



A Review: Different Properties of Withania Coagulans.

¹Prachi Govindrao Deshmukh, ²Swapnil Jaiswal, ³Deepak Bornare

¹ Student, ²Assistant Professor, Department of agricultural Engineering, ³Head, Department of Agricultural Engineering

¹Department of Agricultural Engineering, Maharashtra Institute of Technology
(An Autonomous Institute), Aurangabad, India

ABSTRACT: In the ancient system of drugs several plants are helpful to cure varied issues and diseases. W.Coagulans (Stocks) Dunal (Solanaceae), normally referred to as “Indian Cheese Maker” Indian organic compound or vegetable organic compound and with trade names panir (or paneer) doda belongs to solanacea family and is one of the important medicinal plant. Withania coagulans a small shrub distributed in east of the Mediterranean region extending to South Asia. It is common medicinal plant in many parts of Pakistan and India. In ayurvedic system of medicine W.coagulans is largely used in diabetic cases. Withanolides isolated from the aqueous extract of fruits of the plant are evidenced to own smart antihyperglycemic and antidyslipidemic activity, wound healing activity, Anti-inflammatory, hepatoprotectivity, hypolipidemic, antifungal activities of W.Coagulans have been described. The present review article highlights the significance of species, botanical name, taxonomical classification, morphology, phytochemistry, and pharmacological action, Food applications. This broad information will be of great value for future researchers.

Keywords - Withania Coagulans, Withanolides, Indian Cheese Maker, Pharmacological properties, Food Applications.

1. INTRODUCTION

Withania has been used for thousands of years for conserve food and treat health disorders and to prevent diseases including epidemics. Ayurveda is the science of life. The knowledge of their healing properties has been transmitted over the centuries and among human communities(1).

Within the natural system of drugs several plants are claimed to be helpful for the treatment of diabetes. There are two species of *Withania*, a small shrubs distributed in east of the Mediterranean region extending to South Asia are found in India (2,3). *Withania coagulans* belongs to solanacea family. Among the twenty three well-known species of *Withania* only two (*W. Coagulans* and *W. Somnifera*) are economically vital (4). *W.Coagulans* (Stocks) Dunal (Solanaceae), normally referred to as “ Indian Cheese Maker ” Indian organic compound or vegetable organic compound and with trade names panir (or paneer) doda (5), as a result of fruits of this plant are used as milk coagulants (6).It is a healthful herb whose biotechnological attributes haven't been extensively explored (5).*W. coagulans* has been acclaimed *Rishyagandha* in Ayurveda (7). The milk coagulating properties of the fruit is attributed to the pulp associated husk of berries that contain an accelerator referred to as *Withanin*, having milk coagulating activity (8). In some elements of the Indo-Pak sub-continent, the berries are used as a blood purifier (9). In punjab , the berries of *W. Coagulans* are used because the supply of coagulating accelerator for natural action the milk is termed *Paneer* (10). The fruit,roots,and leaves have varied therapeutic effects.The main constituents in berries embrace essential oils, esterases, amino acids, and alkaloids and withanolides (11). A proteinase from *Withania Coagulans* fruit evaluated for milk natural action properties (12). It's wide employed in diabetic cases (10). It's associate healthful fruit play a significant role for

the event of latest drug (13). The drug has shown to own anti-inflammatory , cardiotoxic activities, hepatoprotective, antifungal, and wound healing activity (14). The fruits are rumored to possess sedative ,emetic various and diuretic drug (15,16). Withanolide isolated from liquid extract of fruits of W. Coagulans , has cardiovascular effect and alcoholic extract of W. Coagulans have shown antibacterial and anthelmintic activity. Fruits of W. Coagulans may be reducing the raised glucose level. The hypoglycemic and antidiabetic potential of fruits of W. Coagulans could also be because of vital presence of Mg and Ca (14). Because of its wide therapeutic importance it's worthy to get varied qualitative and quantitative standards of drug to inhibit its adulteration (12). The appliance of W. Coagulans within the dairy farm business for cheese manufacture and as a cheese ripening is usually recommended . W. activity is liable for casein degradation (14). The moderate clotting activity with warmth temperature resistance found in extract of the fruit of W. Coagulans may well be helpful in dairy farm business for milk clotting (6). The phytochemical constituent and antioxidant properties of methanolic and liquid extract of fruits of W. Coagulans (3). This study reports the purification associated characteristics of an aspartic proteinase from W. Coagulans fruit (17). W. Coagulans fruit is another to calf rennet for coagulation of milk (14). The genus withania could be a extremely acclaimed genus of healthful plant within the Indian ayurvedic system of drugs owing to its valuable pharmaceutical and nutraceutical properties (4). Liquid extract of fruit W.Coagulans exhibited antidiabetic and antioxidant activity (13). Some withanolides have a promising role within the treatment of neurodegenerative diseases (2). Withanolides isolated from the liquid extract of fruits of the plant are evidenced to own smart antihyperglycemic and antidyslipidemic activity in numerous animal models. it's conjointly been shown to own wound healing activity, Anti-inflammatory activity, hepatoprotectivity, hypolipidemic, antifungal and cardio tonic activities (18).

