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Research Paper

Formulation And Evaluation of Watermelon Seeds Loaded Spherules as Nutraceuticals

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ABSTRACT

This research investigates the development of watermelon seed-loaded spherules as a potential delivery system for nutraceutical applications. Watermelon seeds are abundant in beneficial bioactive compounds such as polyphenols, essential fatty acids, and antioxidants, which have been associated with various health advantages, including anti-inflammatory and antioxidant effects. The goal of this study was to create spherules encapsulating watermelon seed and assess their physicochemical and their property to improve the health. The formulation process involved incorporating watermelon seed into spherules using biocompatible materials, with several preparation techniques being explored. The main objective of study is to formulate the spherules and fill in the capsules and carryout Phytochemical analysis which indicated the presence of various active compounds, such as flavonoids, alkaloids, and saponins, which are reported to possess therapeutic properties. Flow properties like angle of repose, bulk density, and Carr's index were analysed to assess the processability of the spherules and to maintain uniformity in the formulation of spherules and weight variation test and disintegration test shows the stability of the capsule.

INTRODUCTION

Epidemiological studies on the relationship between eating habits and illness risk indicates that food has a direct impact on health. It is commonly known that plant-based foods, such as wine, fruits, nuts, vegetables, grains, legumes, spices, and others, can have some beneficial health impacts,

particularly with regard to age-related disorders. The capacity of some plant-derived meals to reduce the risk of chronic illnesses has been at least partially attributed to the existence of non-nutrient secondary metabolites (phytochemicals), which have been shown to exhibit a wide variety of biological functions.¹

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A burgeoning category of natural goods known as nutraceuticals disrupts the connection between medicine and nutrition. Stephen De created the term "nutraceutical" by fusing the terms "pharmaceutical" and "nutrition." Any non-toxic dietary supplements having proven medical advantages for illness prevention and treatment are considered nutraceuticals. One An effective diet "should have a related effect on health and well-being or result in a decrease in illness risk" in the context of this evaluation, according to Roberfroid.²

Since there is no regulation in the field of nutraceuticals—a general term for products derived from food that offer health advantages beyond those of regular nutrition—a wide range of uses and efficacy claims have resulted. In order to better distinguish its numerous products, the medical community in particular has called for a more precise description of the category due to the absence of a widely recognized definition. Actually, a huge variety of goods fall within the nutraceutical category.

Classification of Nutraceuticals^{3,4}

The food sources used as nutraceuticals are all natural and can be categorized as

1. Dietary Fiber
 2. Probiotics
 3. Prebiotics
 4. Polyunsaturated fatty acids
 5. Antioxidant vitamin
 6. Polyphenols
 7. Spices
1. **Dietary Fiber:** Dietary fiber consists of plant-based lignin's and indigestible carbohydrates. Isolated non-digestible carbohydrates having physiological advantages are referred to as functional fiber. For adults, an adequate intake is 25g per day for women and 38g per day for males.

2. **Probiotics:** Live "good" bacteria and yeasts that support intestinal health are known as probiotics. found in meals and supplements as well as naturally in the body.
3. **Prebiotics:** Prebiotics are indigestible fiber substances that promote the growth of good bacteria non the gut and improve the makeup of the microbiome.
4. **Polyunsaturated fatty acids:** Omega-3 and omega-6 polyunsaturated fatty acids are separated. Linoleic acid and α -linolenic acid are essential fatty acids that must be obtained through food in order to maintain good health.
5. **Antioxidant vitamin:** Antioxidants are substances that counteract free radicals, minimizing cellular damage and promoting general well-being.
6. **Polyphenols:** Plant-based substances called polyphenols, which have antioxidant qualities, are present in a variety of meals, including fruits, vegetables, tea, and coffee. They defend against environmental stresses and infections.
7. **Spices:** Beyond only adding taste, spices are used in medicine, nutraceuticals, cosmetics, and pest management. They also have a major economic impact on the nations that produce them.

Nutraceutical Advantages:

- Enhanced overall health.
- Augmented energy levels.
- Alleviated anxiety.
- Improved mental clarity.
- Enhanced sleep quality and quantity.
- Disease prevention.
- Slowed aging process.
- Reinforced immune system.
- Increased life expectancy.

