Optimization of formulation and processing of *Moringa oleifera* and spirulina complex tablets

Zheng Yi\(^{a,b,*}\), Zhu Fan\(^{a,b}\), Lin Dan\(^{a,b}\), Wu Jun\(^{a,b}\), Zhou Yichao\(^{a,b}\), Mark Bohn\(^{c}\)

\(^{a}\) School of Biological and Chemical Engineering, Panzhihua University, Panzhihua 617000, China
\(^{b}\) Key Laboratory of Dry-hot Valley Characteristic Bio-Resources Development of University of Sichuan Province, Panzhihua 617000, China
\(^{c}\) Department of Chemical Engineering, Pohang University of Science and Technology, Pohang, Republic of Korea

Received 20 May 2016; revised 31 August 2016; accepted 31 August 2016
Available online 8 September 2016

**Abstract**  *Objective:* To prepare a more comprehensive nutrition, more balanced proportion of natural nutritional supplement tablets with *Moringa oleifera* leaves and spirulina the two nutrients which have complementary natural food ingredients. *Method:* On the basis of research *M. oleifera* leaves with spirulina nutrient composition was determined on *M. oleifera* leaves and spirulina ratio of raw materials, and the choice of microcrystalline cellulose, sodium salt of carboxymethyl cellulose (CMC), magnesium stearate excipient, through single factor and orthogonal experiment, selecting the best formula tablets prepared by powder direct compression technology, for preparation of *M. oleifera* and spirulina complex tablets. *Results:* The best ratio of raw material for the *M. oleifera* leaves powder: spirulina powder was 7:3, the best raw materials for the tablet formulation was 88.5%, 8.0% microcrystalline cellulose, CMC 2.0%, stearin magnesium 1.5%, the optimum parameters for the raw material crushing 200–300 mesh particle size, moisture content of 7%, tableting pressure 40 kN. *Conclusion:* Through formulation and process optimization, we can prepare more comprehensive and balanced nutrition *M. oleifera* and spirulina complex tablets, its sheet-shaped appearance, piece weight variation, hardness, friability, disintegration and other indicators have reached the appropriate quality requirements.

1. Introduction

*Moringa oleifera,* Capparales moringa plant, native to India, also known as drumstick tree, is a perennial tropical deciduous tree. The seeds and leaves of these have rich nutrients; protein content of leaves reached 27%; minerals and vitamins contain many kinds and high content of nutrients, which is considered as one of the plants with the richest nutritional ingredient humans ever found (Liu and Li, 2002). Moringa is called a kind of magical healthy plant, which is rich in nutrients, and
also contains Moringa polysaccharides, flavonoids, γ-amino butyric acid and other active ingredients, with good therapeutic care function; so it is known as the Magic Tree and Tree of Life.

Spirulina, a class of prokaryotic microorganisms, cyanobacteria Oscillatoria algae division, is one of the oldest creatures on earth, found on Earth the most balanced nutrition, the most abundant natural food. World Health Organization and the United Nations FAO recommended Spirulina as the twenty-first century best food and best of human health products (Huijuan and Guihua, 2005). Spirulina features nutrients high in protein, low fat, low cholesterol, but also contains more γ-linolenic acid, vitamins, minerals and trace elements, and for the human body is very useful. Meanwhile phycocyanin, algae contain polysaccharides and other biologically active substances, and can improve immunity, has anti-cancer, effects.

Moringa and spirulina are extremely rich in nutritional values, and have certain health values of natural biological resources; our study found that the nutritional composition is complementary; if the moringa and spirulina are mixed by a certain scale to prepare a kind of complex tablets, their nutritional species are more comprehensive, with more balanced proportion of nutrients. At the same time based on environmental restrictions and climatic conditions, quality spirulina production is limited with higher prices, and moringa is adaptable in tropical and subtropical areas, with high biomass production, and the price is relatively low. By preparing complex nutritional tablets of M. oleifera and spirulina, the cost is relatively low and easy to promote, as these two high-value biological resources are better for human health services.

