative stress produced by reactive oxygen species. Antioxidants are mainly found in vegetarian foods. Phyto-chemicals such as terpenoids, coumarin, alkaloids, flavonoids, and phenols, specifically, are essential antioxidant compounds with a variety of nutritional advantages [46,47]. These phytochemicals are classified as secondary metabolites as they are found in smaller quantities in vegetation than primary metabolites and are found in specialized plant parts [48-49]. Lycopene, for example, has a greater free radical scavenging rate than carotenoids like tocopherol and carotene.

According to prior research, lycopene has a tenfold greater power to quench singlet oxygen over tocopherol and a double-fold greater capacity over beta-carotene [50]. The presence of polyphenols in *Citrullus lanatus* is accountable for its natural antioxidant potential, and also fresh *Citrullus lanatus* juice contains 16.94-20.23 mg gallic acid equivalents/0.1 L polyphenols. As a result, eating *Citrullus lanatus* as a snack or nutritional drink may increase the human body's antioxidant potential and help enhance cell signaling adhesion and other biological processes. Furthermore, the antioxidant capacity of polyphenols is determined by their chemical structure, quantity, absorption, and bioavailability [51,52]. High-performance liquid chromatography combined with electrospray ionization–quadrupole time-of-flight mass spectrometry was used to analyze phytochemicals contained in a methanolic isolate of *Citrullus lanatus* [51].

Furthermore, the research assessed phytonutrients have recognized antioxidant properties like whole lycopene (3.74 to 6.80 mg/100 g), carotenoids (4.90 to 8.06 mg/100 g), flavonoids (55.60 to 100.93 mg/100 g distill water), tannin (35.07 to 60.83 mg/100 g distill water), and phenol content (16.77 to 21.41 mg/g distill water) [51-53]. In comparison to the yellow-fleshed melon (vitamin C: 52.05 mg/kg, lycopene: 0.04 mg/kg), the red-fleshed melon had greater levels of vitamin C (86.32 mg/kg) and lycopene (9.50 mg/kg), which corresponded with anti-oxidant capability [54,55].

Anticancer Property

Cancer is a terrible illness with a high mortality rate worldwide. The molecular process of tumor-genesis in a living process can be influenced by the relationship between the active components of food and the regulation of gene expression in

many metabolic processes [56, 57]. For example, lycopene, the isolated product of *Citrullus lanatus*, can help to prevent malignancy by inhibiting DNA mutations and preventing metastasis [58].

During female mammary and endometrial cancer, lycopene causes changes in the cell cycle mechanism, most notably by inhibiting the G1 phase. Lycopene treatment has reduced the activity of cyclin-dependent kinase (CDK) 1 and 3 in cancerous cells. Furthermore, lycopene's antioxidant activity minimizes oxidative stress and contributes to the anti-proliferative actions versus malignant cells [59]. Yet, the molecular mechanism for lycopene-mediated gene transcriptional interaction control is still under research.

Cervical and mammary cancers are the two most common malignancies in females, both of which have a high death rate. Products isolated from the *Citrullus lanatus* leaves have been studied for their anti-proliferative properties in these two types of cancer cell cultures [60,61]. In cervical tumor cell cultures (SiHa, HeLa and, C33A) and mammary cancer cell cultures (MCF-7 and MDA-MB-231,) leaves isolates from 6 genotypes of *Citrullus lanatus* were investigated [60,56]. Cervical cancer cell cultures, especially the C33A, showed a significant susceptibility to the extracts. Also, microscopic examinations revealed a drop in the number of cells and cellular diameter in the tumor cell lines MDA-MB-231, MCF-7, and C33A [60].

The second most deadly tumor in the human race is colon-rectal cancer. When the balance between cellular growth and death has been disrupted, this type of cancer can develop [62, 63]. *Citrullus lanatus* feeding reduced cell growth in animals with colorectal cancer [64]. This effect can be related to the presence of copious L-citrulline and its role in the generation of nitric oxide synthase, maybe one of the essential elements in the *Citrullus lanatus*'s antitumor properties. The inclusion of melon powders in the meals of male Sprague-Dawley mice with colon-rectal cancer lowered the likelihood of abnormal crypt foci development by lowering oxidative injury to DNA. Furthermore, increasing the generation of natural nitric oxide reduced carcinogenic effects, and melon feeding regulated the transcription of DNA repair enzymes to combat cancer [65,66].