Spherules are tiny, spherical particles that are usually between 0.1 and 2 mm in diameter. They are made up of a single substance, such as an excipient, drug, or both, that has undergone



spheronization to take on a spherical shape without the need for extra coating or layering.⁵ The most widely used process for making pellets is extrusion-spheronization. Reynolds and Conine and Hadley were the first to disclose this procedure, which consists of four steps:⁶

- a. the moist material is prepared (granulation);
- b. it is prepared into cylinders (extrusion).
- c. Spheronization, the process of breaking up the extrudate and shaping the particles into spheres
- d. Drying
- e. Granulation: Granulation entails getting the material's plastic bulk ready. In order to create

wet masses, binders are used to combine the APIs and excipients.

- f. Extrusion: Pressure is applied to a prepared plastic mass during the extrusion process, which creates the extrudates by forcing the material out through an opening. The physical properties of the materials to be extruded, the extrusion technique, and the post-extrusion particle manipulation can all affect the extrudate length. Screw, sieve and basket, roll, and ram extruders are the four primary types of extruders used in extrusion.⁷.

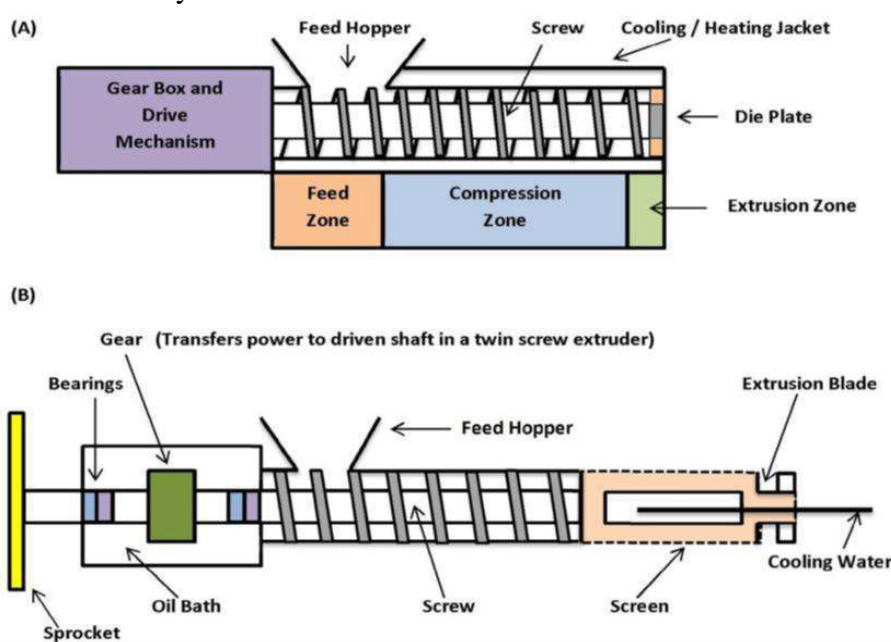


Fig no 1: - Schematic image of Screw extruder A) axial type, (B) radial type.

- g. Spheronization: This process, which is brought about by plastic deformation, breaks the extruded, cylindrical particles into homogeneous lengths and progressively turns them into spherical forms. All three agglomeration shape dimensions are established as extrudates are first broken into nearly uniform lengths, resulting in the production of spheres with a nearly consistent diameter.

Depending on the form of the particles, the spheronization process can be divided into many phases, such as a cylinder over a cylinder with rounded edges, dumbbells, and elliptical particles, and finally complete spheres. There may be another process for pellet formation, according to Baert and Remon. This mechanism causes the cylinder to rotate after rounded-edged cylinders develop, ultimately shattering into two separate pieces. Each component has a flat side and a round side. The flat side's edges fold together like a flower to generate the hollow seen in certain

pellets as a result of the rotational and frictional forces involved in the spheronization process.⁷

A vertical hollow cylinder with a horizontal revolving disk (friction plate) within is called a spheronizer. Through contact with the friction plate, particle collisions, and wall impacts, extrudates are charged onto the revolving plate and split into small pieces. The mechanically fluidized bed is the result of the transmission of mechanical energy from the rotating friction plate into kinetic energy. The extrudate will eventually deform into

a spherical shape with additional processing. The frictional forces are increased by the friction plate's grooved surface. There are two different kinds of groove geometry: radial geometry, which uses a radial pattern, and cross-hatch geometry, which forms right angles. demonstrates the spheronizer's basic parts. The friction plate, which can have different surface textures made for different purposes, is the most crucial part. Where the grooves meet at 90° angles, the cross-hatch pattern is most prevalent.⁷

