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OPTIMIZING THE FORMULATION AND PRODUCTION OF MORINGA OLEIFERA AND SPIRULINA COMPLEX NUTRITIONAL TABLET FOR NUTRIENT SUPPLEMENTATION

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ABSTRACT

The study focused on formulating nutritional tablets using Moringa oleifera and spirulina. In India, the nutritional concentration of vegetables is decreasing due to the increasing population and demand for vegetables. To meet this demand, chemical fertilizers are being used, which do not provide sufficient nutrition. To address this issue, nutritional tablets can be made from Moringa oleifera and spirulina, both of which are excellent sources of protein, vitamins, amino acids, and minerals. The recommended ratio for the tablet formulation of Moringa oleifera leaves powder and spirulina powder is 7:3. The tablet formulation consists of 88.5% Moringa oleifera and spirulina complex, 8.0% microcrystalline cellulose, 2% CMC, and 1.5% magnesium stearate. Through careful optimization of the formulation and manufacturing process, the resulting tablets exhibit desirable characteristics such as appearance, weight variation, hardness, friability, and disintegration. These nutritional complex tablets offer a convenient and effective way to supplement one's diet with a comprehensive blend of essential nutrients. Overall, this review highlights the potential of Moringa oleifera and spirulina powder as key ingredients in the formulation of nutritional complex tablets.

Keywords: Moringa Oleifera, Spirulina, Complex Nutritional Tablet, Formulation, Evolution, Nutraceuticals.

I. INTRODUCTION

Moringa oleifera belongs to the horseradish family and is an effective treatment for malnutrition. Moringa is rich in nutrients as its leaves, pods, and seeds contain a variety of essential phytochemicals. Moringa contains 7 times more vitamin C than an orange, 10 times more vitamin A than a carrot, 17 times more calcium than milk, 9 times more protein than yogurt, 15 times more potassium than a banana, and 25 times more vitamins. It is said that Potassium provides many times more iron than spinach [1]. Children who are not breastfed are more likely to show symptoms of malnutrition. Galactagogues are usually prescribed to nursing mothers to increase breast milk production. Lactogum, produced from phytosterols, serves as a precursor to hormones required for reproductive growth. Moringa is rich in phytosterols, including the hormone precursors stigmasterol, sitosterol, and campesterol. These compounds increase the production of estrogen, which in turn stimulates the growth of milk ducts to produce milk—used to treat malnutrition in children under 3 years old [2].

Moringa leaves contain many valuable compounds, including proteins, vitamins, calcium, iron, ascorbic acid, and antioxidants (carotenoids, flavonoids, phenols**).** They are giving moringa to children in various developing or developing countries of the world [3]. The presence of numerous minerals and vitamins has been reported to help improve immunity against various diseases [4].

Additionally, moringa leaves contain various amino acids. However, nutrient fluctuations frequently occur due to climate, location, and environmental factors [5].

Approximately 3.6 billion years ago, Spirulina was the oldest existing plant on Earth and the first photosynthetic life form to create an oxygen atmosphere that allowed all life to evolve. Blue-green algae are the evolutionary bridge between green plants and bacteria. Currently, the main directions of microalgae biotechnology are biofuels, agricultural biostimulants for crops, wastewater treatment, etc. Microalgae biotechnology is used for the production of health foods, cosmetics, nutritional supplements, medicines, and fuels. The most important microalgae groups are green algae and bacterial algae, while macroalgae are collected in their natural habitat. One of the algae currently cultivated for maximum protein content is the

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cyanobacterial species Athrospira, commonly known as Spirulina. Spirulina was first discovered in 1519 by Spanish scientist Hernando Cortés and the Conquistadors. During a visit to Lake Texcoco in the Valley of Mexico, Cortés noticed that spirulina was eaten on Aztec tables. Pierre Danger discovered the health benefits of spirulina when he observed flamingos living on blue-green algae. Botanist Jean Renard supported Danjard's discovery, and people soon began commercializing spirulina to reap its benefits [6]. The two most important Spirulina species are Spirulina maxima and Spirulina platensis. It is very high in micronutrients and macronutrients[7]. Its chemical composition by dry weight includes proteins, carbohydrates, vitamins such as provitamin A, vitamin C, and vitamin E, and minerals such as iron, calcium, chromium, copper, magnesium, manganese, phosphorus, potassium, sodium, and zinc[8]. It also contains pigments such as the essential fatty acid gamma-linolenic acid (GLA), chlorophyll A, phycocyanin, and carotene. Spirulina is also used in cosmetics, medicine, and wastewater treatment[9]. Its cell wall is composed of polysaccharides, 86% of which are digested and easily absorbed by the human body[10].

