Research Article

Development of Moringa enriched herbal gummies for enhanced nutrition

Varun Kumar, Richa Jha, Tanu Shishodia, Nidhi Jain*, Babita Kumar

Sanskar College of Pharmacy & Research, Ghaziabad, Uttar Pradesh, India

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Abstract

The aim of this study was to design and develop the herbal gummies using extract of moringa with other suitable additives. Moringa (*Moringa oleifera*) serves for its various medicinal uses due to its nutritional profile and presence of different bioactive compounds like Vitamin A, Vitamin B, Vitamin C, Vitamin E, Calcium, Magnesium, Copper, Iron etc. Potential moringa uses includes antioxidant action, anti-inflammatory action, anti-diabetic action, support gut health, liver health and heart health etc. Gummies have advantages over other dosage forms like palatability, portability, chewability and patient acceptability etc. The innovative moringa gummies were crafted using suitable excipients like fructose, gelatin, citric acid, sodium benzoate and flavouring agent to unlock the nutritional potential of Moringa offering a delicious and easy to consume supplement that promote the therapeutic benefits and support overall health and wellness.

***Keywords*:** *Moringa oleifera*, gummies, nutrition, herbal, vitamins

Introduction

There are different type of pharmaceutical formulations and dosage form available in the market, which can be administered from different routes like oral route, transdermal route, intravenous route, ophthalmic route, ocular route etc. Acknowledging all the parameters oral route of administration is considered the most convenient route of administration, till date it's widely accepted among patients with different ages and diseases (Akhtar and Dev, 2017)

Although, one of the problems arise in the oral route of administration experienced by different patient (mainly paediatric and geriatric age group) is difficulty in swallowing the oral dosage form, this is known as dysphagia. Patients with such problems may try to administer the oral dosage form by different remedies like crushing it into a powder form, mixing it with liquid (commonly water or food to be eaten) etc. Such remedies may lead to dosage inaccuracy, changing of drug release and bioavailability etc.

Address for Corresponding Author:

Ms. Nidhi Jain

Associate Professor

Sanskar College of Pharmacy and Research, Ghaziabad- 201302, Uttar Pradesh, India

E-mail: jain.nidhi2505@gmail.com

In order to resolve such problems and difficulty, Gummies formulation serves as an alternative for oral dosage form with several advantages over other oral dosage form (both liquid and solid) like tablets, capsules etc. Gummies provides better flavouring taste, pleasant appearance, palatability, portability, chewability and easy swallowing and increase patient compliance to the patient with or without dysphagia. Gummies turned out of be one of the most convenient methods for delivering the active pharmaceutical ingredient for consumption by children, as they are easily accepted by children and adults as well.

Moringa oleifera belongs to family of Moringaceae, commonly known as drumstick tree, horse radish tree and miracle tree. Moringa oleifera is well known for its uses for therapeutic purpose in pharmaceutical field. Moringa comes out with different therapeutic effects for different diseases and health benefits specially enhancing the immune system (Dhimmar et al., 2015). Nutritional components in moringa plant includes vitamin A, vitamin B1, vitamin B2, vitamin B3, vitamin C, vitamin E, iron, calcium, magnesium, sulphur etc. Resulting, moringa plant is responsible for different therapeutic properties including antioxidant, anti-inflammatory, anti-diabetic, anti-cancer properties and it is mainly used as immunity booster in children (Sanchez-Machado et al., 2010; Sahay et al., 2017).

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Moringa oleifera have high value due to its rich nutritional profile. As per the studies almost every part of moringa plant including leaves, seeds, pods and roots said to have nutritional value for different health benefits, although leaves being the most nutrients containing and commonly used. Moringa leaves contain several macronutrients, vitamins, minerals, phytochemicals and other beneficial compounds (Gopalakrishnan et al., 2016; Aseidu- Gyekye et al., 2014).

Gummies formulation in pharmaceutical field traditionally developed as confectionery products, it have also gained significant attention as novel drug delivery systems for different pharmaceutical active ingredient, nutraceuticals and dietary supplements (Akhtar and Dev, 2017). Gummies formulations are widely used as a medium to delivering the active pharmaceutical ingredient for consumption by children (although it's widely accepted among adults as well) and patient with dysphagia (difficulty in swallowing conventional solid oral medicine and the risk of choking by liquid preparation) (Banjongsinsiriet al., 2020).