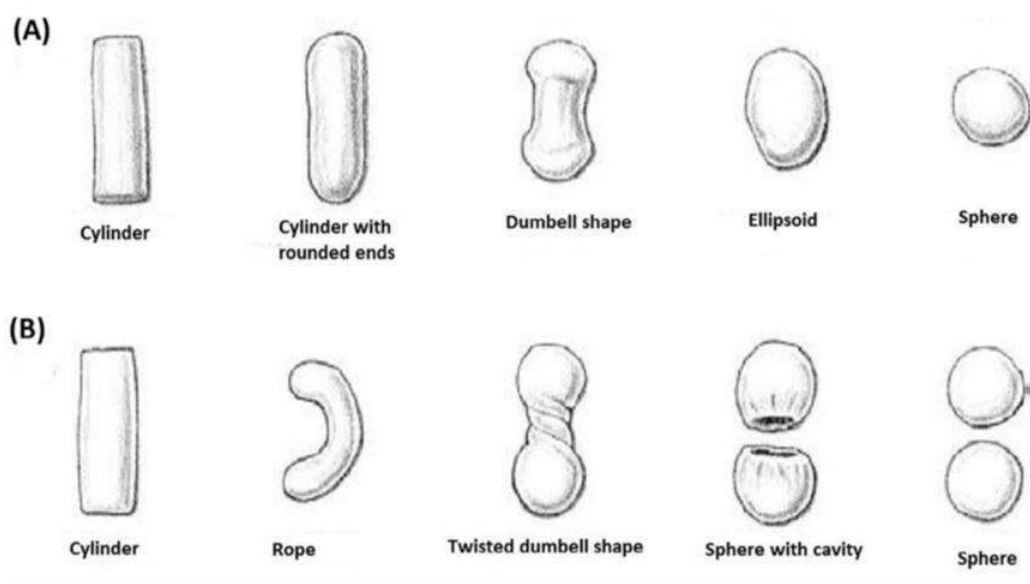


Fig no 2: - Spherules formation mechanism according to a) Remon and b) Beart

Rounding off is the phase that determines the pace at which the extrudate breaks during the first 10% of the spheronization process. Five phases are identified in the evolution of pellet form, and it is discovered that the length of each stage increases with spheronization.⁸ They discovered that spheronization begins with the creation of massive primary nuclei when they investigated high shear spheronization. The fragmentation of the parent nuclei results in the formation of tiny secondary nuclei. The secondary nuclei grew stronger as a result of densification, and growth by coalescence increased exponentially. Net growth is reduced throughout the kneading phase until a stable

condition is reached. The last stage of the kneading phase produced a well-defined product since the mean particle size remained constant.⁹

Advantages of extrusion–spheronization over other techniques includes:⁹

- Ability to incorporate higher levels of active components without producing excessively larger particles.
- Two or more active agents can be easily combined in any ratio in the same unit.
- Physical characteristics of the active ingredients and excipients can be modified.

- Particles having high bulk density, low hygroscopicity, high sphericity, dust free narrow particle size distribution and smoother surface can be produced

Plant profile

During the summer, watermelon is a popular and pleasant fruit. We sometimes overlook the small seeds within while we Savor this luscious apple. On the other hand, these watermelon seeds are packed with healthy elements. The plant known as watermelon, or *Citrullus lanatus*, is indigenous to Africa but is grown extensively across the world due to its sweet flavour and high-water content, which makes it the perfect fruit to drink on hot days. But while eating the fruit, the seeds are frequently thrown away or just viewed as an annoyance.¹⁰

Large and smooth, watermelon fruit comes in a variety of shapes, from spherical to cylindrical. Green or green with yellow stripes might be the skin's colour. Typically, the edible pulp is pink and contains a large number of flat, oval, black seeds. According to earlier research, watermelon seeds are a significant dietary source for human nutrition and well-being.

A watermelon seed is a superfood that may enhance our quality of life and is a very valuable component of a healthy, balanced diet. This can be a great way to get the nutrients we need to be healthy. Despite their tiny size, seeds have a mild nutty flavour and are crisp to the touch, making them ideal for a variety of culinary applications. Additionally, its versatility and wide range of applications in the kitchen will help to maximize its nutritious content, giving the many foods they produce a unique flair.

