JPSCR: Journal of Pharmaceutical Science and Clinical Research
Volume 10, Issue 2, Pages 161 - 175, July 2025
https://doi.org/10.20961/jpscr.v10i2.91338

ISSN 2503-331X (Online)

Formulation of Small Quantity Lipid-based Nutrient Supplement (SQ-LNS) Tablet from Soybean: A Preventive Approach on Stunted Birth for Pregnant and Breastfeeding Women

Virginia Heaven Mariboto Siagian[1,2], Johnessa Cung[1,2], Spica Diani Anandawijaya[1,2], Sandya Amelia Febriliani[1,2], Avika Widyapuspita[1,2] dan Iyan Sopyan[2*]

[1]Pharmacy Undergraduate Program, Faculty of Pharmacy, Padjadjaran University, Sumedang, Indonesia
[2]Department of Pharmaceutics and Pharmaceutical Technology, Faculty of Pharmacy, Padjadjaran University, Sumedang, Indonesia

*Corresponding author: i.sopyan@unpad.ac.id

Received: July 29, 2024; **Accepted:** July 24, 2025; **Published:** July 28, 2025

Abstract
The prevalence of stunting in Indonesia, which has not met the requirements of the WHO, makes stunting a national problem. In line with the nutritional intervention in 2020-2030, UNICEF developed SQ-LNS products as a food paste. As an effort to prevent stunting as well as improve product stability, the formulation of Small-Quantity Lipid-based Nutrient Supplements (SQ-LNS) from soybeans (*Glycine max* (L.) Merr) in tablet form is proposed to be a solution for pregnant and breastfeeding women. Microencapsulation technology is used to entrap soybean oil as the lipid source of this supplement. This study aims to obtain the best concentration of maltodextrin, soy protein isolate, and carboxymethyl cellulose as a soybean oil coating for felting into SQ-LNS tablet preparation. The best microcapsule is produced from a 40% formula with a percent yield of 28%, encapsulation efficiency of 79.83%, PSD microcapsule of 1.003 µm, and round agglomerated particles with a smooth surface without any residual oil seen under the SEM, and obtained the best formulation and evaluation of SQ-LNS tablets so that they meet the quality standards of good stunting supplement tablets.

Keywords: Soybean; Microencapsulation; SQ-LNS; Stunting; Tablet

1. INTRODUCTION

The World Health Organization (WHO) standard sets the stunting prevalence rate at less than 20%. The Indonesian Nutrition Status Survey (SSGI) states that the stunting prevalence rate in 2021 and 2022 was 24.4% and 21.6% respectively, so the percentage of stunting cases in Indonesia has not met the standards set by the World Health Organization (Kemenkes RI, 2023). It should be noted that stunting is incurable and can occur from the first 1,000 days of life (WHO, 2015). Therefore, the nutritional condition of pregnant and breastfeeding women plays an important role in determining the fluctuation of stunting cases.

Based on the results of research on 74 toddlers in Bengkulu City, most of the stunted toddlers lacked zinc intake (79.16%), energy (83.3%), protein (54.16%), carbohydrates (79.16%), fat (25%), and iron (29.16%) (Yuliantini et al., 2022). Soybeans are one of Indonesia's primary food commodities, and they can potentially be the main ingredient in stunting supplements because they are rich in vegetable protein (Waliansyah, 2020). Soybeans are known to contain 34% protein, 19% oil with linolenic fatty acids (omega-3 and omega-6), 34% carbohydrates, 5% minerals such as calcium, iron, zinc, phosphorus, magnesium, and several other components, including vitamins such as thiamine, riboflavin, niacin, and folic acid (Kanchana, 2016). The need for micronutrients is also important in preventing stunting. Zinc and iron are micronutrients vital to children's growth and cognitive development. Therefore, additional iron and zinc are needed through fortification.

UNICEF is committed to encouraging the use and development of SQ-LNS products to address stunting in line with the 2020–2030 nutrition strategy. The Lancet Series on Maternal and Child Undernutrition Notes (2021) provides strong evidence that using Small Quantity Lipid-based Nutrient Supplements (SQ-LNS) can save costs compared to other interventions, prevent child malnutrition, and support child development. However, it cannot be denied that SQ-LNS products in the form of food paste still have shortfalls, especially regarding the stability of products that are very susceptible to oxidation and rancidity (Arimond et al., 2015).