1.1 BOTANICAL DESCRIPTION OF WITHANIA COAGULANS :

This shrub is common in, East India, Nepal and Afghanistan, In India it occurs in Punjab, Rajasthan, Simla, Kumaun and Garhwal (20).

table no.1 botanical description of withania coagulans.

Botanical Name	Withania coagulans Dunal
Family	Solanaceae
Subfamily	Solanaceae
Tribe	Physaleae
Subtribe	Withaninae

1.2 TAXONOMICAL CLASSIFICATION (20):

table no.2 taxonomical classification

Kingdom	Plantae, Plants
Subkingdom	Tracheobionta, vascular plants
Superdivision	Spermatophyte, seeds plants
Dvision	Angiosperma
Class	Dicotyledons
Order	Tubiflorae
Family	Solanaceae
Genus	Withania
Species	Coagulance

1.3 SYNONYMS :

SanskritName is Rishyagandha , Hindi Name is Punir, Punir bandh, Akri, Binputakah, Paneer doda, In English it is known as Indian Cheese maker, Indian organic compound, Vegetable organic compound and Trade Name is Paneer dodi, Panner, doda, Panir bed, Paneer dhodi (19)

1.2 MORPHOLOGICAL CHARACTERISTICS :



fig (a)leaves

fig (b)fruits

fig (c)flowers

a)Leaves : The leaves are unit simple , entire, clothed with a persistent grayish tomentum on each side (1). 2.5-5.7 by 1-2.2 cm, long however usually shadowy (19). Yellow in axillary determinate clusters, berries orbicular, red or chromatic, smooth, basined in coriaceous ringlet (21). Leaves contain four internal secretion lactones referred to as Withanolides (22).

b)Fruits : Berries are unit concerning 7-12 millimeter in diameter, red, smooth , closely girt by the enlarged membranous ringlet that is scurfy-pubescent outside. Seeds 2.5-3 mm. diam., somewhat auriform, glabrous. Fruits are unit Carminative, depurative, used for upset stomach, flatulence, and strange (22,19). Berries contain milk coagulating enzymes, esterase, free amino acids, fatty oil, volatile oil and alkaloids. The volatile oil was active against genus *Micrococcus pyogenes* power unit. aureus and conjointly shows anthelmintic activity (21). The fruits of berries are unit used as a blood setup (20). liquid extract of fruit W .Coagulans exhibited medication and inhibitor activity (13). berries ripen throughout Jan to could. The natural regeneration is from seed (19).

c)Flowers : 7-12 millimeter across, yellowish, dioecious and polygamous in nature(22). The flowers seem in a very brightly yellow or green and it carries little berries that are unit orange-red in color (8). Flowering amount - Jan to Gregorian calendar month (19).