Gummies formulation serves many key advantages and benefits that make them increasingly popular in pharmaceutical, nutraceuticals and dietary supplements preparation. Their characteristics offer distinct benefits and advantages over conventional oral dosage form (tablets, capsules and liquids), which are as enhanced patient compliance, improved aesthetic and sensory appeal, flexible dosing options, masking of unpleasant tastes and odours, no water requirement, market acceptability, suitable for dietary supplements and low manufacturing cost (Arifa-Begum et al., 2018; Crawford et al., 2021; Gan et al., 2022).

Material and Methodology

Materials

Sucrose and gelatin were purchased from Merck, Mumbai; Citric acid was purchased from CDH, New Delhi; Fructose and Sodium benzoate were purchased from Qualikems, New Delhi; Mango flavour, olive oil and Moringa leaves were obtained from local market.

Extraction of Moringa leaves

Moringa leaves constituents were extracted by the steam distillation method. Steam distillation was a process by which volatile bioactive components were evaporated and essential nutrients were condensed back to liquid which was used as active pharmaceutical ingredients for gummies. Fresh moringa leaves were collected and were washed to remove impurities and then were air dried to remove moisture from them. The leaves were loaded into the distillation chamber and the round bottom flask was filled with distilled water. The chamber was turned on to provide heat and steam passed through the leaves and the condensed volatile mixture was collected in the receiver which was cooled by circulating water. Then, by using a separating funnel, the Moringa essential extracts were separated and were collected in a beaker (Alexander and Koidis, 2016; Utsav et al, 2025).

Fabrication of Moringa Gummies

First, gelatin powder was taken with distilled water in a beaker and was heated to form a mixture on a water bath for about 30 minutes. In another beaker, sucrose and fructose were taken to form a mixture on a water bath at 100 °C temperature. Both beakers were removed from the water bath to cool down. When the temperature of the sucrose and fructose mixture reached 80 °C, the gelatin solution was added into it by stirring continuously. The Moringa extract was properly weighed in a beaker, then the formed mixture with mango flavour was added into it when the temperature reached 70 °C by continuous stirring. Other excipients such as sodium citrate,