Origin

Prostate or rising annual herbaceous firm, watermelon has robust stems that can reach a

length of three meters. While the elder sections are hairless, the younger parts are heavily wooly and have yellowish to brownish hairs. The herbaceous but stiff leaves are 60-200 mm long and 40-150 mm wide, with the central lobe being the biggest. The leaves are typically profoundly three lobed, with the segments being either double or again lobed. The leaf stalks may grow up to 150 mm long and have some fur. The tendrils are typically split at the tip and are rather robust. The flower stem is up to 40 mm tall and hairy, and the male and female flowers grow on the same plant (monoecious). In its natural state, the fruit is subglobose, indehiscent, and can reach a diameter of 200 mm. The fruit stem can grow up to 50 mm. The seeds are ovate to elliptical, convex, 0.5-1.5 cm X 0.5-1 cm smooth, yellow to brown or black, and rarely white. The fruit is most often globose to oblong or ellipsoid, occasionally ovoid, 5-70 cm long, and weighs 0.1-3.0 kg (0.1-2.5 kilogram in egusi melon, 1.5-3.0 kg in watermelon).¹¹

Scientific Classification¹²

- Kingdom: Plantae
- (Unranked): Angiosperms
- Order: Cucurbitales
- Family: Cucurbitaceae
- Genus: *Citrullus*
- Species: *C. lanatus*

Common Names

Indian local name-Sanskrit- Kharaboojam, Bengali- Tormuj, Hindi- Tarbooz, Gujarati- Indark, Urdu- Tarbooz, Punjabi- tarabuuja, Tamil- palam, Telugu- puchakaya.

Plant description¹³

It is an annual herb, watermelon. It is mostly grown in warm countries like India. Large hairy leaves, curling tendrils, and long stem (up to 10 m and 32.8 ft) are all present on the ground. The



leaves have three to five lobes and are tough on both sides. Both male and female flowers are found on the same plant, which has long, hairy flower stalks. In its natural state, the fruit has a diameter of 1.5 to 20 cm, is malty, greenish, sub globose, and dark green, with fruit stems that are 50 mm long. The pulp might be dark red (cultivar) or yellow or green (wild form). The ovate, flattened seeds are 9-12×5-7 mm and range in colour from yellow to drab brown or black, and in rare cases, white.

Proximate composition of nutraceuticals¹⁴

Table no 1: Proximate composition of watermelon seeds

Sr no	Nutritional composition	Results ± SE (%)
1	Crude protein	34.73±0.15
2	Crude fat	32.04±0.52
3	Crude Fiber	4.97±0.46
4	Ash	3.67±0.13
5	NFE (Nitrogen Free Extract)	21.20±0.97
6	Moisture	3.39±0.09

Nutritional composition¹⁴

Table no 1: Phytochemical and Mineral Content in watermelon seeds

Sr	Nutritional Composition	mg/100gm
1	Magnesium (Mg)	531.62±1.00
2	Potassium (K)	742.81±1.00
3	Calcium (Ca)	134.31±0.93
4	Sodium (Na)	106.03±1.00
5	Polyphenols	553.93±1.00
6	Flavonoids	386.12±1.00
7	Saponins (%)	0.83±0.09
8	Alkaloids (%)	3.41±0.15

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Watermelon seeds as nutraceuticals^{15,16}

- **Proteins:** Essential for tissue development and immune support
- **Good Fats:** Monounsaturated and polyunsaturated fatty acids beneficial for cardiovascular health
- **Dietary Fiber:** Aids in digestive health and weight management
- **Vitamins:** Vitamin E (antioxidant), B vitamins (niacin, pantothenic acid, vitamin B6)
- **Minerals:** Magnesium (muscle and bone health, blood sugar regulation), zinc (immune system), iron (red blood cell production and oxygen transport)
- **Phytochemicals:** Antioxidant and anti-inflammatory effects from compounds like lignans and cucurbitacin's.