II. MATERIAL AND METHODS

2.1 Materials

2.1.1. Biological materials

M. oleifera fresh leaves are collected from various distinctive local villages[11]. Spirulina is usually obtained from aquatic environments such as lakes, ponds, and tanks[12]. It was one of the earliest photosynthetic creatures in nature, capable of directly converting light for complicated metabolic activities. Spirulina grows optimally in the pH range of 9-11[13].

2.1.2. The main instruments and reagents

Main equipment: constant temperature drying oven, ultrafine grinder, vibrating sieve machine, mixer, constant temperature and humidity chamber, electronic balance, tablet hardness tester, crushing tester, intelligent disintegration tester, and rotary tablet machines.

Reagent: Microcrystalline cellulose (food grade), magnesium stearate (food grade), sodium carboxymethyl cellulose (food grade), and so on [14].

2.2 Methods

2.2.1. Production process

The manufacturing process of M. oleifera and spirulina complex nutritional tablets is shown in Figure 1.

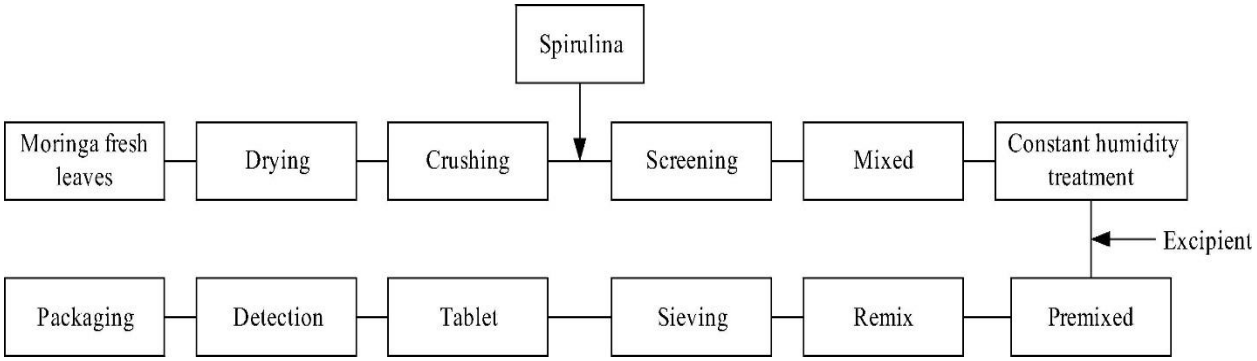

Figure 1. The production process of complex nutritional tablets Moringa oleifera and Spirulina[15].

2.2.2. Process operation points

① After collecting fresh moringa leaves, remove the yellow leaves and rotten leaves, cut off the long petioles, and dry them in an oven preheated to 60℃ for 8 to 12 hours.

② Grind the dried moringa leaves and spirulina separately. For sieving, a vibrating sieve machine is used to obtain raw materials of different sizes and mix them according to the ratio.

The proportion of excipients is low. To ensure even mixing, first take 15-20% of the ingredients and premix with the excipients for 5 minutes. After premixing, add the remaining raw material mixture for 5 minutes and perform the mixing process twice to make the sample homogeneous [15].

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2.2.3. Evaluation index of M. oleifera and spirulina complex nutritional tablets

(1) Establishing evaluation criteria

Referring to Pharmacopoeia (2010 edition) (State, 2010) and other relevant information, the article established M. oleifera and spirulina complex nutritional tablet evaluation index in terms of sheet-shaped appearance, piece weight variation, hardness, friability, disintegration time, and other aspects (see Table 1).