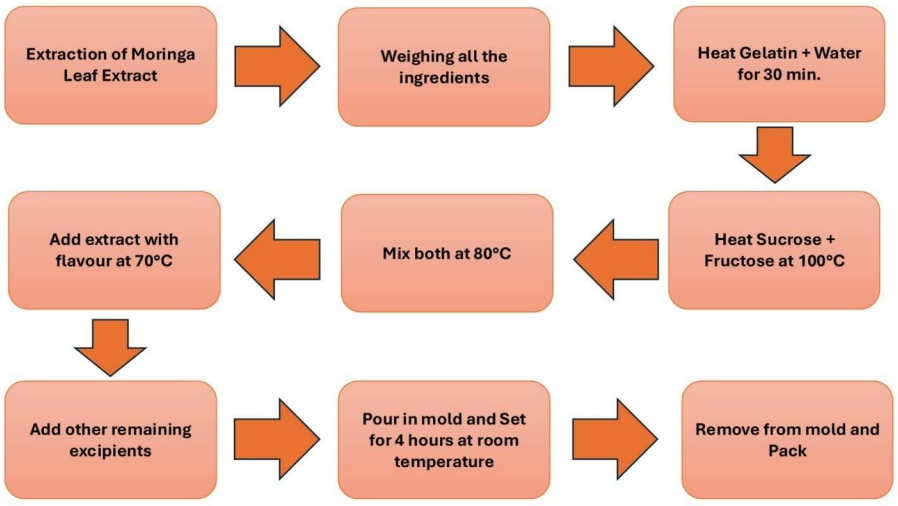

Figure 1. Flowchart Illustrating Moringa Gummies Fabrication

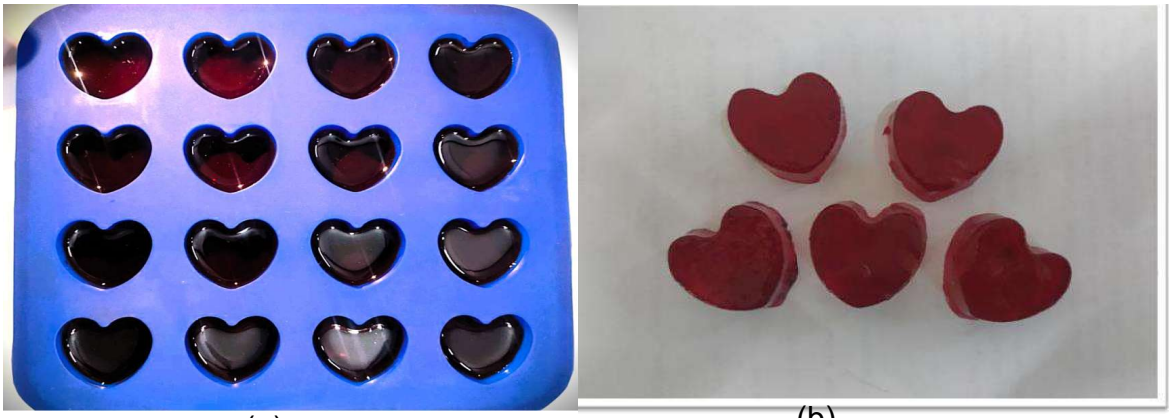

Figure 2: (a) Moulding Moringa Gummies (b) Moringa Gummies

Table 2: Composition of Moringa-Enriched Herbal Gummies

S. No.	Ingredients	F_1	F_2
1	Moringa leaves extract (ml)	10	10
2	Gelatin (gm)	6	9
3	Sucrose (gm)	10	10
4	Fructose (gm)	10	7.5
5	Citric acid (gm)	0.20	0.12
6	Sodium benzoate (gm)	0.07	0.05
7	Olive oil (ml)	5.4	5
8	Mango flavor (gm)	1	1
9	Color (gm)	q. s.	q. s.
10	Distilled water (ml)	80	60

citric acid solution, and sodium benzoate were added with continuous stirring. At last, olive oil was added, which helped to prevent bubbles, i.e., acted as a deformer, along with amaranth colour to give it a characteristic appearance. The gummies solution was prepared. The solution was poured into a silicon-shaped mould to give it a pleasant appearance and was deposited for 4 hours to form gummies. After that, they were removed from the mould carefully without breaking and stored and packed (Delgado and Banon, 2015; Jain and Kumar, 2025).

Evaluation of prepared Gummies

Organoleptic properties

Formulated gummies were evaluated physically for appearance, colour, taste, odour, shape and texture. (Nambiar and Parnami, 2008)

Dimension

The formulated gummies were subjected to dimensional analysis using a vernier calliper to determine thickness and diameter.

Weight variation

To assess weight uniformity, 10 gummies were weighed individually and collectively. The average weight was calculated, and the percentage weight variation was determined.

pH

The pH of the formulated gummies was measured using a calibrated pH meter to determine their acidity or alkalinity. This evaluation is crucial for ensuring the product's stability, safety, and compatibility.

Stickiness and Grittiness

The gummies' texture was assessed for stickiness and grittiness by gently rubbing the gummies between the fingers to check their smoothness and moisture level.

Swelling ratio

A test to analyse amount of water gummies could hold. A gummy was weighed, soaked in 100 mL of distilled water

for 10 seconds, and then re-weighed after cleaning with filter paper. The swelling ratio was calculated by the difference of weight of gummies after and before soaking divided by the weight of gummies before soaking (Panya et al., 2016).

Syneresis study

When the gel structure goes through syneresis, water molecules are released which causes shrinkage of gel structure. A high level of syneresis in chewable gummies shows poor stability and faster softening of texture. To measure the percentage of syneresis, filter paper was placed on the surface of the gummy and the weight difference before and after contact was recorded for 48 hours at room temperature. The percent syneresis was calculated using this weight difference. After 48 hours of storage at room temperature, syneresis testing was done to check changes in gummy consistency or shrinking in size (Rani et al., 2021; Kadhim and Ali, 2019).

$$\% \text{ Syneresis } = \frac{\text{Initial weight } - \text{Final weight}}{\text{Initial weight}} \times 100$$

Dispersion Time

The dispersion time of gummies is used to determine how quickly they dispersed in water. A beaker containing 100 mL of distilled water containing one gummy, was placed on magnetic stirrer for 30 minutes. The time taken for the gummy to completely disperse was recorded with the help of a stopwatch. The dispersion time of gummies is used to determine how quickly they dispersed in water. A gummy was placed in 100 mL of distilled water on a magnetic stirrer for 30 minutes. The time taken for the gummy to completely disperse was recorded with the help of a stopwatch (Khatode et al., 2022; Prakash et al., 2014).