Considering the persistent challenge in lowering stunting prevalence in Indonesia, coupled with the limitations of current SQ-LNS products—particularly their susceptibility to oxidation and limited stability—there is a pressing need for the development of innovative, practical, and shelf-stable nutritional formulations that are rich in essential macro- and micronutrients. Given this urgency, the present research aims to formulate a soybean-based SQ-LNS in tablet form. This formulation is designed to provide a nutrient-dense, stable, and user-friendly alternative for maternal supplementation, thereby supporting national efforts to reduce stunting and promote long-term public health outcomes. Preventive stunting efforts through the formulation of supplements for pregnant women and lactating mothers in the form of SQ-LNS can support government programs in reducing the prevalence of stunting so that the demographic bonus in Golden Indonesia in 2045 with a healthy, productive, and superior generation can be realized.

2. MATERIALS AND METHODS

2.1 Materials

The materials used were 2,2-diphenyl-1-picrylhydrazyl (Sigma Aldrich; St. Louis, MO), avicel pH 102 (IFF; Wilmington, DE, USA), aquadest (Aqua Science; Bandung, Indonesia), carboxymethyl cellulose (IFF; Wilmington, DE, USA), chloroform (Merck; Darmstadt, Germany), ethanol pro analysis (Merck; Darmstadt, Germany), ferrous sulfate (Merck; Darmstadt, Germany), formic acid (Merck; Darmstadt, Germany), hydroxypropyl methylcellulose (Merck; Darmstadt, Germany), isolate soy protein (Marksoy 90), maltodextrin (Merck; Darmstadt, Germany), methanol pro analysis (Merck; Darmstadt, Germany), n-Hexane

(Merck; Darmstadt, Germany), quercetin isolate (Sigma Aldrich; St. Louis, MO), silica gel GF 254 (Merck; Darmstadt, Germany), soybean oil (Misoya; Indonesia), sodium starch glycolate (Merck; Darmstadt, Germany), talcum (Merck; Darmstadt, Germany), and zinc sulfate (Merck; Darmstadt, Germany).

2.2 Microencapsulation of soybean oil

The microcapsule formulation was based on the research of Hasrini et al. (2017), which was optimized and modified. The formulations include a variety of soybean oil concentrations as the core ingredient, as well as a list of polymers that consist of different concentrations of CMC (carboxymethyl cellulose), maltodextrin, and ISP (isolated soy protein) for the microcapsule coating, as seen in Table 1.

Table 1. Formulations of soybean oil microcapsules using varying amounts of maltodextrin, CMC, and ISP. *Description:* Carboxymethyl cellulose (CMC) and Isolated soy protein (ISP).

No.	Materials	Formulations in 300 mL	
		Formula 1	Formula 2
1.	Maltodextrin	63 g	53,99 g
2.	CMC	4,9 g	4,19 g
3.	ISP	2,1 g	1,79 g
4.	Soybean oil	29,99 g	40 g
5.	Aquadest	203 mL	203 mL

Maltodextrin, CMC, ISP, soybean oil, and distilled water were mixed using a colloid mill at 10,000 rpm until an emulsion was formed. The emulsion obtained was then spray-dried using a Buchi Mini Spray Dryer B-290 (Switzerland). The inlet temperature of the device was set at 150°C.

2.3 Evaluation of soybean oil microcapsules

2.3.1 Encapsulation efficiency (EE%)

An amount of 0.5 g of microcapsules from each formula was placed into a different volumetric flask filled with ethanol for analysis, resulting in a precipitated solution of 50,000 ppm. The flask was then sonicated with an Ultrasonic Cleaner Jeken PS-100A (Guangdong, China) for 30 minutes, resulting in a cloudy solution, which was then filtered through a Whatman Filter no. 1 with the help of n-hexane to extract the residual oil that might still be on the microcapsule's surface. The filtrate was then dried in a drying chamber with the temperature set at 218°C, which was weighed as the surface oil on each microcapsule formula (Sucianti et al., 2020). The encapsulation efficiency was determined using Equation 1.

$$\text{Encapsulation Efficiency (\%)} = \left(\frac{TO - SO}{TO}\right) \times 100$$

Equation 1. The encapsulation efficiency of soybean oil microcapsules. *Description*: Total oil (TO), Surface oil (SO).