(2) Evaluation method

- **A leaf-shaped appearance**. Collect 20 samples in clean white porcelain containers under diffused sunlight or artificial light similar to sunlight and visually inspect for color, luster, and condition.
- **Differences in tablet weight**. Take 20 samples, accurately weigh the total weight, determine the average piece weight, and then accurately weigh each piece. Compare the weight of each piece to the average tablet weight per piece. Next, calculate the relative mean deviation.
- **hardness**. Take 20 samples, measure their hardness with a hardness meter, and calculate the average value.
- **Fragility**. Take 20 samples, blow out the powder with a hair dryer, weigh them accurately, insert the crush tester into the cylinder, and rotate them 100 times. The powder is extracted and removed using the same method of precise weighing, statistics, and analysis.
- **Decay time**. Take 20 samples and place them in an intelligent disintegration device to observe and determine the disintegration and calculate the average disintegration time.

Table 1. Moringa oleifera and spirulina complex nutritional tablets evaluation index.

Index and weight			First level	Second level	Third level
Index	Detection method	Weight	0.8–1.0 * weight	0.6–0.8 * weight	0.4–0.6 * weight
Slice shape and appearance	Visual inspection	30 points	Complete and clean, color uniformity, no mottle, no foreign matter	In order, color is not obvious, less clutter and foreign matter	Irregular edges, dull, with a clear clutter or foreign objects
Weighing difference	Electronic weighing scales calculate the relative average deviation	10 points	less than 5%	5–10%	>10%
Hardness	Tablet hardness measuring instrument	20 points	40–60 N	15–40 N	<15 N
Friability	Friability tester	20 points	Did not check the breaks, cracks, and crushed pieces, weight of more than 1%	Did not check the breaks, cracks, and crushed pieces, weight of more than 1%	Detect breaks, cracks, and crushed piece
Disintegration time	Measured by intelligent disintegration instrument	20 points	6–10 min	3–6 min	<3 min, >10 min

2.2.4. Formulation of M. oleifera and spirulina complex nutritional tablets

(1) Raw material ratio between Moringa leaf powder and spirulina powder

There have been several studies conducted on the nutritional value of Moringa leaves and spirulina[16]. the primary nutrients which are represented in Table 2, by the recommended daily nutrition guidelines put forth by the International Union of Nutritional Sciences body in 2011; through extensive analysis and statistical calculation, the optimal raw material ratio of Moringa leaf powder and spirulina powder is obtained[17].

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Table 2. Comparison of major nutrients between Moringa and spirulina (per 100 g).

Components	Protein (gm)	Dietary Fibers(gm)	Linolenic Acid(mg)	Carotenoids (mg)	Dimensions C (mg)	Dimensions E (mg)	B	Biotin (µg)
Moringa Leaf	27.50	19.2	300	41.87	73.90	155.67	184.57	78.60
Spirulina	69.0	3	1500	170.0	8.80	12.00	60.00	25.00
Ratio	1:2.5	6.4:1	1:5	1:4.06	8.40:1	12.97:1	19.74:1	3.14:1
ADI	55-65	20-30	3000-4000	6-15	60-100	10-12	200-300	30-40
Composition	P(mg)	Ca(mg)	K(mg)	Mg(mg)	Fe(mg)	Mn(mg)	Zn(mg)	Se(µg)
Moringa Leaf	280.80	2357.03	1759.37	395.03	13.54	64.32	2.78	13.10
Spirulina	1090.00	148.00	1600.00	270.00	38.00	2.44	4.82	10.0
Ratio	1:3.89	15.93:1	1.10:1	1.46:1	1:2.81	26.36:1	1:1.74	1.31:1
ADI	600-700	700-800	2000	315-360	10-15	3.5-4	12-15	50-100

(1) Selection of excipients

Excipients are a crucial part of tablet manufacturing that works in conjunction with the main active components. They include a wide variety of ingredients, such as wetting agents, lubricants, diluents, disintegration agents, and binders. The unique properties of the raw ingredients and the production method for tablets determine which excipients should be used. The main objective of this study is to improve material flow, pressure, and tablet disintegration through the use of lubricants, disintegrators, and binders. We use a lot of data, and Table 1 is what we use as an evaluation criterion. We first take into account various excipient concentrations, such as sodium carboxymethyl cellulose (ranging from 0.5% to 2.5%), microcrystalline cellulose (ranging from 2% to 10%), and magnesium stearate (ranging from 0.5% to 2.5%), to perform a single-factor test[18].

(2) Optimization of formulas

Using range analysis, create an orthogonal optimization test based on the study of individual excipient characteristics, and score the results by Table 1. This will help you choose the best combination of ingredients for your formula[19].