Health Benefits of Watermelon seeds

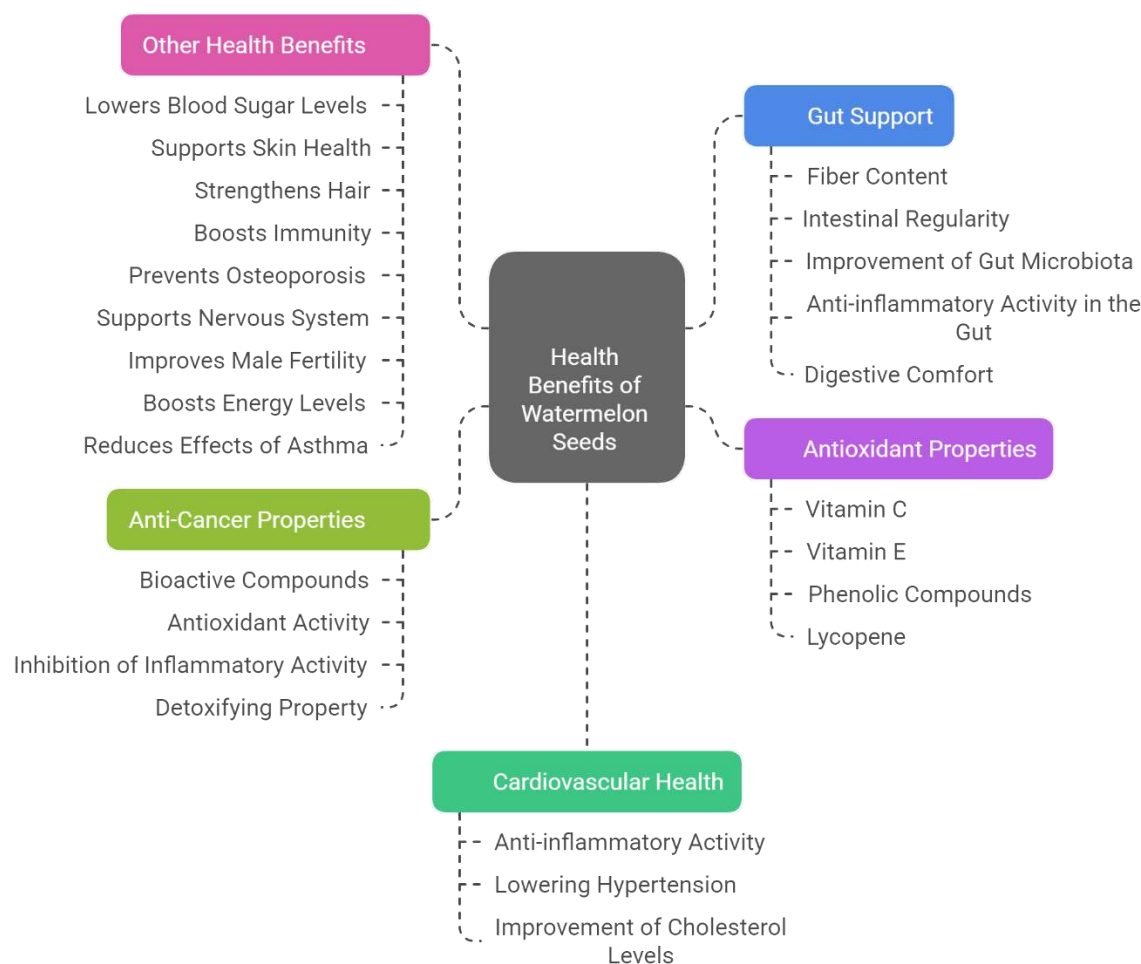


Fig no 3: Health benefits of watermelon seeds

MATERIAL AND METHODOLOGY

Collection:

The honey and watermelon seeds were purchased at the Butibori local market. The rice mill next to Mouda is the source of the rice husk used as a diluent. The remaining chemicals came from Kamla Nehru College of Pharmacy's pharmacognosy and pharmaceutical labs at Butibori.

Phytochemical tests¹⁷

a) Alkaloids: Dragendorff's test: Adding 1 mL of Dragendorff's reagent to 2 mL of extract

results in an orange red colour, suggesting alkaloids.

b) Glycosides: Keller Killiani test: Mix 0.5 mL of glacial acetic acid, 2-3 drops of ferric chloride, and 2 mL of extract. One ml of concentrated H₂SO₄ was then added along the test tube's walls. When two liquids joined, a blue-green ring formed, signifying the presence of glycosides.

c) Saponins: - Foam test: 1 ml of extract solution was diluted with 10 ml of distilled water and forcefully shaken for 15 minutes. Saponins are present when the foam is stable.

d) Tannins test: Dilute 1 ml of filtrate with purified water and add 2 drops of ferric

chloride. The presence of tannins is indicated by a brief greenish-black colour.