Results and discussion

As seen in the given table the evaluated parameters are included. Both the F_1 and F_2 readings are given below.

The organoleptic properties of gummies were perceived by our sense organ. The gummies were reddish brown in colour by the use of amaranth colour, and the gummies were sweet in taste with pleasant smell. The shape of gummies were found to be heart shaped in both F_1 and F_2 and the texture of gummies were also smooth in both, F_1 and F_2. The texture of chewable gummy remains unchanged from when it was initially kept. Both formulations, F_1 and F_2 are easily chewable. F_1 gummies were little bit sticky but F_2 were found to be non-sticky. The Proper moulding showed no grittiness. The uniform spreading of gummies solution in mould resulted the non-sticky and no grittiness in gummies. The diameter and thickness of the moringa gummies were approximately 2.5cm and 0.8 cm respectively.

The citric acid was used as a pH modifier to improve the gelling power of the gelatin, this is regarded somewhat acidic. The pH meter was used to check the gummies, whether they are acidic or basic in nature. The pH of gummies was 3.3.

All the prepared gummies were found uniform in weight. In about 10 to 15 min the gummies were broken down in distilled water. The more rapidly the gummy dissolved in water, the faster the medication release. The numerous factors can affect how faster gummies dissolved. When the gummy is placed in the mouth they combine with saliva that breakdown the gelatin, sucrose and other ingredients. The disintegration can be influenced by the factors like pH, temperature, thickness and enzymes involved in saliva.

Table 3: Evaluation Parameters of prepared gummies

Parameters	F_1	F_2
Colour	Reddish brown	Reddish brown
Flavour	Sweet	Sweet
Odour	Pleasant	Pleasant
Shape	Heart shaped	Heart shaped
Texture	Smooth	Smooth
Chewiness	Chewable	Chewable
Stickiness	Sticky	Non-sticky
Grittiness	Non-gritty	Non-gritty
Diameter	2.6 cm	2.5 cm
Thickness	1cm	0.8cm
pH	3	3.3
Average Weight	4.49 ± 0.08	4.52 ± 0.11
Swelling ratio	0.06 ± 0.01	0.04 ± 0.02
% Syneresis	0.29 ± 0.02	0.21 ± 0.03
In vitro dispersion time	10 to 12 min	13 to 15 min

The swelling ratio is a test that is used to analyse the amount of water gummies hold. The swelling ratio of Moringa gummies were 0.04 ± 0.02 and the % Syneresis of gummies were about 0.21±0.03. The high level of syneresis in chewable gummies show poor stability and faster softening of texture. This testing was done to check changes in consistency or shrinkage size of gummy.

The *in vitro* dispersion was conducted on gummies to get an overview on how the gummy disintegrate and release active ingredients from their carrier. Evaluating *in vitro* dispersion time can also predict how quickly the drug starts working. The quicker the gummy dissolves, the faster the dissolved active ingredients can be absorbed. The *in vitro* dispersion time of gummies was approximately 13 to 15 min, which is optimal disintegration period of herbal gummy.

Conclusion

The study demonstrates the successful development of gelatin-based gummies incorporating Moringa extract, showcasing its potential as a nutritious and palatable supplement. The optimized gummies exhibited desirable physicochemical properties, including uniform texture, appealing color, and satisfactory stability. The incorporation of *Moringa oleifera* significantly enhanced the nutritional profile of the gummies, providing a rich source of vitamins, minerals, and antioxidants. These findings suggest that Moringa-based gummies can serve as a promising functional food product, contributing to the growing demand for healthy and convenient nutritional supplements. Future studies can focus on scaling up production, conducting sensory evaluations, and exploring the potential health benefits of Moringa-based gummies in various populations.

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