2.2.5. Production process optimization of M. oleifera and spirulina complex nutritional tablets

The quality of the tablet is directly influenced by the size of the raw powder in the direct powder compression process. Larger powder particle sizes can lead to tablets displaying lobes, spots, and excessive hardness[21]. Conversely, smaller powder particle sizes result in quicker tablet passage[22]. However, excessively small sizes may induce agglomeration during mixing, adversely affecting the mixing process and increasing the likelihood of sticking during tablet compression[23].

For single-factor experiments, powder sizes within the ranges of 40–80, 80–120, 120–200, 200–300, and 300–500 have been experimentally selected. Additionally, the moisture content of the raw powder has a direct impact on tablet quality[25]. High moisture levels can impede material flow, promote microorganism and mold

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growth, and reduce shelf life[26]. Conversely, overly low moisture content can result in loose and incomplete tablets, inadequate hardness, and a significantly reduced tablet passage rate[27].

To assess the impact of moisture content, a single-factor test for tableting is conducted using moisture content levels of 4%, 6%, 8%, 10%, and 12% with M. oleifera and Spirulina powders[28]. Raw material moisture content is controlled using a constant humidity chamber with controlled relative humidity and drying time[29].

The manufacturing pressure plays a crucial role in tablet formation and quality[30]. In the experiment, pressure is incrementally increased (15, 20, 30, 40 kN) to evaluate its effect on tablet compression[31].

The study created an orthogonal optimization test, rated it in Table 1, and used range analysis to identify the ideal process parameters based on the single-factor tests and prior recipe optimization findings.

III. RESULT

3.1. Formulating research results of M. oleifera and spirulina complex nutritional tablets

3.1.1. The best ratio of raw materials

According to literature reports, using tablets of moringa or spirulina whose nutrients are not very complete, or some nutrition indicators are low, can prevent you from fully meeting the requirements of a balanced diet. However, analysis has revealed that the nutritional ingredients in moringa and spirulina are highly complementary, resulting in composite tablets with more complete nutrition indicators. The information provided can satisfy a variety of purposes or come close to doing so. We can establish that the proportion of spirulina powder to moringa leaf powder is 7:3 by a thorough examination of each index. The complex tablet's nutrient content ratio is the most reasonable, and preparation costs are also quite cheap.

3.1.2. Experimental result from formulation optimization

By orthogonal table L9 (34) orthogonal experimental design, single-factor test findings indicate that the optimal amounts of microcrystalline cellulose, sodium carboxymethyl cellulose, and magnesium stearate are 8%, 2%, and 1.5%, respectively.

Table 3. The formula of Moringa oleifera and spirulina complex nutritional tablets L9 (34) factor level.

Level	Factor			
	A(Moringa oliefera and Spirulina,g	B (microcrystalline cellulose, g)	C (sodium carboxymethylcellulose, g)	D (magnesium stearate, g)
1	91.5	7	1.5	1.0
2	88.5	8	2	1.5
3	86.5	9	2.5	2.0

Table 4 displays the findings of orthogonal tests and data analysis for nutritious tablets with a complex M. oleifera and spirulina formula. The following elements are listed in the following sequence, as seen in Table 4: Magnesium stearate, microcrystalline cellulose, and sodium carboxymethyl cellulose are all placed in this order: M. oleifera and spirulina powder. A2B2C2D2 is the ideal formula pairing. The average product composite score for this formula combination is 89.2, suggesting that it is one of the finest recipe combinations, according to the study's three parallel tests. The proportion of each component is as follows: M. oleifera with powdered spirulina sodium carboxymethyl cellulose, also known as microcrystalline cellulose Because the ratio of magnesium stearate is 88.5:8:2:1.5, the manufactured 100 g tablet comprises 61.95 g of moringa powder and 26.55 g of spirulina powder.

Table 4. The formula of Moringa oleifera and spirulina complex nutritional tablets L9(34) orthogonal test results and data analysis.