2.3.2 Flowability test

Flowability of the microcapsule powder was evaluated using the Hausner Ratio (HR), an established indicator of interparticle cohesion and powder flow behavior. Bulk density (ρ_{bulk}) was measured when the powder flowed unimpeded into a container, reflecting the packing density under natural flow conditions. Tapped density (ρ_{tapped}) was obtained by compacting the powder through tapping. The formula is presented using Equation 2.

$$\text{Hausner Ratio} = \left(\frac{\rho_{tapped}}{\rho_{bulk}}\right)$$

Equation 2. The flowability of soybean oil microcapsules is expressed as the Hausner ratio. *Description*: Tapped density (ρ_{tapped}), Bulk density (ρ_{bulk}).

2.3.3 Compressibility test

Compressibility was evaluated by calculating the Carr's compressibility index, a parameter that estimates the propensity of a powder to reduce in volume under pressure. The formula is presented using Equation 3.

$$\text{Carr's Index} = \left(\frac{\rho_{tapped} - \rho_{bulk}}{\rho_{bulk}}\right) x100$$

Equation 3. The compressibility of soybean oil microcapsules is expressed as Carr's Index. Description: Tapped density (ρ_{tapped}), Bulk density (ρ_{bulk}).

2.3.4 Scanning Electron Microscope (SEM)

Morphological tests of the microcapsules were carried out using a JEOL JSM-6510 Scanning Electron Microscope (Tokyo, Japan). The microcapsules were previously coated with platinum (Pt) with an electric current of 10 mA within 150 seconds. Finally, the surface morphology of the microcapsules was observed at 1000x, 3000x, and 5000x magnification.

2.3.5 Particle Size Analysis (PSA)

Microcapsule particle size testing was characterized using a Particle Size Analyzer (PSA) type Beckman Coulter TM LS 13 320 (Indonesia). The microcapsule particle size test uses the PSA working principle of scattered light caused by laser diffraction. Particle Size Distribution (PSD) parameters were observed through SPAN values (Equation 4) (Zegzulka et al., 2020).

$$\text{SPAN Index} = \frac{d_{90} - d_{10}}{d_{50}}$$

Equation 4. The SPAN index of the particle size distribution. *Description*: D_{10}, D_{50}, and D_{90}: Percentile diameters representing 10%, 50%, and 90% of the particle size distribution, respectively.

2.3.6 Antioxidant activity test

0.5 g of microcapsule was dissolved in 5 mL of ethanol for analysis and sonicated for 30 minutes. The sample filtrate was dotted on the thin-layer chromatography (TLC) Silica Gel F254 plate and compared with quercetin as the standard. Then, the TLC plate was developed

with the eluent chloroform:methanol: fumaric acid (9:1:1.5). The eluted TLC was dipped in 1,000 ppm DPPH solution and dried in a dark room (Ningsih et al., 2018). This test aims to qualitatively confirm the inherent antioxidant activity of the microcapsules, which is crucial for preventing the rapid oxidation of the encapsulated oils and extending the stability of the final tablet formulation.

2.4 Preparations of SQ-LNS tablets

A tablet containing 700 mg in total weight was prepared using a direct compression method. The microcapsule as the active ingredient was first sieved with mesh no. 16 and then placed in the oven at 40℃ for 30 minutes due to the microcapsule's agglomerated and high water content. The dried microcapsule was then mixed with other active substances, $FeSO_4$ and $ZnSO_4$, which had previously been refined. After all that, it was combined with excipients, which are Avicel pH 102, HPMC, sodium starch glycolate, and talc.

A selected microcapsule formulation was advanced to the tablet development stage. This selection was based on its favorable characteristics, particularly in encapsulated lipid content, and its alignment with the primary objective of developing a lipid-based nutrient supplement to prevent stunting. Furthermore, a comprehensive evaluation of multiple formulations was not pursued due to practical constraints related to time and available resources. Accordingly, the chosen formulation was considered the most appropriate candidate for subsequent processing and characterization. The optimized soybean oil microcapsules obtained from this study were combined to develop the SQ-LNS tablets (Table 2).

Table 2. SQ-LNS tablet formulation with the percentage of each ingredient.

Materials	Formula (%)
Soybean oil microcapsule	42%
Ferrous sulfate ($FeSO_4$)	9.4%
Zinc sulfate ($ZnSO_4$)	6%
Avicel 102	25%
HPMC	7%
Sodium starch glycolate	2%
Talkum	q.s

2.5 Evaluation of SQ-LNS tablets

According to the Indonesian Pharmacopoeia VI (2020), mandatory quality control tests for tablet dosage forms include weight uniformity, content uniformity, friability, disintegration, dissolution, and assay. In the present study, the evaluation of physical characteristics of the formulated SQ-LNS tablets encompassed organoleptic observation for preliminary stability, weight uniformity, size uniformity, tablet hardness, friability, and disintegration time tests. However, content uniformity and dissolution testing were not conducted due to limitations in analytical instrumentation and resource availability. Despite this, both parameters are considered critical quality attributes that reflect the consistency of drug content and in vitro release performance. Therefore, future studies will incorporate these tests to ensure compliance

with pharmacopoeial standards and further support the quality, safety, and efficacy of the developed SQ-LNS tablets.

