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Original Article

Formulation and Evaluation of Nutraceutical Dosage Form Derived from *Vigna aconitifolia, Eleusine coracana* and *Chenopodium quinoa*

Ritu Saini*, Meenakshi Bajpai

Institute of Pharmaceutical Research, GLA University, Mathura, Uttar Pradesh, INDIA.

ABSTRACT

Background: Natural products such as plants and herbs are primely opted for by the consumers these days for the treatment or mitigation of any health condition. And countless options present in our surroundings, that can offer an aid in the management and cure of many nutritional health conditions. *Vigna aconitifolia* (Moth bean), *Eleusine coracana* (Finger millet) and *Chenopodium quinoa* (Quinoa) are some of the examples, that are enriched with a huge amount of nutrients like vitamins and minerals (iron and calcium) that has a potential to be utilized as for the management of Iron deficiency anemia. But the limitations associated with these herbs is, their fluctuating therapeutic effects due to low solubility, poor bioavailability, and low stability. **Materials and Methods:** In order to overcome all these limitations, *Vigna aconitifolia, Eleusine coracana* and *Chenopodium quinoa* were formulated as nutraceutical granules (a standardized solid dosage form). These crops are well-known for their lofty nutritional potential, which includes a wide range of bioactive ingredients and amino acids, as well as minerals and vitamins. This study examined the use of various materials, such as binders (potato and maize starch), flavors, sweeteners, and other necessary components, to formulate the nutraceutical granules using wet-granulation method. The granules were then tested for different standardization parameters like micromeritic evaluation, organoleptic characterization, physico-chemical evaluation, and *in vitro* dissolution study. The herbal powders of *V. aconitifolia, E. coracana* and *C. quinoa* were successfully formulated into nutraceutical dosage form. **Results and Discussion:** The results revealed that these nutraceutical granules showed improved physico-chemical, and micromeritic properties as compared to their powdered forms. *In vitro* dissolution profile of the granules was found to be upto 99.32%. **Conclusion:** These are the economical and feasible options for the conventional formulations available for the management of nutritional disorders like iron deficiency anemia due their remarkable mineral (iron) content.

Keywords: Nutraceutical, Moth beans, Finger millet, Quinoa, Granules.

Correspondence:
Ms. Ritu Saini
Institute of Pharmaceutical Research, GLA University, Mathura, Uttar Pradesh, INDIA.
Email: akanshapharma24@gmail.com
ORCID: 0000-0003-0705-8603

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INTRODUCTION

India has a long history of relying on herbal remedies, reason being their safety and efficacy. Worldwide, there are millions of households that are utilizing these herbal remedies on regular basis, and within the next few years, that figure is expected to be two-fold.[1] The phrase 'Nutraceutical' originates from the concepts of, 'nutrients' and 'pharmaceuticals' which combine the advantages of both.[2] A Nutraceutical is a food constituent which is safe and medicinally effective in both preventing and treating a range of medical conditions.[3] These are derived or formulated from dietary ingredients and marketed as medicines that are not often connected with food but offers protection from chronic illness.[4] People occasionally recognized the nutraceuticals as "pharma-foods" and considered them as food supplements even though they have the power to evolve into an arsenal that can be utilized in averting and management of various health conditions, additionally to nutrition but ahead of medication use.[5] Therefore, nutraceuticals define an entirely new segment thar blurs the line separating drugs and foods, and may perhaps be perceived as the expansion of dietary regimes. Though pharmaceuticals necessarily stick to certain guidelines concerning their effectiveness, safety, manufacturing, and usage in therapy, to be qualified as authorized and marketable goods, but these regulations are often do not applicable for nutraceuticals.[6]

In addition to gaining a foothold in the global food market, nutraceuticals and functional foods have also penetrated the psychology of the middling buyer by providing the body with high-quality nutrients through the simple consumption of

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various supplement formats, such as capsules, pills and tablets, etc.,[7] Nutraceuticals are a big part of the dietary supplements market, and is projected to generate USD 279.6 billion in revenue by 2032. This segment is characterized by the widespread consumption of dietary supplements, such as vitamins, minerals, and herbal extracts, as well as probiotics, for supplementation and enhancement of nutrition. The interest in dietary supplements is driven by the growing awareness of preventative health care and personal wellness practices, as well as the growing number of malnourished populations.[8]