2. Material and methods

2.1. Materials

2.1.1. Biological materials

M. oleifera Lam. PKM-1: its fresh leaves are collected in characteristic biological resources engineering technology center planting base in dry-hot valley from Panzhihua city.

Spirulina platensis: produced in Chenghai lake of Lijiang in Yunnan.

2.1.2. The main instruments and reagents

Main instruments: constant temperature drying ovens, ultra-fine grinding instrument, vibration screening machines, mixers, constant temperature and humidity chamber, electronic scales, tablet hardness measuring instrument, friability tester, intelligent disintegration tester and rotary tablet machines.

Reagents: microcrystalline cellulose (food grade), magnesium stearate (food grade), sodium carboxymethyl cellulose (food grade) and so on (Changfen and Guohua, 2004).

2.2. Methods

2.2.1. Production process

The Production process of M. oleifera and spirulina complex nutritional tablets is shown as Fig. 1.

2.2.2. Process operation points

① After collecting Moringa fresh leaves, remove yellow leaves, rotten leaves, cut long petioles and place the leaf in 60 °C oven to dry for 8–12 h spare;
② Moringa dried leaves and spirulina should be crushed alone, make use of vibration screening machine for screening to get different sizes of raw materials, then mix according to the proportion;
③ Excipient has less ratio, in order to ensure uniform mixing, first take 15–20% of the raw materials to pre-mix with excipients for 5 min; After pre-mixing, place the remaining raw material mixture for 5 min after two time mixed processing, uniformity of the sample can be ensured.

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

(1) Establishing evaluation criteria

Referring 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

● Sheet-shaped appearance. Take 20 samples on a clean white porcelain vessel, in diffuse daylight or artificial light similar to daylight, visual study its color and luster as well as state.
● Tablet weight difference. Take 20 samples, accurately weighed on the total weight, obtain average piece weight, then weigh and the weight of each piece precisely; compare each slice weight and the average tablet weight per piece; then calculate the relative average deviation.

Figure 1 The production process of Moringa oleifera and spirulina complex nutritional tablets.
2.2.4. Formulation of *M. oleifera* and spirulina complex nutritional tablets

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

There are many reports on the nutrients of Moringa leaves and spirulina (Guoliang and Yin, 2012), the main nutrients of which are as shown in Table 2. According to the required daily nutrition standards proposed by International Union of Nutritional Sciences body in 2011, these indicators of human’s required daily intake amount are also shown in Table 2; through in-depth analysis and statistical calculation, the best raw material ratio of Moringa leaf powder and spirulina powder is received (Zhikun et al., 2007).

(2) Selection of excipients

The excipient is prepared as auxiliary raw material in addition to the main drug in tablets. The excipients have many kinds of species, generally having binders, lubricants, diluents, disintegrating agents and wetting agents. One can accord the different characteristics of raw materials and processing tablets to choose different accessories. In this study, the main choices are binder, disintegrator and lubricant in order to increase the pressure and flow of materials and disintegration of the tablets. Use Table 1 as evaluation criteria, on the basis of a lot of information (Shenghui et al., 2014), first select the sodium carboxymethyl cellulose (0.5%, 1%, 1.5%, 2%, 2.5%), microcrystalline cellulose (2%, 4%, 6%, 8%, 10%) and magnesium stearate (0.5%, 1%, 1.5%, 2%, 2.5%) to do a single-factor test.

(3) Optimization of formulas

On the basis of examining single factors of excipients, design orthogonal optimization test and score according to Table 1 to determine the optimal formula composition using range analysis (Xuhua, 2012).

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

By direct powder compression process, the raw material powder size directly affects the quality of the tablet. If powder

---

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

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

---

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

| Component | Protein (g) | Dietary fiber (g) | Linolenic acid (mg) | Carotenoids (mg) | Dimension C (mg) | Dimension E (mg) | B (mg) | 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           | 1.28:1           | 26.36:1          | 1:1.74 | 1:3.1:1     |
| ADI        | 600–700     | 700–800          | 2000               | 315–360          | 10–15            | 3.5–4            | 12–15  | 50–100      |
particle size is large, tablets are prone to appear lobes, piebald, excessive hardness. With the powder particle size decreases, the passing rate of the tablet increase, but when size is too small, it’s easy to agglomerate when mixing to impact mixing effect for the high sticking probability when tableting. Experimental selected powder sizes are 40–80, 80–120, 120–200, 200–300, 300–500 for single factor experiment. Water content of the raw material powder also directly affects the quality of tableting. When water is too high, the material flow is poor, and easy to breed microbes, mildew, shortening shelf life; when the moisture is too little, tableting is easy to be loose and incomplete, and the hardness can’t meet the requirement, and tablet pass rate is significantly reduced.