2.5.1 Organoleptic observation and tablet stability

A total of 4 tablets were taken randomly and observed for their physical condition, including their color and odor, every 3 days for the observation time interval.

2.5.2 Weight uniformity

A total of 20 tablets were taken randomly and weighed one by one. The weighing results are then calculated using their average, SD, and %RSD for comparison with the Indonesian Pharmacopoeia IV (1995) requirements.

2.5.3 Size uniformity

A total of 20 tablets were taken randomly for the diameter and thickness measured using a Precision Vernier Caliper 84-090. The measurement results were compared with the requirements of Indonesian Pharmacopoeia V (2014).

2.5.4 Disintegration time

A total of 6 tablets were taken randomly and put into each basket on the test equipment, Disintegration Apparatus Agilent Varian VK 100, which had already been set to 37±2°C using distilled water as the disintegration medium. After that, discs were also inserted into the tube on the test device. Then, the tablet disintegration time was observed, and the results were compared with the Indonesian Pharmacopoeia VI (2020) requirements. Further research on dissolution testing will use 0.1 N HCl as the medium to simulate stomach conditions.

2.5.5 Tablet friability

A total of 10 tablets taken randomly were weighed, and the initial weight was recorded. The tablets were then inserted into the Agilent Dual-drum Friability Tester. The tool was then set with a rotation of 100x, then those 10 tablets were weighed again, and the final weight was recorded. Tablet friability was determined using Equation 5.

$$\text{Friability} = \frac{W_0 - W_1}{W_0} \times 100\%$$

Equation 5. The friability percentage of tablets after mechanical stress. *Description*: Initial weight (W_0), Final weight (W_1).

3. RESULTS AND DISCUSSION

3.1 Microencapsulation of soybean oil

The result of each microcapsule concentration can be seen in Figure 1 based on the color of the microcapsule and how it is agglomerated with other microcapsules after being stored in a refrigerator.

Formulation 30% has a white powdered color, lighter than formulation 40%, which has a yellowish-white powdered color. This color difference happened due to the higher

concentration of soybean oil in formula 40%, causing a darker color and a change in how agglomerated the powder is. The high oil content of 40% will increase the water content and oil content on the surface of the microcapsules, so that the microcapsules will tend to stick, because formulas that have a higher core content will be more difficult to evaporate the water used as a carrier during the spray drying process (Supriyadi & Rujita, 2013).

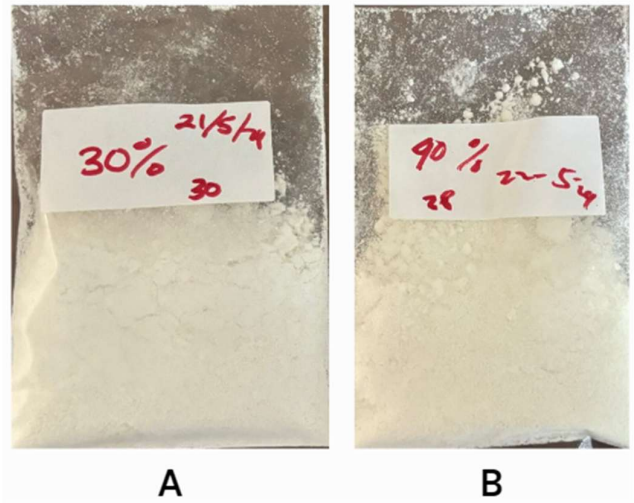

Figure 1. The result of the microcapsule of the soybean oil formulation. *Description*: (A) Formula 30% and (B) Formula 40%

3.2 Evaluation of soybean oil microcapsules

3.2.1 Encapsulation efficiency (EE%)

The encapsulation efficiency value for the 30% and 40% microcapsule formulations was 93.36% and 79.83%, respectively. The higher %EE value in the 30% formulation can be attributed to the higher proportion of maltodextrin and isolated soy protein (ISP), which enhances the efficiency of soybean oil coating. Although commonly used as an encapsulation material, maltodextrin has relatively low emulsification capacity, which may lead to inadequate film formation. The addition of ISP stabilizes the emulsion, improving encapsulation performance (Wardani et al., 2021; Purnamayati et al., 2016).