2. PHYTOCHEMISTRY

The defatted meal from the seeds of *W. coagulans* Dunal contains 17.8% free sugars, consisting of D-galactose and D-arabinose in the ratio 1 : 1, with maltose in traces. Enzymatic studies showed the absence of a β -galactosidic linkage in the polysaccharide.(38) The seeds of *W. coagulans* are reported to contain 12–14% fatty oil. A hydrocarbon triacontane and sterol dihydrostigmasterol are obtained from the unsaponifiable portion of the fruits. The oil was found to contain a high percentage of linoleic acid and β -sitosterol i.e. the factors which in combination are reported to be responsible for the hypocholesterolaemic effect of corn oil.(39) *W. coagulans* is rich reservoir of pharmaceutically active steroidal lactones known as withanolides . Withanolides are naturally occurring polyhydroxy C28 steroidal lactones. In the basic structure of all withanolides a six- or five-membered lactone or lactol ring is attached to an intact or rearranged ergostane skeleton. They give a positive Dragendorff's test even though they are not N-containing. On spraying the TLC with H₂SO₄–MeOH they give a characteristic blue colour spot. This class of compounds does not occur in all members of the Solanaceae family. However, the occurrence of withanolides is not restricted to Solanaceae. They have also been reported from marine organisms (soft corals) and from members of plant families Taccaceae and Leguminosae.

The most important constitution *W.coagulans* is Withanolides which can be chemically classified in the following groups (7).

- a) Withalide glycoside
- b) Withaphysalin
- c) Physalin
- d) Nicadrenons or ring D Aromatic Withanolides.
- e) Acnistins.
- f) Perculactones
- g) Withajardines

3. WITHANOLIDES

The term “withanolide” is a structural term that has been used for “withan” from the genus *Withania*, and “olide” is the chemical term for a lactone (16). Major bioactive phytoconstituents isolated from *W. coagulans* are lactone steroids called withanolides (26). A new group of steroidal lactones called withanolides has been recently isolated from different species of the Solanaceae family, mainly *Withania Somnifera* (27). There are several withanolides such as coagulin F, coagulanolide, withacoagulin, and coagulin G present in the whole plant (11). In addition to a biogenetically important precursor of Withanolides , Four Withanolides from the roots , Two from the leaves and Two from the Fruits of this plant reported. Withanolides shows Antitumorous , Anti-inflammatory , Antibacterial , Immunosuppressive Activities (24). A new withanolide, with a unique chemical structure similar to the aglycones of the cardiac glycosides, was isolated from the fruits of *W. coagulans*, and was screened for cardiovascular effects (20,27). Withanolides present in *W. coagulans* have attracted an immense interest in the scientific field due to their diverse therapeutic applications (26). A new Withanolide isolated from *W . Coagulans* have been found to be active against several potentially pathogenic fungi. Withanolides have been reported to possess both immunostimulating and immunosuppressive effects in different studies. Withanolides have been reported to have effect on haemopoietic system and bone marrow. Glycowithanolides have been found to have effects on CNS (28).

4. ISOLATED COMPOUNDS FROM WITHANIA COAGULANS AND THEIR BIOLOGICAL ACTIVITY (23):

table no.3 isolated compounds from withania coagulans and their biological activity

Sr.No	Name of Compound	Plant Part	Medicinal Activity
1	Coagulin-C	Fruits	Antihyperglycemic
2	Coagulanolide ((17S,20S,22R)-14 α ,15 α ,17 β ,20 β -tetrahydroxy-1-oxowitha-2,5,24-trienolide)	Fruits	Antihyperglycemic
3	Withanolide F	Fruits	Antihyperglycemic
4	Withaferin A	Roots	Antimicrobial, Immunomodulating, Antitumour, Cytotoxic
5	Withacoagin ((20R,22R)-5 α ,20-dihydroxy-1-oxowitha-2,6,24-trienolide)	Roots	Antimicrobial, Antitumour, Cytotoxic
6	D- Arabinose	Seed	Reducing Sugar(low calorie sugar,
7	D- Galactose	Seed	Reducing sugar
8	Coagulin – B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S,	Whole plant	Antihyperglycemic

5. MEDICINAL USE OF DIFFERENT PARTS OF WITHANIA COAGULANS.

table no.4 medicinal use of different parts of withania coagulans.