- e) Flavonoid test: involves taking 1 ml of extract and adding a few drops of a 10% lead acetate solution. When a yellow-coloured precipitate appears, flavonoids are present.

Formulation of Spherules¹⁸

- 1) The watermelon seeds were bought from the local store of the butibori and dried in sunlight.
- 2) Grind the sun-dried watermelon seeds into powder using home grinder and passed from the sieve number 40.
- 3) Measure the components given below in the table

Table no 1: - contents of spherules

Component	Quantity
Seeds	40g
Rice husk	30g
Talc	10g
Honey	QS
Water	QS

- 4) The formulation of spherules includes 3 steps:
- Granulation
 - Extrusion
 - Spheronization
 - Drying
 - Granulation: - The watermelon seed powder, rice husk, talc was well mixed and formed into a wet mass using the honey as a binder.
 - Extrusion: the above wet mass was extruded using VJ extruder in Kamla Nehru college of pharmacy.

- The extrudes are converted into spherules us VJ spheronizer in Kamla Nehru College of Pharmacy.
- Drying: Drying was done by hot air oven at 120⁰c using hot air over in Kamla Nehru College of Pharmacy.

- 5) The spherules were filled in the 0-size capsule
- ### Evaluation

Bulk Density: A graduated cylinder is filled with 75g of precisely weighted spherules that have been measured and poured in ml. The cylinder's graduation mark serves as a direct indicator of the spherule volume. the measured volume is referred to as bulk volume and Bulk density is measured as follows:¹⁹

$$\text{Bulk Density} = \frac{\text{Weight of spherules}}{\text{Bulk Volume}}$$

Tapped Density: - After measuring bulk volume same cylinder is used to measure tap density. The cylinder is tapped at the rate of 100 taps per minutes for 500 taps. The obtained value is noted as Va and again tapped up to 750 times and the next volume is noted as Vb. If the difference between two volume is not more than 2% then Vb is considered as final tapped volume and the tap density is measured as follows:¹⁹

$$\text{Tapped Density} = \frac{\text{Weight of spherules}}{\text{Tapped Volume}}$$

Carr' s index: - Carr' s index of spherules was determined by using formula¹⁹

$$\text{Carr's index} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}}$$

Hausner Ratio: - Hausner ratio was determined by using formula¹⁹

$$\text{Hausner ratio} = \frac{\text{Tapped density}}{\text{bulk density}}$$

Table no 3: - Range of Carr's index and Hausner ratio

Carr's Index (%)	Flow property	Hausner's ratio
≤10	Excellent	1.00-1.11
11-15	Good	1.12-1.18



16-20	Fair	1.19-1.25
21-25	Passable	1.26-1.34
26-31	Poor	1.35-1.45
32-37	Very poor	1.46-1.59
>38	Very very poor	>1.60

Angle of Repose: - To determine the angle of repose the spherules were passed through a funnel which is fixed at a definite position at 2cm height of base of funnel. The pile of spherules is formed until it touches the base of funnel. The radius of pile is measured. The angle of repose was calculated by using formula¹⁹: -

$$\text{Angle of repose} = \tan^{-1} \left(\frac{h}{r} \right)$$

Where h = Height, r = Radius

Table no 4: - Range of angle of repose

Flow Property	Angle of Repose
Excellent	25-30
Good	31-35
Fair-aid not needed	36-40
Passable-may hang up	41-45
Poor-must agitate, vibrate	46-55
Very poor	56-65
Extremely poor	>66

Close length test: - In this test overall, closed length is measured to check how long each sized capsule is when it has been completely shut with the powder inside.