In general, secondary-metabolites present in plants such as this that present in different parts of *Citrullus lanatus* efficiently inhibits the growth of cancer cells. Additional research could be benefitial for discovering and extracting phytochemicals with powerful anticancer potential [67,68].

Toxicological Studies

Academics have investigated the effects of consuming natural products on the human body by looking at indications in rats' livers and kidneys. Rats were given WMR isolates in doses of 1500, 3500, and 5000 mg/kg daily for four weeks. When compared with control, there was no substantial ($p<0.05$) elevation in the levels of liver enzymes like aspartate aminotransferase and alanine aminotransferase [69].

While ethanolic isolates of WMSs were taken orally at 250, 500, and 1000 mg/kg for approximately four weeks to evaluate immediate and recurrent toxicity compared to the control group. The findings revealed no substantial effect ($p<0.05$) on water intake, body weight, biochemical, cognitive, and histological indicators. The authors concluded that WMSs isolates showed no significant side effects at a dose of 1000 mg/kg. Furthermore, the ethanolic isolates of WMSs are suitable for use in therapeutic applications and preclinical investigations [70].

On male and female Wistar mice, the possible hazard of WMSs, particularly long-term use of WMSs-enriched food, was evaluated. All mice were fed diets featuring WMSs as 2.5% or 5% concentrations for three weeks. The WMSs-enriched food resulted in a considerable ($p<0.05$) reduction in body weight but did not affect the mass of the liver or brain. Furthermore, compared with control, there were no significant differences in all animals' functions and plasma levels of alkaline phosphatase, cholesterol, triglycerides, and alanine aminotransferase. Nevertheless, compared with control, there was a considerable ($p<0.05$) rise in plasma creatinine and urea levels in the test animals [71].

Medicinal plants are a natural and effective source of natural medicines [72-75]. Many medicinal plants, either raw or processed or in fruits and teas, can be used for therapeutic purposes and have therapeutic applications [74-79]. Studies demonstrated that edible herbs can be used for human health due to their active ingredients and medicinal and antioxidant compounds [78-83].

Conclusions

WMSs and WMR are *Citrullus lanatus* fruit secondary by-products that are a repository of beneficial chemicals that can be used to replace, enhance and generate new, value-added nutrients. Investigations of *Citrullus lanatus* fruit by-products' biomedical potentials have shown that they are useful in treating kidney problems, ulcers, cancer, and metabolic syndromes such as heart disease and diabetes. WMR is high in dietary fibers, phenolic compounds, minerals, carbohydrates, and fatty acids. It also includes phytates, saponin, alkaloids, and carotenoids. While WMSs are a high-protein source, including glutelin, prolamin, globulin, and albumin. Besides, it contains vitamin B-complex, phenolic substances, essential and non-essential amino acids, and polyunsaturated fatty acids. Utilizing these secondary metabolites can help improve the sustainability of numerous industries, including pharmaceuticals, food, and cosmetics, by reducing food scraps and their environmental effect. More investigation is needed to expand their usage in biopharmaceutical, immune-enhancer medical production, and agro-food to prevent these nutrient-dense leftovers from being categorized as landfills.

Acknowledgments

The authors are very grateful to the University of Mosul/College of Pharmacy for their provided facilities, which helped to improve the quality of this work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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References