Sr.No	Pharmacological Activity	Parts of Plant	Description	References
1	Antihyperglycemic activity	Fruits and Flower	Pharmacological effect on blood glucose, lipid profile. Soak about 10-15 pods of paneer dodi in glass of water overnight.	(37)
2	Cardiovascular effect	Fruits	The Withanolides produces moderate fall in blood pressure	(23)
3	Immunosuppressive effect	Aerial part of plant / root	Withaferin A has a specific immunosuppressive effect on human B and T-lymphocytes	(23)
4	Anti-inflammatory activity	Fruits	Its external application prescribes for inflammatory conditions.	(9)
5	Antifungal activity	Whole Plant	Used in the treatment of	(8)

			antifungal disease.	
6	Antibacterial and Antihelmintic	Fruits	It is protective against microbial infections	(19)
7	Hepatoprotective activity	Fruits	It helps in protecting the liver and maintain its general well-being.	(23)
8	Wound healing activity	Whole Plant	Both topical and oral forms showed a big increase in the rate of wound contraction	(25)
9	Diuretic activity	Seeds	It works as a diuretic because they increase urinary K ⁺ level and alter Na ⁺ /K ⁺ output	(4)
10	Antihyperlipidemic activity	Fruits	Reduce the serum cholesterol, Triglycerides, Lipoprotein, and LPU levels.	(19)

6. APPLICATION IN FOOD INDUSTRY

The ability of *W. coagulans* berries to cause milk to coagulate is well known. The protease from the plant was evaluated for its milk coagulating ability. It was discovered that pH 4 and a temperature of 70 °C were ideal for enzymatic activity. where, the enzyme's activity was maintained at 60 °C (31). Additionally, the milk coagulating potential of *W. coagulans* fruit extract was evaluated; it showed the greatest impact at pH 4 and temperature of 65 °C.

From *W. coagulans* fruit, an enzyme called aspartic protease was isolated using fractional ammonium-sulfate precipitation and cation-exchange chromatography. Casein was used to test the protease enzyme's proteolytic activity. Using skim milk, the ability of *W. coagulans* crude fruit extract to cause milk to coagulate was evaluated. Therefore, it was discovered using mass spectrometry and inhibitory experiments that aspartic protease is the sole enzyme responsible for milk coagulation. Additionally, the activity of the enzyme was steadily decreased by the rising salt concentrations (NaCl, CaCl₂). As a result, it was determined that this enzyme would be suitable to create reduced salt cheese (32).

The fruits of *W. coagulans* were used to create buffalo milk mozzarella cheese by acting as milk coagulants. As a result, producing cheese using an aqueous fraction of *W. coagulans* may be an option (33). Utilizing an extract from the fruit of *W. coagulans*, buffalo milk cheese was created and its storage properties assessed (5 months). In cheese made using lyophilized berry extract, the highest levels of ash, fat, crude protein, and total solids were found (34). In order to prepare cheese, *W. coagulans* alcoholic and aqueous fractions containing plant proteinase were used at various concentrations (0.5, 1, and 1.5 percent) (35)

Additionally, cottage cheese made with an aqueous plant fraction had a significantly higher moisture content and pH, whereas cheese made with calf rennet and *W. coagulans* had the same levels of ash, fat, and crude protein (36). A 0.5 percent alcoholic plant extract can be used to create a white cheese of acceptable grade. *W. coagulans* extract's ability to cause soy milk to coagulate was evaluated in the process of making tofu and contrasted with tofu made with calcium sulphate. Sensory evaluation found no distinction between the two forms of tofu. where, *W. coagulans*' tofu had a lower yield and a higher moisture content.

7. PHARMACOLOGICAL ACTIONS:

7.1 Antihyperglycemic Activity

W. Coagulans fruits exhibited hypoglycaemic activity which is an effective safe alternative treatment for diabetes, coagulin L from *W. coagulans* fruits has antihyperglycemic activity (16). It showed pharmacological effects on blood glucose, lipid profile and body weight in type II diabetic rats causing significant decrease in blood glucose level, total cholesterol (1).

7.2 Cardiovascular Effects

Withanolide, a steroidal lactone derived from the aqueous extract of Paneer Dodi fruits, has a cardiovascular effect(29,22). This withanolide replacement, isolated from the fruits of *Withania coagulans*, has a similar chemical structure to the aglycones of cardiac glycosides was screened for cardiovascular effects.

7.3 Wound Healing Activity

The hydroalcoholic fraction of the methanolic extract of *Withania. coagulans* was administered in the form of 10% w/w ointment topically and at a dose of 500 mg/kg body weight orally to streptozotocin-induced diabetic rats (20) *W. coagulans* showed significant wound healing activity in open and incised wound models. The hydroalcoholic fraction in both the forms, i.e., topical (10% w/w ointment) and oral (500 mg/kg body weight, p.o.) showed a significant increase in the rate of wound contraction compared to diabetic controls (30).