Despite having a lower %EE, the 40% formulation was selected for further characterization and development. This decision was based on the higher absolute amount of encapsulated oil, 31.93 grams, compared to 27.99 grams in the 30% formulation. Considering the potential application of this formulation as a lipid-based nutritional supplement, the higher oil content provided by the 40% formulation was deemed more suitable for progression to the tablet formulation stage. Additionally, the 40% microcapsule formulation exhibited favorable physicochemical properties, including uniform spherical morphology with minimal surface oil, as observed via scanning electron microscopy (SEM), and a narrow SPAN value of 1.003, indicating homogeneous particle size distribution. These properties further validate the selection of this formulation as the optimal candidate for further powder characterization, including flow and compressibility assessment, as well as subsequent tablet production.

3.2.2 Flowability test

Flowability of the 40% soybean oil microcapsule powder was evaluated using the Hausner ratio (HR). In this study, the bulk density was 0.424 g/mL (25.02 g/59 mL), and the tapped density was 0.511 g/mL (25.02 g/49 mL)—substitution into Equation 6.

$$\text{Hausner Ratio} = \left(\frac{0.511}{0.424}\right) = 1.205$$

Equation 6. The result of the Hausner Ratio calculation for microcapsule powder. *Description*: Tapped density = 0.511 g/mL; Bulk density = 0.424 g/mL.

USP <1174> (2024) states that a Hausner ratio below 1.25 indicates passable flowability, while values above 1.25 represent poor flow. The obtained value of 1.205 suggests that the microcapsule powder exhibits passable but not optimal flowability. This outcome is consistent with the properties of spray-dried microcapsules containing oil-based cores, where residual moisture and surface oil can increase cohesiveness and hinder free flow. This limitation was acceptable given the formulation goal, and further tableting was facilitated by adding excipients to improve blendability.

3.2.3 Compressibility test

Using Carr's compressibility index, compressibility was assessed to evaluate the powder's capacity to decrease volume under mechanical pressure. Substituting the same densities into Equation 7.

$$\text{Carr's Index} = \left(\frac{0.511 - ,424}{0.511}\right) x\ 100 = 17.02\%$$

Equation 7. The result of Carr's Index calculation for microcapsule powder. *Description*: Tapped density = 0.511 g/mL; Bulk density = 0.424 g/mL.

According to the USP <1174> (2024), Carr's index between 16–20% reflects fair compressibility, suggesting moderate packing efficiency with a tendency toward interparticle cohesion.

3.2.4 Scanning Electron Microscope (SEM)

A morphological analysis of the microcapsules of the 40% formulation conducted by scanning electron microscope (SEM) showed a picture of microcapsules adhering to each other, as shown in Figure 2. However, the microcapsules appeared solid and round, with minimal visible oil on the microcapsule surface. According to the research conducted by Khamidah et al. (2017), the small globules observed on the surface of the microcapsules are presumed to be unencapsulated oil. Based on the SEM results obtained in this study, the presence of oil globules on the surface of microcapsules was minimal, indicating that the encapsulation process was effective and optimal. Furthermore, adhesion between microcapsules can occur due to high water content during sample analysis. (Khamidah et al., 2017).

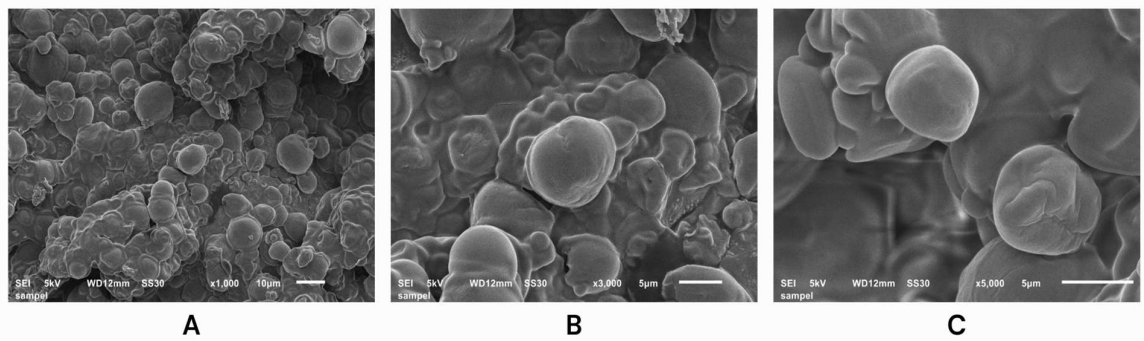

Figure 2. Morphological profile of the 40% soybean oil microcapsule formulation. *Description*: (A) 1000x magnification, (B) 3000x magnification, and (C) 5000x magnification.