[1]. Gouda S., Das G., Sen S.K., Shin H.S., Patra J.K., *Front. Microbiol.*, 2016, **7**:1 [Crossref], [Google Scholar], [Publisher]
[2]. Edeoga H.O., Owku D.E., Mbaebie B.O., *Afr. J. Biotechnol.*, 2005, **4**:68 [Crossref], [Google Scholar], [Publisher]
[3]. Vinhas A.S., Sousa C., Matos C., Moutinho C., Vinha A.F., *World Journal of Advance Healthcare Research*, 2021, **5**:302 [Crossref], [Google Scholar], [Publisher]
[4]. Jett L.W., Baker T.P., Corwin B., *MU Extension*, 2002 [Google Scholar], [Publisher]
[5]. Mehra M., Pasricha V., Gupta R.K., *J. Pharmacogn. Phytochem.*, 2015 **3**:98 [Google Scholar], [Publisher]
[6]. Yadav S., Kumar Tomar A., Jithesh O., Khan M.A., Yadav R.N., Srinivasan A., et al., *Proteins*, 2011, **30**:575 [Crossref], [Google Scholar], [Publisher]
[7]. Patel S., Rauf A., *Biomed. Pharmacother.*, 2017, **91**:330 [Crossref], [Google Scholar], [Publisher]
[8]. Leskovar D.I., Bang H., Crosby K.M., Maness N., Franco J.A., Perkins-Veazie P., *J. Hortic. Sci. Biotechnol.*, 2004, **79**:75 [Crossref], [Google Scholar], [Publisher]
[9]. Lim T.K., *Edible Medicinal and Non-Medicinal Plants: Fruits*, Volume 2, 2012 [Crossref], [Google Scholar], [Publisher]

[10]. Kumar R., Dia M., Wehner T.C., *HortScience*, 2013, **48**:960 [Crossref], [Google Scholar], [Publisher]
[11]. Pengelly A., Bone K., *The Constituents of Medicinal Plants*, 3rd Edition, 2020 [Crossref], [Google Scholar], [Publisher]
[12]. Romelle F.D., Rani A.P., Manohar R.S., *European Journal of Food Science and Technology*, 2016, **4**:12 [Google Scholar], [Publisher]
[13]. Dieng S.I.M., Diallo A.J., Fall A.D., Diatta-Badji K., Diatta W., Sarr A., Bassene E., *J. Pharmacogn. Phytochem.*, 2017, **6**:801 [Google Scholar], [Publisher]
[14]. Zia S., Khan M.R., Shabbir M.A., Aslam Maan A., Khan M.K.I., Nadeem M., Khalil A.A., Din A., Aadil R.M., *Food Rev. Int.*, 2020, 1 [Crossref], [Google Scholar], [Publisher]
[15]. Alemika T.E., Ojerinde O.S., Samali A., Mustapha B.K., Gamaniel K.S., *J. Pharm. Bioresources*, 2018, **14**:253 [Crossref], [Google Scholar], [Publisher]
[16]. Guillaume D., Pioch D., Charrouf Z., *Ramadan M., Fruit Oils: Chemistry and Functionality.* Springer, 1st Edition, 2019, 317 [Crossref], [Google Scholar], [Publisher]
[17]. Alka G., Anamika S., Ranu P., *J. Pharmacogn. Phytochem.*, 2018, **7**:2222 [Google Scholar], [Publisher]
[18]. Sangita C., Alka G., *Int. J. Home Sci.*, 2016, **2**:27 [Google Scholar], [Publisher]
[19]. Miranda A.M., Steluti J., Fisberg R.M., Marchioni D.M., *Br. J. Nutr.*, 2016, **115**, 1061. [Crossref], [Google Scholar], [Publisher]