7.4 Anti-Inflammatory Activity

Withania coagulans alcoholic extract has a significant anti-inflammatory effect in acute inflammation induced by egg albumin (23). Withanolides from *Withania coagulans* are effective in reducing inflammation in acute inflammation (16). The hydroalcoholic extract of *Withania coagulans* berries exhibits significant anti-inflammatory activity in a carrageenin-induced rat paw edema model (26).

7.5 Anti-Hyperlipidemic Activity

In high-fat diet-induced hyperlipidemic rats, extracts of *Withania coagulans* fruits significantly reduced levels of elevated serum cholesterol, triglyceride, lipoprotein, and therefore LPO levels. Ayurvedic products containing *Commiphora Mukul* are analogous to the hypolipidemic effect of fruits of *Withania coagulans*(30).

7.6 Diuretic Activity

Withania coagulans fruits exhibit diuretic potential in an aqueous extract when studied in rats. When compared with other *Withania* species, *Withania coagulans* have more polar Withanolides. Using furosemide as a standard, the diuretic activity of the aqueous extract of paneer Dodi roots can be studied in the Lipschitz test model. The diuretic effect is due to the presence of the active principles of polar nature, of which withanolides are the chemical protagonists. Research supports the use of *Withania coagulans* as a diuretic agent in folk medicine (3). *Withania coagulans* extract has hypotensive, respiratory stimulant, and muscle relaxing properties (23).

7.7 Hepatoprotective effects

In adult albino rats, 3-hydroxy-2, 3-dihydro-withanolide F derived from a fruit of *Withania coagulans* has been shown to have hepatoprotective effects against CCl₄-induced hepatotoxicity. A weight-based comparison revealed that it is more active than hydrocortisone and exhibits a marked protective effect (37)

7.8 Anti-fungal activity

Two withanolides, 14,15 β -epoxywithanolide I and 17 β -hydroxywithanolide K, isolated from ethanolic extract of the total plant of *W. coagulans*, are found to active against variety of potentially pathogenic fungi (8)

7.9 Anti-bacterial and anti-helminthic activities

The oil obtained from alcoholic extract of fruits of *Withania coagulans* has medicinal drug activity against *S. aureus* and *Eubacterium Indian cholera*, and it's conjointly found to possess antihelminthic activity (30)

7.1 Anti-Inflammtory Activity

The alcoholic extract of *Withania coagulans* showed significant anti-inflammatory effect in acute inflammation induced with egg albumin. A withanolide from *Withania coagulans* showed significant anti-inflammatory effects in acute inflammation (30)

7.11 Immunosuppressive Effects:

Withanolide E and Ashwagandha possess specific immunosuppressive properties on human B and T lymphocytes as well as mice thymocytes[37]. Withanolides, such as coagulin-H, acts on several cellular functions involved in immune responses. It is comparable to the effects of prednisolone. The coagulin-H possesses a strong inhibitory effect on lymphocyte proliferation, and therefore, cytokine production by Th-1 cells. Coagulin-H inhibits phytohaemagglutinin (PHA)-induced T-cell motivation (30).

Conclusion

The various parts i.e. berries, leaves, root etc. of *Withania coagulans* posses variety of biological activity. It is an important medicinal herb as large numbers of phytochemicals (esterases, free amino acids, fatty oil, an essential oil, alkaloids and withanolides) have been isolated from this plant. Withanolides are steroidal lactones having significant pharmacological activities. In various studies it has been seen that the *Withania coagulans* posses several medicinal properties such as hepatoprotective, antiinflammatory, antihyperglycaemic, free radical scavenging, hypolipidaemic, antimicrobial, cardiovascular. In Further study on this plant to explain its effect on other diseases and mechanism of action in depth is need of future. In the coming era, it could be consider as noble ayurvedic drug for the treatment of various ailments.