3.2.3 Particle Size Analysis (PSA)

Particle size analysis of microcapsules with PSA in Figure 3 shows particle size results and their span value. Microcapsules are generally defined as particles with a size range of 1-1,000 µm (Peng et al., 2023). Meanwhile, some sources (Shahidi & Han, 1993; Ravi & Parthasarathy, 2013) define microcapsules more broadly or include the submicron range (0.1-1 µm) up to several millimeters with various shapes, depending on the method used. Therefore, the result of the average particle being 1.452 µm still meets the criteria for microcapsules and does not fall into the domain of nanocapsules 10–1000 nm (0.01–1 µm) (Tolve et al., 2016). The width of the particle distribution can be seen from the span value. The span value of the microcapsules was 1.46. A narrower span value indicates a more uniform particle shape and size. Therefore, the SPAN value can also be used to assess a powder's flowability, where the span value of S≤1.5 indicates good flowability, while S>1.5 indicates poor flowability (Zegzulka et al., 2020). Based on the span value obtained, it is known that the microcapsules have good flowability, especially for the tabletting process.

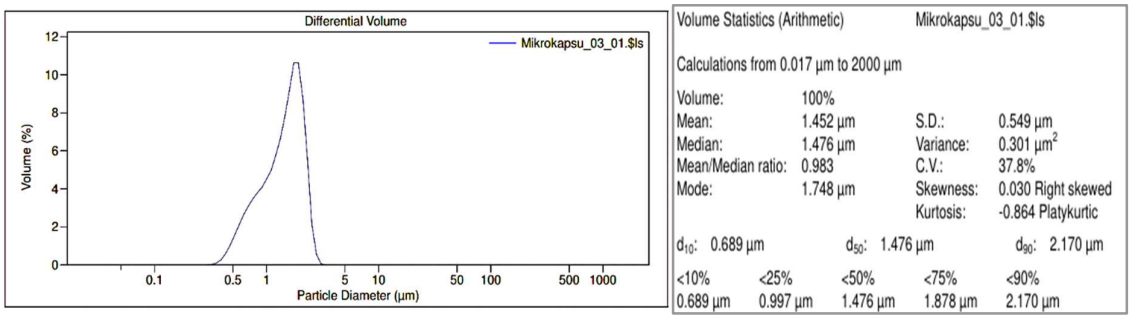

Figure 3. Particle size analysis results of the 40% soybean oil microcapsule formulation.

3.2.4 Antioxidant activity test

The analysis was done qualitatively using the thin-layer chromatography method with DPPH spotting. The results of antioxidant activity are shown in Figure 4.

Quercetin is used for comparison because it is a flavonoid compound with strong and stable antioxidant activity (Cizmarova et al., 2023). This activity is caused by the formation of

hydrogen bonds between hydroxyl groups on ring B and electronegative atoms on other rings, with the hydroxyl group at the third position on ring C playing an important role in stabilizing free radicals (Parcheta et al., 2021). The difference in retention time at the sample point (S) compared to the quercetin standard (B) may be due to the difference in the composition of antioxidant compounds contained in quercetin and the microcapsule sample. Microcapsules contain soy protein isolate (ISP) as the coating matrix, which naturally contains isoflavone antioxidant compounds such as genistein and daidzein (Sulistyowati et al., 2018). Differences in chemical structure and types of antioxidant compounds can both affect color stability and retention time. Quantitative antioxidant analysis was not conducted due to time and cost constraints and because it was not the primary focus of this research.

Meanwhile, this qualitative test primarily aims to confirm the presence of antioxidant compounds in the matrix after the microencapsulation process. The results show a pale yellow color on the TLC plate with DPPH, indicating that the microencapsulated samples, particularly ISP, have antioxidant activity. Antioxidant compounds will reduce DPPH and produce a yellow color (Sumardi et al., 2024). Antioxidants function in reducing oxidative stress that can cause cell and DNA damage. Continuous cell and DNA damage can lead to inflammation or recurrent infectious diseases, contributing to stunting (Rizzo et al., 2023; Badrya et al., 2024).