The growing awareness in people about the connection between diet and health has pushed intake of these items to new highs, especially in nations where the aged population resides and health-care expenses are going-up,[9] therefore it is essential to explore fresh and more up-to-date sources of nutraceuticals together with organic and nutritious supplements with the anticipated effectiveness.[10] Diets fortified with food substances enriched with nutrients demonstrated to impart antioxidant properties that can be employed to formulate health nourishing goods.[11] Wholegrain cereals-based formulations are gaining popularity due to their richness of phytochemicals and dietary fibers, which imparts a variety of positive impacts on health.[10] "There is nothing exists on the earth that cannot be employed for medicinal application under the correct conditions and settings" Sutrasthana, XXVI, 12: Charaka Samhita.[5] Reported literatures indicated that nutraceuticals with numerous health benefits may pose a supportive approach for treatment and management of diseases.[12,13] A daily dose of nutraceuticals might help you keeping healthy and keeping the doctor away.[14] The utilisation of nutraceuticals as a means of achieving desired therapeutic goals with fewer side effects than conventional therapeutic treatments has been a huge financial success. Pharmaceutical and biotechnology businesses have a strong preference for the research and manufacture of nutraceuticals over medications.[5]

It has recently been proposed to reframe the notion of nutraceuticals in order to distinguish them from supplements and medicines in a more precise manner. Nutraceuticals are different for each type of food. For instance, a phyto-complex is a nutraceutical of plant-based food while the reservoir of secondary metabolites is the nutraceutical of animal-based food. Both nutraceuticals and pharmaceuticals are concentrated and delivered in the appropriate pharmaceutical form, and can yield positive health outcomes, whether it is preventing and/or treating a disease.[6,12] Nutraceuticals are a new toolset in medicine that has yet to be fully explored for its full potential. Compounds with nutritious and nutraceutical value include anti-oxidants; vitamins; polyunsaturated fatty acids, dietary fibres, pre-biotics, and pro-biotics. Nutraceuticals currently exist in a limbo amid pharmaceutical products and food hence, their efficacy and safety profile must be backed with clinical evidence.[5,6,12]

Vigna aconitifolia, famously called by the name 'moth beans' is the most underappreciated but incredibly beneficial legume amongst the Vigna genus that includes many well-known food species such as mung beans, black gram beans, and cowpeas.[15] It is widely consumed in the northern part of India, being an excellent source of proteins, amino acids, carbohydrates together with fibre, vitamins B-complex, and minerals viz. calcium magnesium, zinc, iron potassium and phosphorous.[16] This crop has great potential towards strengthening the food security and offer sustainable nutrition solutions to areas with limited resources. This legume has been found to be efficient in protecting against a variety of health matters, including hypertension, Parkinson's disease, bacterial infections, diabetes, cancer, obesity and hypo-cholesterolemia. Additionally, it has been shown to possessed with antioxidant and diuretic properties.[17]

Eleusine coracana, widely acknowledged as ragi or finger-millets, is a primordial grain, distinguishes itself as a nutritional power station that is highly enriched with protein, fibers, carbohydrates, amino acids, minerals calcium,[18] iron, and antioxidants. Its nutrients profile and flexibility to a broad spectrum of farming environments have rendered it an indispensable chief food in countless parts of the world. In many developed countries, millets do not get attention they deserve. But in developed nations, there is a ton of potential to turn millet into delicious, nutritious foods and drinks.[19] Plus, since millets do not have gluten, therefore a great option for people with celiac disease. It is packed with antioxidants, anti-ageing, anti-cancer, anti-diabetic, anti-microbial and anti-hyperlipidemic benefits, plus it helps prevent digestive issues, malnutrition, bone disease, and more.[10,13]

Chenopodium quinoa, at times, referred to as 'superfood,' is a pseudo-grain renowned for its great nutritional and gluten free content, that has an incredible balance of vital amino acids along with a rich content of proteins, lipids, fiber, vitamins and antioxidants, and minerals like iron, magnesium and calcium that give it an edge over other crops. Moreover, it has significant levels of phyto-constituents that have positive effects on healthiness, such as saponins, phytosterols, and phytoecdysteroids. Quinoa has been demonstrated to provide substantial benefits for digestive, cardio-vascular, and gastro-intestinal related issues but still it is not frequently consumed despite all these advantages.[20] The reason being are its expensive importation, and consumer ignorance of the benefits it provides. By contributing about fifty percent of one's daily requirements for both protein and calories, grains play a vital role in the human diet. Furthermore, it could be a great alternative for people who are at risk of certain health issues, for instance, children, women at risk of osteoporosis, older person, athletes or one with lactose intolerance, anemia, diabetes, obesity, dyslipidaemia, and celiac disease. Quinoa has also been recommended by NASA to meet the needs of people on astronomical missions.[21]