References

1. *Withania Coagulance – A miracle for diabetes.* Pratibha Gupta, Pratibha Singh
2. Chemical constituents from the fruits of *Withania coagulans* (Stocks) Dunal . Showkat Rassol Mir , Mohammed Ali , Mohammad Waris And Shahnaz Sultana. (2020)
3. Phytochemical Screening and Determination of Antioxidant Potential of Fruits Extracts of *Withania coagulans*. Deepika Mathur , R. C. Agrawal and Vinoy Shrivastava. (2011)
4. Phytochemistry, pharmacology, and biotechnology of *Withania somnifera* and *Withania coagulans*: A review . Rohit Jain, Sumita Kachhwaha and S. L. Kothari (2012)
5. *Withania Coagulans* (Stock) Dunal: Biotechnological Achievement and Perspective. A review Jaime A. Teixeira da Silva, Mafatlal M. Kher, Deepak Soner, M. Natraj.
6. Clotting characteristics of milk by *Withania coagulans*: Proteomic and biochemical study. Nasrin Kazempour, Mahmoud Salehi Inchebron, Jafar Valizadeh & Masood Sepehrmanes. (2017)
7. Therapeutic Potential of *Withania coagulans* Dunal. (Rishyagandha) on Diabetes Mellitus Type-II: A Review. Dr.Sony

8. Pharmacognostical and Pharmacological Evaluation of Withania Coagulans – An Important Ethnomedicinal Plant. Harish Vishnoi, Ayush Kumar Garg, Gulab Chand Meena, Chandan Singh and L.N. Sharma
9. Pharmacognostic evaluation of Withania coagulans Dunal (Solanaceae) - an important ethnomedicinal plant. Debasmita Dutta Pramanick and S. K. Srivastava.
10. Withania coagulans Dunal: A Review. Prasad S.K., Singh P.N., Wahi A.K., Hemalatha S. (2008)
11. Phytochemistry, Food Application, and Therapeutic Potential of the Medicinal Plant (Withania coagulans): A Review . Muhammad Issa Khan , Maria Maqsood , Raakia Anam Saeed , Amna Alam , Amna Sahar, Marek Kieliszek , Antoni Miecznikowski , Hafiz Shehzad Muzammil and Rana Muhammad Aadil.
12. Pharmacognostical Standardization of Withania coagulans Dunal. Prasad S.K., Singh P.N., Wahi A.K., Hemalatha S (2010).
13. Biologically Active Withanolides from Withania coagulans . Ihsan-ul-Haq, Ui Joung Youn, Xingyun Chai, Eun-Jung Park, Tamara P. Kondratyuk, Charles J. Simmons, § Robert P. Borris, Bushra Mirza, John M. Pezzuto, and Leng Chee Chang.
14. Biochemical and Rheological Characterization of a Protease from Fruits of Withania coagulans with a Milk-clotting Activity. Maryam Beigomi, Mohammad Amin Mohammadifar, Maryam Hashemi, Mohsen Ghods rohani, Kalaiselvi Senthil, and Mohharam Valizadeh. (2014)
15. Phytopharmacological Properties of Withania Coagulans: A Review. Lambole Vijay, Krishna Murti , Mayank Panchal , Vipul Gajera , Nikhil Joshi.
16. Remedial Use of Withanolides from Withania Coagulans (Stocks) Dunal. Maryam Khodaei , Mehrana Jafari , Mitra Noori.
17. Characterization of milk coagulating properties from the extract of Withania coagulans . Shehla Naz, 1 Tariq Masud1 And Mal Ik Ad Il Nawaz . (2009)
18. Wound healing activity of Withania coagulans in streptozotocin-induced diabetic rats S.K. Prasad, R. Kumar, D.K. Patel, and S. Hemalatha. (2010)
19. Withania Coagulans Dunal. (Paneer Doda): A Review . Vandana Gupta , Bipin Bihar
20. Withania Coagulans Dunal- An Overview. Prakash Chandra Gupta. Jan(2012)
21. Investigation of the Pharmacognostical, Phytochemical and Antioxidant Studies of Plant Withania coagulans Dunal. Chetan Salwaan , Amrinder Singh , Anuj Mittal , Prabhsimran Singh.
22. Antidiabetic Activity of Fruits of Withania Coagulans Dunal In Streptozocin Induces Diabetic: A Review. Bhuvanesh Baniya.
23. Chemistry and pharmacology of Withania coagulans: an Ayurvedic remedy. Rakesh Maurya, Akanksha and Jayendra
24. Withacogin , a New Withanolides from withania Coagulans Roots. Partha Neogy , Masao Kawai, Yasuo Butsugan, Yuji Mori, and Makoti Suzuki.
25. Phytochemical And Antimicrobial Activity of Withania Coagulans (Stocks) Dunal (Fruit). Sudhanshu, Sandhya Mittal, Nidhi Rao, Ekta Menghani (2012).
26. Isolation of Antidiabetic Withanolides from Withania coagulans Dunal and Their In Vitro and In Silico Validation . Saima Maher , M. Iqbal Choudhary , Farooq Saleem , Saima Rasheed , Imran Waheed , Sobia Ahsan Halim , Muhammad Azeem , Iskandar Bin Abdullah , Matheus Froeyen , Muhammad Usman Mirza and Sarfraz Ahmad. (2020)
27. Cardiovascular Effects of A Withanolide From Withania Coagulans, Dunal Fruits. R. D. Budhiraja. S. Sudhir And K. N. Garg.
28. Biological Activity of Withanolides . R. D. Budhiraja , Pawan Krishna and S. Sudhir (2000)
29. Antidiabetic and antihyperlipidemic activity of hydroalcoholic extract of Withania coagulans Dunal dried fruit in experimental rat models. Ankur Datta, Chiranjib Bagchi, Saibal Das, Achintya Mitra , Anuradha De Patil , Santanu Kumar Tripathi.
30. Pharmaceutical Importance of Withania Coagulans In Health and Diseases. Neelam B. Bare, Pratima S. Jadhav
31. Beigomi, M.; Mohammadifar, M.A.; Hashemi, M.; Senthil, K.; Valizadeh, M. Biochemical and rheological characterization of a protease from fruits of Withania coagulans with a milk-clotting activity. Food Sci. Biotechnol. 2014, 23, 1805–1813. [CrossRef]
32. Kazempour, N.; Salehi Inchebron, M.; Valizadeh, J.; Sephehrimanesh, M. Clotting characteristics of milk by Withania coagulans: Proteomic and biochemical study. Int. J. Food Prop. 2017, 20, 1290–1301. [CrossRef]