[20]. Fan J., Park E., Zhang L., Edirisinghe I., Burton-Freeman B., Sandhu A.K., *J. Agric. Food Chem.*, 2020, **68**:7393 [Crossref], [Google Scholar], [Publisher]
[21]. Romdhane M.B., Haddar A., Ghazala I., Jeddou, K.B., Helbert C.B., Ellouz-Chaabouni S., *Food Chem.*, 2017, **216**:355 [Crossref], [Google Scholar], [Publisher]
[22]. Geleta B., Makonnen E., Debella A., Tadele A., *Front. Pharmacol.*, 2016, **7**:1 [Crossref], [Google Scholar], [Publisher]
[23]. Bunkar A.R., *Int. J. Adv. Sci. Res.*, 2017, **2**:23 [Google Scholar], [Publisher]
[24]. Chatterjee S., Khunti K., Davies M.J., *Lancet*, 2017, **389**:2239 [Crossref], [Google Scholar], [Publisher]
[25]. Aldewachi H., Mustafa Y.F., Najm R., Ammar F., *Sys. Rev. Pharm.*, 2020, **11**:289 [Google Scholar], [Publisher]
[26]. Sorour H.A., Selim M.M., EL-Sayed EL-Moselhy L., Ahmed S.G., *Egypt. J. Histol.*, 2019, **42**:10 [Crossref], [Google Scholar], [Publisher]
[27]. Rezq A.A., *Egypt. J. Nutr.*, 2017, **32**:1 [Google Scholar], [Publisher]
[28]. Manivannan A., Lee E.S., Han K., Lee H.E., Kim D.S., *Molecules* (Basel, Switzerland), 2020, **25**:5258 [Crossref], [Google Scholar], [Publisher]
[29]. Rashdan H.R.M., Gomha S.M.,El-Gendey M.S., El-Hashash M.A., Soliman A.M., *Green Chem. Lett. Rev.* 2018, **11**:264 [Crossref], [Google Scholar], [Publisher]
[30]. Kasim S.M., Al-Dabbagh B.M., Al-Shakarchi W., Mustafa Y.F., *Appl. Nanosci.*, 2021, 41002 [Crossref], [Google Scholar], [Publisher]
[31]. Sari Y., Isworo A., Upoyo A.S., Sumeru A., Kurniawan D.W., Sutrisna E., *IOP Conf. Ser. Earth Environ. Sci.*, 2021, **746:**012018 [Google Scholar], [Publisher]
[32]. Khalil R., Ali Q, Hafeez M.M., Malik A., *J. Biol. Clin. Sci. Res.*, 2020, **2020** [Crossref], [Google Scholar], [Publisher]
[33]. Babaiwa U.F., Eraga S.O., Akerele J.O., *Bio-Research*, 2020, **18**:1103 [Google Scholar], [Publisher]
[34]. Mustafa Y.F., Abdulaziz N.T., *Sys. Rev. Pharm.*, 2020, **11**:438 [Google Scholar], [Publisher]
[35]. Hassan L.E.A., Sirat H.M., Yagi S.M.A., Koko W.S., Abdelwahab S.I., *J. Med. Plant Res.*, 2011, **5**:1338 [Crossref], [Google Scholar], [Publisher]
[36]. Hassan L.E.A., Sirat H.M., Yagi S.M.A., Koko W.S., Abdelwahab S.I., *J. Med. Plants Res.*, 2011, **5**:1338 [Crossref], [Google Scholar], [Publisher]
[37]. Owoeye O., Akinbami R.O., Thomas M.A., *Afr. J. Biomed. Res.*, 2018, **21**:43 [Google Scholar], [Publisher]
[38]. Finbarrs E., Chinedu F., Ojo O.P., *Era'S J. Med. Res.*, 2018, **5**:1 [Crossref], [Google Scholar], [Publisher]