Locking length of filled capsule as per standards should be 10 mm. The acceptance criteria ± 0.2

Weight Variation test of capsules: - the weight variation test denned by USP XX is a sequential test, in which 20 intact capsules are individually weighed and the average weight is determined. The test requirements are met if none of the individual weights are less than 90%, or more than 110%, of the average. If the original 20 do not meet these criteria, the individual *net weights* are determined. These are averaged, and differences are determined between each individual net content and the average. The test requirements are

met (1) if not more than two of the individual differences are greater than 10% of the average, or (2) if in no case any difference is greater than 25%.¹⁹

Acceptance criteria

Table no 5: Acceptance criteria for weight variation test

Average Weight	Percent Difference
350mg or less	7.5 % w/w
More than 350mg	5% w/w

Disintegration Test: - To test for disintegration time, one capsule is placed in each tube and the basket rack is positioned in specified medium at $37 \pm 2^\circ\text{C}$ such that capsule remains 2.5cm below the surface of the liquid on their upward movement and descend not closer than 2.5cm from the bottom of the beaker. Perforated plastic discs may also be used in the test. A standard motor driven device is used to move the basket assembly containing the capsules up and down through distance of 5 to 6cm at frequency of 28 to 32 cycles per minute. The capsule complies with the test according to USP, if all of the capsules have disintegrated completely. If 1 or 2 capsules fail to disintegrate completely, repeat the test on 12 additional capsules. The requirement is met if not less than 16 of the totals of 18 capsules tested are disintegrated.¹⁹

Table no 6: - Acceptance criteria of disintegration






Capsules	Disintegration time
Hard gelatin capsules	30 minutes



RESULTS**Phytochemical screening of watermelon seeds**

The watermelon seeds were powdered and passed from the sieve no 40 and kept in the solvent for 24hrs.

Table no 7: Result of phytochemical screening

Phytochemical	Test	Observation	Results
Alkaloids	Dragendorff 's test	Orange-red colour solution was observed 	Alkaloids are Present
Glycosides	Killer Killiani test	Blue-green ring at the junction of two liquids 	Glycosides are Present
Saponins	Foam Test	Stable foam 	Saponins are Present
Tannins	Ferric chloride test	Greenish-black colour 	Tannins are Present
Flavonoids	Lead acetate test	Yellow colour precipitate 	Flavonoids are Present

Preliminary Analysis

Table no 8: Result of preliminary analysis

Density	Result
Colour	Brownish yellow
Shape	Spherical
Bulk density	0.75g/ml
Tapped density	0.80g/ml

Flow properties:

The flow properties of formulated spherules were calculated and mentioned below: -

Table no 9: Result of flow properties

Sr no	Evaluation parameter	Result	Property
1	Angle of repose	14.9	Excellent
2	Carr's index	6.25	Excellent
3	Hausner's ratio	1.06	Excellent

Close length test: -

The close length test was calculated for 3 capsules and mentioned below

Table no 10: Result of close length

Capsules	Result
1	9mm
2	10mm
3	10mm

Acceptance criteria: + or - 2

Weight variation test

Table no 11: Weights of capsules

Sr. no.	Weight in mg
1	484mg
2	474mg
3	494mg
4	477mg
5	486mg
6	491mg
7	462mg
8	493mg
9	472mg
10	492mg
11	485mg
12	477mg
13	489mg
14	476mg
15	471mg
16	472mg
17	480mg
18	462mg
19	475mg
20	486mg

Average	479.9
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Therefore the 5% of 479.9 is 23.9mg, so the capsule should not have weight more than 503.8mg and less than 455.9mg.

Hence it passes the weight variation test

Disintegration test: The disintegration test of capsule was performed 3 time and it is in the range of 3:47 to 4:41 minutes

Table no 12: Result of disintegration

Capsule	Time
1	4:41minutes
2	3:47minutes
3	4:17minutes

Acceptance criteria: up to 30min

It passed disintegration test.

CONCLUSION

The development of watermelon seed powder-loaded spherules as a nutraceutical offers an innovative way to enhance the health benefits of watermelon seeds. By encapsulating the seed powder into spherules, we can improve the bioavailability of its beneficial compounds. The spherules showed good physical characteristics, including appropriate size and effective encapsulation, making them suitable for oral use with a controlled release of nutrients. With the natural antioxidants and anti-inflammatory properties of watermelon seeds, these spherules have the potential to act as a valuable supplement for improving health and preventing chronic conditions. This formulation provides a more stable and convenient way to consume watermelon seeds' nutrients compared to traditional supplements. Future research could focus on refining the formulation, testing its stability, and exploring its effects in living organisms to better understand its full potential as a nutraceutical product.