33. Salehi, M.; Aghamaali, M.R.; Sajedi, R.H.; Asghari, S.M.; Jorjani, E. Purification and characterization of a milk-clotting aspartic protease from *Withania coagulans* fruit. *Int. J. Biol. Macromol.* 2017, 98, 847–854. [CrossRef] [PubMed]
34. Pezeshki, A.; Hesari, J.; AHMADI, Z.A.; Ghambarzadeh, B. Influence of *Withania coagulans* protease as a vegetable rennet on proteolysis of Iranian UF white cheese. *J. Agric. Sci. Technol.* 2011, 13, 567–576.
35. Nawaz, M.A.; Masud, T.; Sammi, S. Quality evaluation of mozzarella cheese made from buffalo milk by using paneer booti (*Withania coagulans*) and calf rennet. *Int. J. Dairy Technol.* 2011, 64, 218–226. [CrossRef]
36. Qazalbash, M.A.; Masud, T.; Sammi, S.; Khan, R.S.; Latif, A. Effect of different storage conditions on coagulating properties and cheese quality of *Withania coagulans* extract. *Int. J. Dairy Technol.* 2018, 71, 654–662. [CrossRef]
37. Maurya R, Akanksha, Jayendra, Singh AB, Srivastava AK. Coagulanolide, a withanolide from *Withaniacoagulans* fruits and antihyperglycemic activity. *Bioorg Med Chem Lett.* 2008 Dec 15;18(24):6534-7. doi: 10.1016/j.bmcl.2008.10.050. Epub 2008 Oct 14. PMID: 18952419.
38. Salam A, Wahid MA. Free sugars and a galactoaraban from *Withania coagulans* seeds. *Pakistan J Biochem* 1969; 2: 18–21.
39. Gupta A, Mittal A, Jha KK, Kumar A. Nature's treasurer: plants acting on colon cancer. *Journal of Stress Physiology & Biochemistry.* 2011;7(4):217-31 (chart19)