[39]. Olamide A.A., Olayemi O.O., Demetrius O.O., Olatoye O.J., Kehinde A.A., *Eur. J. Med. Plants*, 2011, **1**:171 [Crossref], [Google Scholar], [Publisher]
[40]. Oluwole F.S., Balogun M.E., Adedeji T.G., *Ann. Rev. Res. Biol.,* 2013, **3**:358 [Google Scholar], [Publisher]
[41]. Erhirhie E., Ekene N., *Int. J. Res. Pharm. Biomed. Sci.*, 2014, **4**:1305 [Google Scholar], [Publisher]
[42]. Mustafa Y.F., Abdulaziz N.T., *Sys. Rev. Pharm*., 2020, **11**:438 [Google Scholar], [Publisher]
[43]. Braunersreuther V., Jaquet V., *Curr. Pharm. Biotechnol.*, 2011, **13**:97 [Crossref], [Google Scholar], [Publisher]
[44]. Oglah M.K., Mustafa Y.F., *J. Glob. Pharma Technol.*, 2020, **12**:854 [Google Scholar], [Publisher]
[45]. Oglah M.K., Mustafa Y.F., Bashir M.K., Jasim M.H., *Sys. Rev. Pharm.*, 2020, **11**:472 [Google Scholar], [Publisher]
[46]. Forni C., Facchiano F., Bartoli M., Pieretti S., Facchiano A., D'Arcangelo D., Norelli S., Valle G., Nisini R., Beninati S., et al., *BioMed Res. Int.*, 2019, 16 [Crossref], [Google Scholar], [Publisher]
[47]. Mustafa Y.F., Mohammed E.T., Khalil R.R., *Egypt. J. Chem.*, 2021, **64**:4461 [Crossref], [Google Scholar], [Publisher]
[48]. Oglah M.K., Bashir M.K., Mustafa Y.F., Mohammed E.T., Khalil R.R., *Sys. Rev. Pharm.*, 2020, **11**:717 [Google Scholar], [Publisher]
[49]. Jain C., Khatana S., Vijayvergia R., *Int. J. Pharm. Sci. Res.*, 2019, **10**:494 [Crossref], [Google Scholar], [Publisher]
[50]. Ahmad W., *Curr. Chem. Lett.*, 2020, **9**:105 [Cressref], [Google Scholar], [Publisher]
[51]. Albegali A.A., Aftab T., Rehman A., Rashid A., Mohammad M., *Pakistan J. Zool.*, 2022, **54**:1 [Crossref], [Google Scholar], [Publisher]
[52]. Mustafa Y.F., Bashir M.K., Oglah M.K., Khalil R.R., Mohammed E.T., *NeuroQuantology,* 2021, **19**:129 [Crossref], [Google Scholar], [Publisher]
[53]. Mustafa Y.F., Mohammed E.T., Khalil R.R., *Sys. Rev. Pharm.*, 2020, **11**:570 [Google Scholar], [Publisher]
[54]. Choo W.S., Sin W.Y.A., *Adv. Appl. Sci. Res.*, 2012, **3**:2779 [Google Scholar], [Publisher]
[55]. Mustafa Y.F., *J. Med. Chem. Sci.*, 2021, **4**:612 [Crossref], [Google Scholar], [Publisher]
[56]. Mustafa Y.F., Khalil R.R., Mohammed E.T., Bashir M.K., Oglah M.K., *Arch. Razi Inst.*, 2021, **76**:1297 [Crossref], [Google Scholar], [Publisher]
[57]. Mustafa Y.F., Oglah M.K., Bashir M.K., *Sys. Rev. Pharm.*, 2020, **11**:482 [Google Scholar], [Publisher]
[58]. Bray F., Ferlay J., Soerjomataram I., Siegel R.L., Torre L.A., Jemal A., *CA: A Cancer J. Clin.*, 2018, **68**:394 [Crossref], [Google Scholar], [Publisher]
[59]. Butt A.J., Caldon C.E., McNeil C.M., Swarbrick A., Musgrove E.A., Sutherland R.L., *Adv. Exp. Med. Biol.*, 2008, **630**:189 [Crossref], [Google Scholar], [Publisher]
[60]. Sueakham T., Chantaramanee C., Lawsipo P., *NU. Int. J. Sci.*, 2018, **15**:89 [Google Scholar], [Publisher]
[61]. Mustafa Y.F., Abdulaziza N.T., Jasim M.H., *Egypt. J. Chem.*, 2021, **64**:1807 [Crossref], [Google Scholar], [Publisher]
[62]. Han Y., Chen P., Zhang Y., Lu W., Ding W., Luo Y., Wen S., Xu R., Liu P., Huang P., *Cancers*, 2019, **11** [Crossref], [Google Scholar], [Publisher]
[63]. Mustafa Y.F., Mohammed N.A., *Biochem. Cell. Arch.*, 2021, **21**:1991 [Google Scholar], [Publisher]
[64]. Fesseha M., Hong M.Y., *Current Developments in Nutrition*, 2019, **3**:442 [Crossref], [Google Scholar], [Publisher]
[65]. Glenn K., Klarich D.K.S., Kalaba M., Figureueroa A., Hooshmand S., Kern M., Hong M.Y., *Nutr. Cancer*, 2018, **70**:938 [Crossref], [Google Scholar], [Publisher]
[66]. Mustafa Y.F., Abdulaziz N.T., *NeuroQuantology*, 2021, **19**:175 [Crossref], [Google Scholar], [Publisher]
[67]. Mustafa Y.F., Khalil R.R., Mohammed E.T., *Egypt. J. Chem.*, 2021, **64**:3711 [Crossref], [Google Scholar], [Publisher]
[68]. Mustafa Y.F., Bashir M.K., Oglah M.K., *Sys. Rev. Pharm.*, 2020, **11**:598 [Google Scholar], [Publisher]
[69]. Arojojoye O., Ladokun O., Aminu A., Durosinlorun O., *Croatian Journal of Food Science and Technology*, 2018, **10**:173 [Crossref], [Google Scholar], [Publisher]