Text number	Factor				Score
	A	B	C	D	
1	1	1	1	1	80.6
2	1	2	2	2	88.2

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3	1	3	3	3	84.2
4	2	1	2	3	86.2
5	2	2	3	1	85.7
6	2	3	1	2	87.2
7	3	1	3	2	81.2
8	3	2	1	3	81.4
9	3	3	2	1	80.3
K1	84.333	82.667	2.433	82.200	
K2	86.367	85.100	84.900	85.533	
K3	80.967	83.900	83.700	83.933	
R	5.400	2.433	1.833	3.333	

3.2. M. oleifera and spirulina production process optimization results in complex nutrition tablets

According to the results of a single-factor experiment, the ideal conditions for raw material powder particle size are between 200 and 300 mesh, with a suggested material moisture level of 8%. The appropriate tableting pressure was also determined to be 30 kN. These findings were then used as a starting point for orthogonal optimization experiments utilizing an L9 (33) orthogonal table, which was aimed to methodically evaluate and enhance the whole process.

Table 5. Production process parameters of Moringa oleifera and spirulina complex nutritional tablets 9(33) factor level.

Level	**Factor**		
	A (raw material particle size, order)	B (raw material moisture, %)	C (flaking pressure, kN)
1	120–200	7	20
2	200-300	8	30
3	300–500	9	40

The direct optimization of complex nutritional tablets made from Moringa and spirulina powder was conducted, and the results of the orthogonal test, as well as the data analysis, are presented in Table 6. According to the findings in Table 6, it is evident that the factors impacting the sensory quality of the tablets follow the order of importance: moisture content > tableting pressure > powder particle size. The most favorable combination of factors identified in this study is A2B1C3, which corresponds to the following conditions: raw material particle size of 200–300 mesh, material moisture content of 7%, and a tableting pressure of 40 kN. To confirm the validity of this optimal combination, three separate tests were conducted in parallel, and the average composite score achieved was 96.2. This score indicates that the A2B1C3 combination represents the best set of process parameters for producing these complex nutritional tablets.

Table 6. Production process parameters of Moringa oleifera and spirulina complex nutritional tablets L9 (33) orthogonal test results and data analysis.

Text number	**A**	**B**	**C**	
1	1	1	1	93.2
2	1	2	2	88.6
3	1	3	3	89.2
4	2	1	2	94.5
5	2	2	3	94.8

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6	2	3	1	86.2
7	3	1	3	93.2
8	3	2	1	88.4
9	3	3	2	91.2
K1	90.333	93.633	89.267	
K2	91.833	90.600	91.433	
K3	90.933	88.867	92.400	
R	1500	4.766	3.133	

IV. CONCLUSION

The focus of this review is on the formulation and optimization of nutritious tablets made from Moringa oleifera and spirulina. Given the declining nutritional content of vegetables as a result of population increase and the use of chemical fertilizers, Moringa, and spirulina give a good alternative to deliver vital protein, vitamins, amino acids, and minerals. For these tablets, the suggested formulation ratio is 5:5, emphasizing the equal blend of Moringa oleifera and spirulina powder. Microcrystalline cellulose, CMC, and magnesium stearate are also present in specified amounts in the tablet formulation.

To ensure the high quality of the tablets, the research ran several tests to improve the formulation and manufacturing process. The evaluation criteria, which are shown in Table 1, comprised elements including appearance, weight fluctuation, hardness, friability, and disintegration time.

Key findings from the study include:

The vital elements proteins, vitamins, calcium, iron, and antioxidants are abundant in moringa oleifera, whereas spirulina has a high protein content, essential fatty acids, and a variety of micronutrients.

The most complete and economical nutritional profile for the tablets was found to be created by combining spirulina powder with Moringa leaf powder in a ratio of 7:3.

The best excipient ratio, according to tests on formulation optimization, is 8% microcrystalline cellulose, 2% sodium carboxymethyl cellulose (CMC), and 1.5% magnesium stearate.

A 200–300 mesh raw material particle size, a moisture content of 7%, and a tableting pressure of 40 kN were found to be the ideal parameters by the manufacturing process optimization trials.

The composite score for the best combination of process parameters (A2B1C3) was determined to be 96.2, indicating that this is the optimum recipe for manufacturing complex nutritious tablets.

In conclusion, the study showcases the potential of Moringa oleifera and spirulina as vital ingredients for formulating complex nutritional tablets. These tablets offer a convenient and effective way to supplement diets with a wide range of essential nutrients. The study provides valuable insights into the ideal formulation and production process parameters for producing high-quality nutritional tablets using these ingredients, which could contribute to addressing nutritional deficiencies in regions with limited access to balanced diets.

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