Moth beans, Finger millet, and Quinoa grains contain a substantial number of bioactive compounds, and the incorporation of these components into a nutraceutical dosage format offers the potential for beneficial health outcomes. Furthermore, the formulation of nutraceutical products from these natural sources provides an opportunity to utilize their nutritional capabilities, potentially leading to the development of functional foods and supplements tailored to a broad range of health requirements. The objective of the research paper is to deliver a comprehensive examination of the manufacturing processes, as well as a rigorous quality evaluation of nutraceutical granules derived from the Moth beans, Ragi, and Quinoa plants, by describing the fundamental principles underpinning the preparation of such products. This provides the opportunity for health benefits, and we hope to gain valued information that can result in the production of novel functional foods, as well as innovative nutraceutical-based interventions addressing a wide range of health necessities and improved health indicators.

MATERIALS AND METHODS

Collection of Herbs

Moth beans, Finger millets and Quinoa grains were procured from the local seeds market of Roorkee, Uttarakhand, India. Maize starch and Potato starch was sourced from Shop palace, while Tomato powder was obtained from Shree Hari Industries, Stevia was acquired from Parashakti Industries and Quercetin was procured from Chemdyes Corporation. Remaining all reagents and chemicals were of analytical grade.

Preparation of Herbal Powder

The seeds of Moth, Finger millet, and Quinoa were bought, cleaned by washing, and dried to a consistent weight in the shade. These dried seeds were then ground in a grinder and then sifted through sieve No. 60. The seeds powder was then used to prepare the nutraceutical granules.[22]

Organoleptic Characterization

Organoleptic characteristics of Moth Beans Powder (MBP), Finger Millet Powder (FMP), and Quinoa Grains Powder (QGP) were determined by the analysis of their colour, smell, and taste at room temperature.[23-25]

Pre-liminary Phytochemical Screening of Herbal Powders

Phytochemical evaluation on the prepared seed powders MBP, FMP, and QGP were performed for the occurrence of alkaloids, anthraquinones, cardiac-glycosides, flavonoids, polyphenol, saponins, tannins, and carbohydrates using standard procedures of.[24,25]

Physico-chemical Characterization of Herbal Powders

Total Ash Value

Each powder was poured into a weighed crucible (X) weighing 2 g (Y) and heated to a consistent weight of 105°C. after the cooling period, the crucible and its contents were reheated in a carefully controlled manner to draw out moisture and char the sample completely. Gradually, the temperature was increased until the sample was almost carbon-free. The sample was then heated to 600°C, and the residue appeared almost white, demonstrating the lack of carbon. After cooling, both the crucible and contents were weighed (Z) and the process of heating and cooling was repeated to reach a residue weight that did not represent any further substance loss. Calculation of the ash value was done using the following expression:[26]

Weight of empty crucible=X;

Weight of herbal powder=Y;

Weight of crucible+Ash=Z;

Weight of Ash=X-Z;

'Y' g of herbal powder gives=(X-Z) g of Ash;

100g of herbal powder gives=100x (X-Z) %w/w of Ash.

% Loss on Drying (%LOD) or % Moisture Content

Each sample of 2g (W1) powder was carefully placed in separate glass petri dishes (pre-heated and pre-weighed). The glass petri dishes were dried then using hot-air oven at 130°C for 2 hr or until a uniform weight is reached. After drying, the samples were transferred to the desiccator to cool, and then the petri dishes were Weighed again (W2). The difference between the pre-dried and post-dried weight is expressed as the percentage loss on drying or % moisture content.

$$Moisture\ content\ (\%) = \frac{(W1 - W2)}{W1} \times 100$$

Bulk Powder Characteristics

The parameters were determined to evaluate the bulk powder characteristics of the herbal powder, including bulk density (ρb), tapped density (ρt), percentage compressibility index (Carr's index) and Hausner ratio. A previously weighed quantity of each powder was transferred into a graduated cylinder, and the volume it occupied was noted down as, V_0. Then the graduated cylinder was then tapped on a flat surface until a constant volume attained, V_t. The calculation of bulk density and the tapped density were done using the following formulae and expressed as g/mL.

$$Bulk\ density\ (\rho b) = \frac{w}{V_0}$$

$$Tapped\ density\ (\rho_t) = \frac{w}{V_t}$$

Table 1: Composition of Nutraceutical Granules of Moth Beans, Finger Millet, and Quinoa powder.