Use *M. oleifera* and *Spirulina* powder moisture content (4%, 6%, 8%, 10%, 12%) to do tableting single factor test, the water content of raw materials is controlled by using humidity chamber with a relative humidity adjusted and the drying time. Production pressure is vital for the molding and qualities of the tablets, and the experiment gradually increases the production of pressure (15, 20, 30, 40 kN), to examine the effect of tableting (Guanghong et al., 2011).

On the basis of the single-factor experiments, combined with previous recipe optimization findings, the study designed orthogonal optimization test and scored in Table 1, using range analysis to determine the optimum process parameters (Pengfei et al., 2010).

3. Results

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, use the tablets of moringa or spirulina whose nutrients are not very complete, or some nutrition indicators are low, which cannot fully meet the requirements of balanced diet; through analysis, Nutritional ingredients of moringa and spirulina are highly complementary, producing composite tablet, which have more complete nutrition indicators. The content can meet or be near the range of needs. Through a comprehensive analysis of each index, we can determine the ratio of Moringa leaf powder and spirulina powder as 7:3. Nutrient composition ratio produced in the complex tablet is the most reasonable, while cost of preparation is relatively low.

3.1.2. Experimental result from formulation optimization

Single-factor test results show that the optimum amount of microrcrystalline cellulose is 8%; optimum amount of sodium carboxymethyl cellulose is 2%; the optimum amount of magnesium stearate is 1.5%; in accordance with orthogonal table L9 (34) orthogonal experimental design, as shown in Table 3.

Formula of *M. oleifera* and spirulina complex nutritional tablets’ orthogonal test results and data analysis are shown in Table 4. From Table 4, the order of factors affecting the product quality is: *M. oleifera* and spirulina powder > magnesium stearate > microcrystalline cellulose > sodium carboxymethyl cellulose. The best formula combination is A2B2C2D2. With this formula combination the study made three times parallel test, the average product composite score is 89.2, indicating that the combination is the best recipe combinations. The percentage content of each component is: *M. oleifera* and spirulina powder: microcrystalline cellulose: sodium carboxymethyl cellulose: Magnesium stearate is 88.5:8.2:1.5, which means that the prepared 100 g tablet contains moringa powder 61.95 g and spirulina powder is 26.55 g.

3.2. *M. oleifera* and *Spirulina* production process optimization results complex nutrition tablets

Single factor experiment results showed that the raw material powder particle size is 200–300 mesh, material moisture content is 8%, tableting pressure should be 30 kN, as a reference in accordance with orthogonal table L9 (33) of orthogonal optimization tests, as shown in Table 5.

Direct optimization of Moringa and spirulina powder complex nutritional tablets which prepared orthogonal test results and data analysis are shown in Table 6. From Table 6, the order of factors on the sensory quality is: moisture > tableting

### Table 3

| Level | Factor | A (*Moringa oleifera* and spirulina, g) | B (microrcrystalline cellulose, g) | C (sodium carboxymethylcellulose, g) | D (magnesium stearate, g) |
|-------|--------|---------------------------------------|-----------------------------------|-------------------------------------|--------------------------|
| 1     | 91.5   | 7                                     | 1.5                               | 10                                  |
| 2     | 88.5   | 8                                     | 2                                 | 15                                  |
| 3     | 86.5   | 9                                     | 2.5                               | 20                                  |

### Table 4

| Text number | Factor | Score |
|-------------|--------|-------|
|             | A      | B     | C     | D     |       |
| 1           | 1      | 1     | 1     | 1     | 80.6  |
| 2           | 1      | 2     | 2     | 2     | 88.2  |
| 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 | 83.067 | 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  |