REFERENCES

- Ezquerro L, Coimbra R, Bauluz B, Núñez-Lahuerta C, Román-Berdiel T, Moreno-Azanza M. Large dinosaur egg accumulations and their significance for understanding nesting behaviour. *Geoscience Frontiers*. 2024 Sep 1;15(5).
- Bajaj M, Menon K. International Journal of Nutrition. A Study on Nutraceuticals International Journal of Nutrition. 2024;7(36):36–54.
- Singh J, Pharm IJ, Sci B, Sinha S. International Journal of Pharmacy and Biological Sciences (eISSN: 2230-7605) CLASSIFICATION, REGULATORY ACTS AND APPLICATIONS OF NUTRACEUTICALS FOR HEALTH [Internet]. Available from: www.paulingblog.wordpress.com].
- Srivastava R, Ahmed H, Dixit R, Dharamveer, Saraf S. *Crocus sativus L.: A comprehensive review*. Vol. 4, *Pharmacognosy Reviews*. 2010. p. 200–8.
- Kv V, Vidyapeetham AV, Hansan M, Kamalasanan K. Formulation of different polymer coated spherules from granules [Internet]. Vol. 3, Article in *Journal of Pharmaceutical Sciences and Research*. 2019. Available from: <https://www.researchgate.net/publication/333185382>
- Boddeda B, Bandaru P, Rao YS. A Review on Extrusion-Spheronisation. *International journal of pharmaceutics*. 1995 Mar 28;116(2):131-46.
- Venkatesh ND, Shrestha A, Venkatesh Dhandapani N, Shrestha N, Thapa A, Sandip G, et al. Pelletization by Extrusion-Spheronization: A detailed review Pelletization by Extrusion-Spheronization: A



- detailed review Pelletization by Extrusion-Spheronization-A detailed review [Internet]. Vol. 3, All Res. J. Biol. 2012. Available from: <https://www.researchgate.net/publication/341000800>
8. Lau CL, Yu Q, Lister VY, Rough SL, Wilson DI, Zhang M. The evolution of pellet size and shape during spheronisation of an extruded microcrystalline cellulose paste. *Chemical Engineering Research and Design*. 2014 Nov 1;92(11):2413-24.
 9. Muley S, Nandgude T, Poddar S. Extrusion-spheronization a promising pelletization technique: In-depth review. Vol. 11, *Asian Journal of Pharmaceutical Sciences*. Shenyang Pharmaceutical University; 2016. p. 684-99.
 10. Paris HS. Origin and emergence of the sweet dessert watermelon, *Citrullus lanatus*. *Ann Bot*. 2015 Aug 1;116(2):133-48.
 11. Paris HS. Origin and emergence of the sweet dessert watermelon, *Citrullus lanatus*. *Ann Bot*. 2015 Aug 1;116(2):133-48.
 12. Patel MB. WATER MELON-THE MUST MELON. *Indo American Journal of Pharmaceutical Research* [Internet]. 2019; Available from: www.iajpr.com
 13. Compositional Studies of *Citrullus lanatus* (Egusi melon) Seed. *Internet J Nutr Wellness*. 2012 Jun 28;6(1).
 14. Sajjad S, Israr B, Ali F, Pasha I. Investigating the effect of phytochemicals rich watermelon seeds against hypertension. *Pak J Agric Sci*. 2020 Jul 1;57(4):1157-64.
 15. San Miguel M, Garcia -Moreno D, San Miguel A, San Miguel J. Watermelon seeds a healthy source of nutrients. The forgotten superfood. *Certified Journal | Miguel et al World Journal of Pharmaceutical Research* 1 *World Journal of Pharmaceutical Research* SJIF Impact Factor 8084 [Internet]. 2023;12:1-16. Available from: www.wjpr.net
 16. *Fruit Oils: Chemistry and Functionality*. Fruit Oils: Chemistry and Functionality. Springer International Publishing; 2019.
 17. Pandey A, Tripathi S. Concept of standardization, extraction and pre phytochemical screening strategies for herbal drug. Vol. 2, ~ 115 ~ *Journal of Pharmacognosy and Phytochemistry*. 2014.
 18. Swarbrick J, Augsburger LL, Dressman JB, Hughes JA, Jones TM, Lee VHL, et al. DRUGS AND THE PHARMACEUTICAL SCIENCES Executive Editor Advisory Board. 2005.
 19. Mundhe AG, Dhapke P, Padole N, Dhoble N, Dod SR. Formulation and Evaluation of Nutraceutical Capsules. *Research Journal of Pharmacognosy and Phytochemistry*. 2024 Jul 1;16(3):159-64

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