Ingredients	Moth Beans Formulation				Finger Millet Formulation				Quinoa Formulation			
	MBF 1	MBF 2	MBF 3	MBF 4	FF 1	FF 2	FF 3	FF 4	QF 1	QF 2	QF 3	QF 4
Active Ingredient (g)	1	1	1	1	1	1	1	1	1	1	1	1
Potato Starch (%)	2	5	2	5	2	5	2	5	2	5	2	5
Maize Starch (%)	2	5	5	2	2	5	5	2	2	5	5	2
Tomato Powder	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs
Stevia (S)	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs
Preservative (P)	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs	qs

Table 2: Organoleptic characteristics of Powders.

Para-meters	MBP	FMP	QGP
Appearance	Powder	Powder	Powder
Colour	Creamy white with brown tinge to it.	Greyish brown in colour with red tinge to it.	Creamy yellow to ivory white in colour.
Odour	Smells like nutty powder.	Smells like wheat flour.	Earthy, grass like smell.
Taste	Nutty taste, or taste like moth beans.	Sweet taste with little dryness.	Earthy, grassy and a little bitter in taste.

The calculation of Carr's index as well as the Hausner ratio were done using following expressions.[27]

$$Carr's\ Index\ (\%) = \frac{\rho t - \rho b}{\rho^t} \text{x}100$$

$$Hausner\ ratio = \frac{\rho t}{\rho^b}$$

Angle of Repose

A funnel was placed over graph paper on a plane surface at a specific height. Each powder was poured through the funnel and formed a conical pile of granules. Then, its (pile) height (h) and its base radius (r) were measured to determine the angle of repose using the formula.[28]

$$Angle\ of\ Repose\ (\theta) = \tan^{-1} h/_r$$

Preparation of Granules

The moist granulation technique was used to prepare the nutraceutical granules. All the components were weighed as indicated in Table 1 and carefully incorporated. Subsequently, the powder mixture was supplemented with a small quantity of binder paste to form a wet mass. The wet mixture was strained through sieve number 12. The pre-processed moist granules were dried under the oven at 40°C. The granules were re-strained through sieve number 16 to minimize the number of larger granules. The process was repeated for all the remaining compositions.[29]

Evaluation of Nutraceutical Granules

The granules produced were subjected to a variety of evaluation parameters in accordance with the methods previously described. These tests covered the following: Organoleptic characteristics; micromeritic properties (bulk density; tapped density; angle of repose; Carr's index; Hausner ratio) and % Loss on drying.[26-28]

In vitro Dissolution Study

The *in vitro* dissolution study of the granules was performed by employing USP-apparatus type-2, or paddle type. The granules equivalent to 1 g of the herbal powder were submerged in 900 mL, 0.1 M HCl buffer maintained at of 37±0.5°C and with a rotation rate 0f 50 per minute. Aliquots of the dissolved medium were taken from the container at intervals of 5, 15, 30, 45, 60, 90, and 120 min and immediately replaced with freshly prepared dissolution medium. After dilution, the drug release was evaluated using UV-visible spectrophotometer (Elico SL-210) at 372 nm.[30] The percentage of drug release was calculated and a graph was generated in relation to time using a graphical assessment technique to compare the dissolving pattern and the concentration of the reference marker, Quercetin dihydrate,[10,17,21] for different time-points.[29]

RESULTS

Organoleptic Characteristics

At room temperature, color, odour, and taste were examined. The organoleptic characteristics of MBP, FMP, and QGP are shown in Table 2.

Preliminary Phytochemical Screening of Herbal Powder

Preliminary phytochemical analysis was performed on all powder sample and the tests revealed the occurrence of Phyto-ingredients such as alkaloids and cardiac-glycosides as well as flavonoids, polyphenol, tannins, saponins and carbohydrates in Moth beans powder,[17,31-34] Finger millet powder,[35-37] and Quinoa grain powder.[38-40] However, some results were negative for instance, anthraquinones and triterpenes, which referred to their absence in all the samples, as presented in Table 3.