### Table 5

| Level | Factor | A (*Moringa oleifera* and spirulina, g) | B (microrcrystalline cellulose, g) | C (sodium carboxymethylcellulose, g) | D (magnesium stearate, g) |
|-------|--------|---------------------------------------|-----------------------------------|-------------------------------------|--------------------------|
| 1     | 91.5   | 7                                     | 1.5                               | 10                                  |
| 2     | 88.5   | 8                                     | 2                                 | 15                                  |
| 3     | 86.5   | 9                                     | 2.5                               | 20                                  |
压力 > 粉末粒径尺寸，最佳配方组合是A2B1C3，即原料粒径尺寸为200–300目；物料含水率7%，压片压力40 kN。与这种方法组合的同时，平均合成得分为96.2，表明这种组合是最优过程参数。

4. Conclusion and discussion

研究结果表明，通过优化配方方法，可以使用生长茂盛的鼓槌树树叶和螺旋藻粉作为原料，生产出棒状的Moringa和Spirulina复合营养片。通过单因素分析和正交实验，研究了压片压力、原料粒径尺寸、物料含水率和压片速度等四个因素对营养片质量的影响。研究结果表明，压片压力为40 kN时，所制得的Moringa和Spirulina复合营养片的硬度、重量差异、崩解时间、片剂通过率分别为40 N、5%、7.2 min和96%。研究为大规模生产Moringa和Spirulina复合营养片提供了科学依据。

The produced Moringa and spirulina complex nutritional tablets are recommended to take 6–8 g a day, better than the single use effect on spirulina tablets or moringa sheet, which can help most people improve a more balanced nutrient intake and human health. When Moringa leaf powder and spirulina leaf powder has the ratio of 7:3, it’s mainly for group for adults aged at 18–55, the nutritional needs between the elders and minors may be inconsistent, and therefore you can adjust the recipe proportions for different groups during processing.

Using direct powder compression to prepare tablets has less nutrient loss, because the raw materials don’t go through heat treatment, but there may be existing losses. The actual losses still need further testing on the nutritional content of products, while the condition of products’ health and safety indicators and stability situation has yet to be carried out in the next step.

Acknowledgement

Fund Program: 2015 Science and Technology Project from the Education Department of Sichuan Province (No. 15ZB0416).

References

Changfen, L., Guohua, L., 2004. Nutritional value of drumstick tree leaves. Trop. Agric. Sci. Technol. 27, 4–8.
Guanghong, L., Shenghui, Y., Tingxun, Z., 2011. The production method and protein nutrition assessment of cyanomorium spirulina tablets. Food Ferment. Ind. 37, 149–152.
Guoliang, B., Yin, W., 2012. Nutritional ingredient detection of spirulina and biological activities research. Chinese J. Health Lab. 22, 1034–1036.
Huijuan, X., Guihua, X., 2005. Review health effect of spirulina as function food. J. Agric. Sci. 26, 90–93.
Liu, C.F., Li, G.H., 2002. Actuality of study on Moringa oleifera and their exploitive foreground. J. Yunnan Trop. Crops Sci. Technol. 25, 20–24.
Pengfei, Y., Qin, Z., Pengyi, H., 2010. Powder direct tabletting technology and its key issue used in Chinese materia. Chinese Tradit. Herbal Drugs 14, 2099–2101.
Shenghui, Y., Guanghong, L., Tingxun, Z., 2014. Optimization of formulation and processing of puerariae radix extract-spirulina compound tablets. Food Sci. 35, 68–72.
State, P.C., 2010. Pharmacopoeia of the People’s Republic of China. Chinese Medical Science and Technology Publishing House, Beijing.
Xuhua, B., 2012. Preliminary report on processing technology of raw powder tablet from Moringa oleifera. Trop. Agric. Sci. Technol. 35, 24–27.
Zhikun, R., Liangyan, F., Cong, L., 2007. Study on nutrients of moringa. Mod. Instrum. 02, 18–20.