3.3 Preparations of SQ-LNS tablets

Microcapsules with a 40% formula made SQ-LNS tablets because they had more encapsulated oil at 39.93 g. The 40% microcapsule formula will be mixed with iron, zinc, and other excipients to assist in tableting. Iron has physical characteristics in the form of crystals and is yellow-brown in color; thus, when the materials are homogenized and the tablet is compressed, the tablets do not appear homogeneous.

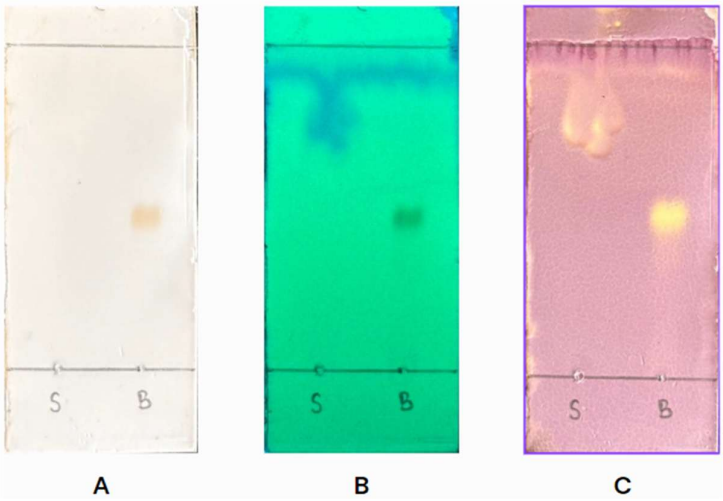

Figure 4. Antioxidant activity on TLC Plate of S: 40% soybean oil microcapsule formulation compared with Quercetin (B). *Description*: (A) Visible light, (B) UV light 254 nm, and (C) Visual after DPPH.

3.4 Evaluation of SQ-LNS tablets

3.4.1 Organoleptic observation and tablet stability

Organoleptic results of the tablets showed a white color with brown spots that were unevenly distributed. The tablets also exhibited a distinctive soybean-like odor. Stability was assessed visually by monitoring these physical attributes during storage in brown glass bottles placed in a closed room under ambient conditions. Observations were conducted at three-day intervals, as presented in Figure 5. There were no significant changes in odor and color throughout the observation period; therefore, the supplement tablets were considered to maintain acceptable stability during storage.

However, it should be noted that the stability evaluation in the present study was limited to organoleptic observations due to constraints in available analytical resources and instrumentation. Comprehensive stability studies, including moisture content analysis, active ingredient assay, and degradation profiling per the guidelines of the International Council for Harmonisation (ICH), are planned in future investigations to ensure the developed formulation's long-term quality and shelf life.

3.4.2 Weight uniformity

Tablet weight uniformity testing was obtained from the weights of each of the 20 tablets. Tablet size requirements are compared with the requirements according to the Indonesian Pharmacopoeia IV Edition (1995), which, for tablets with weights greater than 300 mg, has the requirement that no more than two tablets deviate by 5% from the average weight and none of the tablets deviate by 10% from the average weight of the tablets. Based on the results obtained, the 20 tablets meet the requirements (Table 3).

Table 3. Weight uniformity test data of SQ-LNS Tablets

Number of tablets	Weight (mg)	Number of tablets	Weight (mg)
1	701.9	11	701.2
2	701.5	12	699.1
3	699.2	13	704.5
4	702.5	14	701.3
5	701.0	15	701.5
6	702.1	16	700.7
7	699.5	17	700.9
8	699.4	18	701.1
9	702.7	19	701.4
10	703.0	20	703.4
Average tablet weight (mg)		701.395	
Upper limit 5% (mg)	701.395	Upper limit 10% (mg)	771.53
Lower limit 5% (mg)	666.32	Lower limit 10% (mg)	631.25

3.4.3 Size uniformity

Tablet size uniformity testing obtained results in the diameter and thickness of each of the 20 tablets. Tablet size requirements are compared with the requirements of the rules

according to the Indonesian Pharmacopoeia Edition V (2014). The results of measuring tablets based on their diameter show that the conditions do not exceed 3 times the thickness of the tablet and are not less than 4/3 times the thickness. The tablet's thickness requires that the deviation be less than 5% overall. The deviation of the thickness of 20 tablets is 2.87%. Based on the results obtained, the 20 tablets meet the requirement (Table 4).