Standardization of Herbal Powders

Physico-chemical Parameter

The quantification of % LOD or moisture content and ash content in the nutritional analysis of herbal powders is of the utmost importance as it directly affects the nutritional content of food materials, the shelf-life of the foodstuffs, storage, etc. The ash value and % LOD of MBP, FMP, and QGP were determined (Table 4).

Micromeritic Characterization of Herbal Powders

The flow-ability of the herbal powders is of utmost importance in powder micromeritics[41] and was determined by looking at the results of Angle of repose, Carr's index and the Hausner ratio. All the powders passed the test well, in terms of Carr's index, Hausner ratio and Angle of repose with values ranging respectively from (23 to 25)%, above 1.20, and (35 to 46)°. Table 5 illustrated the micromeritic properties as well as bulk powder characteristics including bulk density and tapped density of herbal powders, which are also important factors to consider when looking at the flow properties.

Table 3: Phytochemical Screening Results of MBP, FMP and QGP.

Phyto-Constituents	MBP	FMP	QGP
Alkaloids	+	+	+
Anthraquinones	-	-	-
Cardiac-glycosides	+	+	+
Flavonoids	+	+	+
Polyphenol	+	+	+
Saponins	+	+	+
Tannins	+	+	+
Triterpenes	-	-	-
Carbohydrates	+	+	+

Table 4: %LOD or Moisture content and Ash value of Herbal Powders.

Para-meters	MBP	FMP	QGP
%LOD or Moisture content (%w/w) Mean (n=3)±SD	8.7±0.15	9.4±0.25	3.3±0.15
Ash Value (%w/w) Mean (n=3)±SD	2.94±0.02	3.53±0.05	3.16±0.20

Table 5: Micromeritic properties and Bulk Powder Characteristics of Herbal Powder.

Para-meters	MBP	FMP	QGP
Carr's Index (%) Mean (n=3)±SD	23.52±0.011	25.66±0.017	23.73±0.017
Hausner Ratio Mean (n=3)±SD	1.21±0.011	1.33±0.005	1.33±0.005
Angle of Repose (°) Mean (n=3)±SD	35.36±0.017	46.64±0.026	43.81±0.015
Bulk density (g/mL) Mean (n=3)±SD	0.718±0.003	0.568±0.008	0.428±0.010
Tapped density (g/mL) Mean (n=3)±SD	0.880±0.001	0.768±0.007	0.555±0.005
Type of Flow	Passable	Passable	Passable

Table 6: Organoleptic characteristic of Nutraceutical Granules.

Para-meters	MBF1	MBF2	MBF3	MBF4	FF1	FF2	FF3	FF4	QF1	QF2	QF3	QF4
Appearance	Granular structure.				Granular structure.				Granular structure.			
Colour	Creamy reddish.				Reddish brown in colour.				Creamy reddish.			
Odour	Smells like nutty powder.				Smells like wheat flour.				Earthy, grass like smell.			
Taste	Sweet with slightly nutty taste.				Sweet taste.				Sweet taste.			