[70]. Belemkar S., Shendge P.N., *Biosci. Rep.*, 2021, **41** [Crossref], [Google Scholar], [Publisher]
[71]. Oyenihi O.R., Afolabi B.A., Oyenihi A.B., Ojo G.B., *Drug Chem. Toxicol.*, 2021, **25**:1 [Crossref], [Google Scholar], [Publisher]
[72]. Abbasi N., ghaneialvar H., Saneei S., zangeneh M.M, zangeneh A., *Plant Biotechnol. Persa*, 2021, **3** [Crossref], [Google Scholar], [Publisher]
[73]. Teo B.S.X., Gan R.Y., Abdul Aziz S., Sirirak T., Mohd Asmani M.F., Yusuf E., *J. Cosmet. Dermatol.*, 2021, **20**:993 [Crossref], [Google Scholar], [Publisher]
[74]. Palaksha M.N., Ahmed M., Das S., *J. Nat. Sci. Biol. Med.*, 2010, **1**:12 [Crossref], [Google Scholar], [Publisher]
[75]. Alwan S., Al-Saeed M., Abid H., *Baghdad J. Biochem. Appl. Biol. Sci.*, 2021, **2**:138 [Crossref], [Google Scholar], [Publisher]
[76]. Zharif N., Santosh F., Kiran C.N., Fadli A., Ibrahim A., Nizam G., *Int. J. Med. Toxicol. Leg. Med.*, 2018, **21**:167 [Crossref], [Google Scholar] [Publisher]
[77]. Bhale, S.P., Yadav, A.R., Pathare, P.G., Tekale, S.U., Franguelli, F.P., Kótai, L., et al., *Eur. Chem. Bull.*, 2021, **9**:430 [Crossref], [Google Scholar], [Publisher]
[78]. Zharif N., Santosh F., Kiran C.N., Fadli A., Ibrahim A., Nizam G., *Int. J. Med. Toxicol. Leg. Med.*, 2018, **21**:167 [Crossref], [Google Scholar], [Publisher]
[79]. Halim S., Sina T., Ridzuan P.M., Anna D., Abdullah S., Jasmi N.A., *Int. J. Med. Toxicol. Leg. Med.*, 2020, **23**:67 [Crossref], [Google Scholar], [Publisher]
[80]. Alwan S.H., Al-Saeed M.H., Abid H.A., *Baghdad J. Biochem. Appl. Biol. Sci.*, 2021, **2**:138 [Crossref], [Google Scholar], [Publisher]
[81]. Fattepur S., Nilugal K.C., Darshan T.T., Bacayo M.F., Asmani F., Abdullah I., et al., *Int. J. Med. Toxicol. Leg. Med.*, 2018, **21**:141 [Crossref], [Google Scholar], [Publisher]
[82]. Aluwi A.W.N.A., Sabiqi B., Rahmat A., Ali N.A.M., *Int. J. Med. Toxicol. Legal Med.*, 2020, **23**:73 [Crossref], [Google Scholar], [Publisher]
[83]. Mustafa Y.F., Bashir M.K., Oglah M.K., *J. Med. Chem. Sci.*, 2022, **5**:518 [Crossref], [Google Scholar], [Publisher]

HOW TO CITE THIS ARTICLE
Reem Nadher Ismael, Yasser Fakri Mustafa, Harith Khalid Al-Qazaz. *Citrullus lanatus,* a Potential Source of Medicinal Products: A Review, *J. Med. Chem. Sci.*, 2022, 5(4) 607-618
https://dx.doi.org/10.26655/JMCHEMSCI.2022.4.16
URL: http://www.jmchemsci.com/article_145016.html