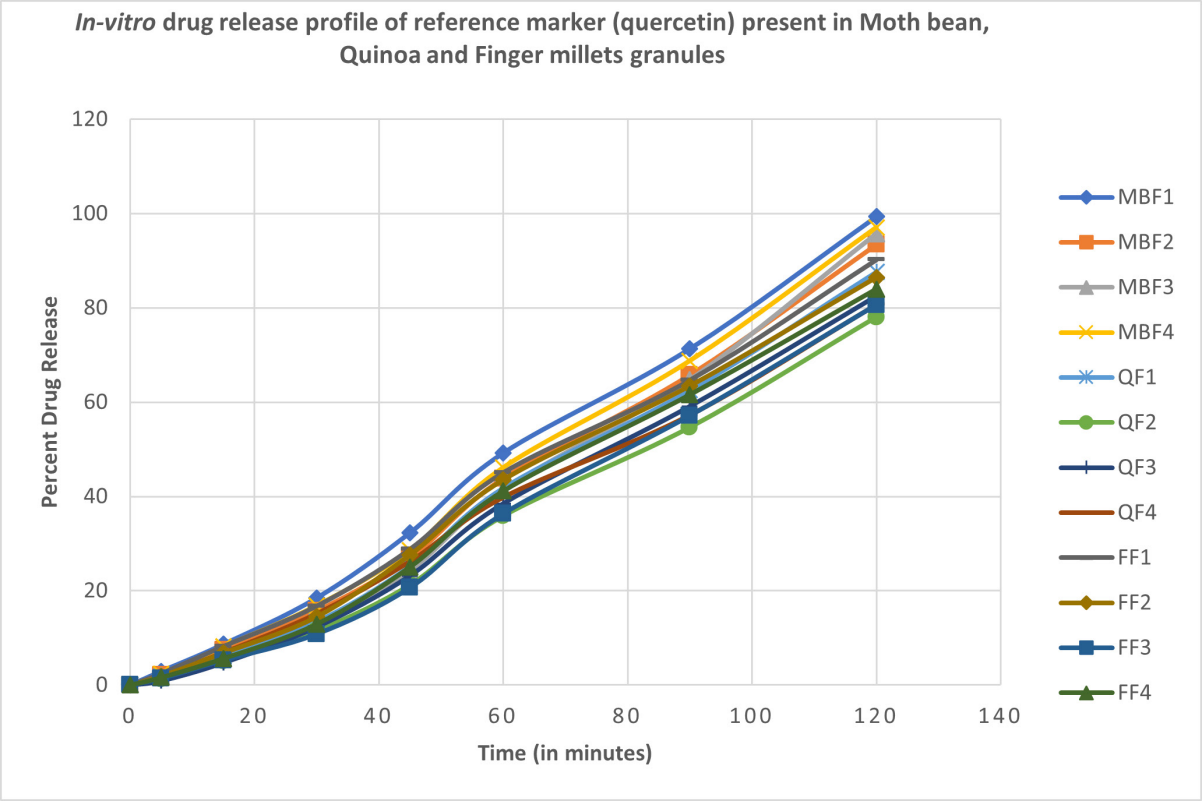

Figure 1: *In vitro* drug release profile of reference marker (Quercetin) present in Moth bean, Finger Millets, and Quinoa granules.

Evaluation of Nutraceutical Granules

Table 6 shows the organoleptic characterization of the nutraceutical granules. There slight difference in the taste and color of the formulated granules in comparison to their powdered forms while the odour remained characteristic of their powder forms. The results of micromeritic as well as physicochemical parameters performed on various granules formulated is presented in the Table 7. Mostly, these granules demonstrated better flow properties than their powdered forms, owing to the presence of binder in the composition. The primary reason behind this is, when a binder is present, the granules tend to be denser and bigger than their powder particles. In general, the more the size of the particles, the lesser the surface area, leading to a more efficient flow.

In vitro Dissolution Study

Different nutraceutical granules had different levels rate of dissolution (Figure 1). Moth bean granules had higher rate of dissolution than Quinoa and Finger millet granules in terms of Quercetin (99.32%) in 120 min.

DISCUSSION

The formulator might gain an understanding of issues pertaining to the herbal powders by examining the organoleptic qualities (Table 2). The phytochemical screening (Table 3) was performed to identify the herbal powders and found to be within the acceptable range. The resulting moisture content of the herbal powders ranging from 3.3% to 8.7% is under the permitted range and indicates the ability to inhibit the growth of yeast, fungi, or bacteria due to its low value.[40] The percentage of ash value is from 2.94 to 3.53% for the herbal powders. According to FSSAI guidelines, the herbal powders' total ash level on a dry basis cannot be higher than 7.50% (Table 4).[42] The micromeritic characterization (Table 5) of the powders indicated their sticky nature, so in order to make them flowable, granulation of the powders is required. In order to improve the taste and cover the

Table 7: Flow properties and Bulk Powder Characteristics of Nutraceutical Granules.

Para-meters	MBF1	MBF2	MBF3	MBF4	FF1	FF2	FF3	FF4	QF1	QF2	QF3	QF4
Carr's Index (%) Mean (n=3)±SD	21.41±0.17	18.45±0.27	21.39±0.53	11.58±0.52	12.56±0.25	21.36±0.27	20.33±0.57	21.35±0.56	11.45±0.05	18.45±0.32	14.68±0.07	18.48±0.23
Hausner Ratio Mean (n=3)±SD	1.25±0.017	1.22±0.005	1.26±0.01	1.13±0.005	1.14±0.005	1.25±0.01	1.24±0.01	1.25±0.005	1.11±0.005	1.22±0.005	1.17±0.005	1.22±0.01
Angle of Repose (°) Mean (n=3)±SD	27.68±0.41	29.16±0.13	28.24±0.20	19.52±0.45	31.66±0.22	29.65±0.04	30.46±0.13	28.60±0.35	29.45±0.39	30.40±0.51	30.36±0.31	32.40±0.35
Bulk density (g/mL) Mean (n=3)±SD	0.64±0.010	0.49±0.020	0.63±0.032	0.73±0.034	0.47±0.025	0.47±0.023	0.42±0.020	0.45±0.020	0.57±0.026	0.54±0.020	0.52±0.015	0.55±0.026
Tapped density (g/mL) Mean (n=3)±SD	0.77±0.025	0.67±0.030	0.82±0.025	0.80±0.041	0.53±0.017	0.54±0.03	0.52±0.025	0.58±0.011	0.62±0.020	0.66±0.025	0.61±0.015	0.66±0.020
Moisture content (%w/w) Mean (n=3)±SD	1.85±0.04	1.99±0.12	1.91±0.03	1.86±0.05	1.74±0.04	1.62±0.02	1.93±0.06	1.86±0.05	1.68±0.09	1.74±0.04	1.73±0.04	1.34±0.18

smells of the herbal powders and making them more palatable, flavours and sweeteners are also added.[41]

Nutraceutical granules were then formulated using herbal powders (MBP, FMP, and QGP). In order to determine if the granules were suitable for use, different parameters such as, organoleptic properties, flow properties, bulk powder characteristics, physicochemical properties were evaluated on the granules (Tables 6 and 7). The flowability of granules is directly associated to the angle of repose, which was (19-33)º quite well[28] in all the prepared granules when compared to their powdered forms. As the particle size increased, the flow of the powders also improved. The compressibility index (Carr's index) and Hausner ratio of the granules were also improved from (23-26)% to (11-22)% and (1.21-1.33) to (1.10-1.26). There was not much difference in the case of bulk density and tapped density of the granules, which were (0.50-.82) and (0.42-0.73) respectively.

Four batches of each powder *i.e.*, 24 batches were prepared by using potato starch and maize starch as binder at concentrations (2 to 5)%w/v. All 24 batches were subjected to *in vitro* dissolution assessment (Figure 1). From *in vitro* dissolution profile, granules of Moth Bean powder (MBF1 to MBF4) were having better release profile of the Quercetin dihydrate (reference marker) about 99.32% in uniform manner within 120 min. The solubility of the herbal powders was enhanced by its granule formation, which increased the powder's surface area in contact with the dissolving media. It is anticipated that lower drug solubility will result in a reduced dissolution rate. Also, the Noyes-Whitney law states that the surface area and concentration gradient are directly related to the dissolution rate. Although the granules of quinoa as well as finger millet were also had a uniform drug release but less in comparison to moth bean granules.

CONCLUSION

The herbal powders prepared using moth beans, finger millet, and quinoa grains were extensively evaluated and provided the basis, to determine their feasibility to be formulated into the nutraceutical granules. Organoleptic characterization, physiochemical parameter analysis and micromeritic and phytochemical screenings were all positive, indicating that the powders had qualities within acceptable parameters. Extensive evaluation of the granules was conducted to determine their suitability for use. Parameters such as organoleptic properties, flow characteristics, bulk powder characteristics, physiochemical properties and *in vitro* dissolution study were carefully evaluated on the granules. The results suggest that these nutraceutical granules are advantageous due to its plant-based formulation, which reduces the risk of adverse side effects when comparing to other conventional formulations. This study highlights the potential for nutraceutical delivery using moth bean granules, and highlights the importance of thoughtful formulation design to achieve optimal release profiles, thus contributing to the wider

field of herbal nutraceutical development. It is an ideal supplement for the management of iron deficiency anemia. The herbs used in these granules are readily available during any season and are not expensive, making it an economically viable product.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

MBP: Moth bean powder; **FMP:** Finger-millet powder; **QGP:** Quinoa grain powder; **MBF1 to MBF4:** Moth bean formulations; **FF1to FF4:** Finger-millet formulations; **QF1 to QF4:** Quinoa grain formulations.

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