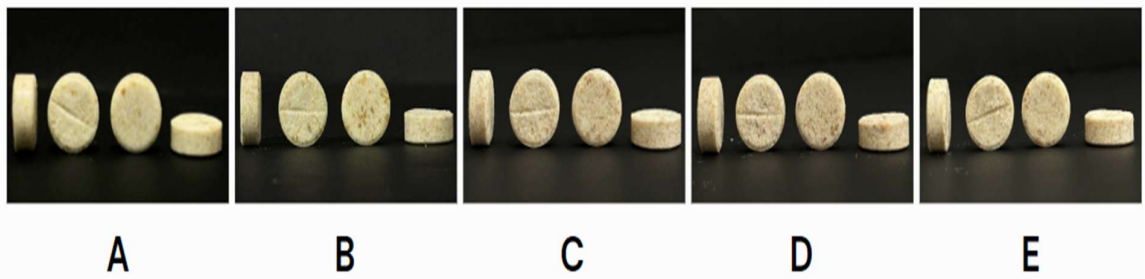

Figure 5. Organoleptic observation of tablets formulated with 40% soybean oil microcapsules on (A) First week, (B) Second week, (C) Third week, (D) Fourth week, and (E) Fifth week.

Table 4. Measurements of SQ-LNS tablet thickness and diameter.

Number of tablets	Diameter (mm)	Thickness (mm)	Number of tablets	Diameter (mm)	Thickness (mm)
1	12.05	5.025	11	12.05	5.050
2	12.05	5.075	12	12.05	5.025
3	12.05	5.000	13	12.025	5.025
4	12.05	5.125	14	12.05	5.050
5	12.025	5.025	15	12.05	5.000
6	12.05	5.025	16	12.05	5.000
7	12.05	5.025	17	12.05	5.025
8	12.075	5.025	18	12.05	5.025
9	12.05	5.025	19	12.05	5.025
10	12.05	5.025	20	12.025	5.000
Average tablet diameter (mm)				12.0475	
Average tablet thickness (mm)				5.03	
Upper limit of diameter (mm)				15.09	
Lower limit of diameter (mm)				6.71	
Deviation of tablet thickness				2.87%	

3.4.4 Disintegration time

Tablet disintegration time was obtained from when 6 of the tablets completely disintegrated without leaving any residue or palatable mass behind on the basket tubes. The result of the disintegration test was ±3 minutes 29 seconds for one batch of rounds, which has passed the requirements of Indonesia Pharmacopeia VI (2020) for disintegrating tablets, which is supposed to be less than 15 minutes for uncoated tablets.

The result shows a relatively early disintegration of the tablets due to sodium starch glycolate (Primojel) acting as a superdisintegrant. Primogel is an enhancing agent that can effectively accelerate the tablet disintegration process without making it physically brittle or

losing its structural integrity (Zarmpi et al., 2017). This capability is achieved through a dual mechanism, namely, enhancing the wetting of particle surfaces (wicking) and facilitating the rapid expansion of the tablet matrix. This combination accelerates fluid penetration and prompts the tablet to disintegrate in about 2 to 3 minutes.

3.4.5 Tablet friability

Measurement of friability or tablet fragility showed a value of 0.38%. Syukri (2018) states that a standard tablet has a friability value of <1%. The results of the tablet friability test were concluded to meet the literature requirements—the type and concentration of binder influence tablet friability. HPMC is known as a good binder in direct compression tablet formulation. The higher the HPMC concentration, the smaller the tablet friability value (Thomas et al., 2021; Khatri et al., 2018)

4. CONCLUSION

Microcapsules with a formulation comparing maltodextrin, CMC, IPK coating materials to soybean oil of 40% are the best comparison formulations. The formulation yields 28% and 79.83% encapsulation efficiency (%EE) of 79.83%. The 40% formulation microcapsules have a *Span Value* of 1.003 µm, and the morphology looks round and minimal oil on the surface of the microcapsules, indicating that the 40% formulation can encapsulate the core material well. The characteristics of SQ-LNS tablets meet the organoleptic observation test, size uniformity, weight uniformity, disintegration time, and tablet friability.

ACKNOWLEDGEMENT

This study was funded by Padjadjaran University and the Ministry of Research, Technology, and Higher Education Indonesia (Ristekdikti). The authors would like to express their gratitude to Parlan and Nandang Permadi for their contributions and support to this research.

CONFLICT OF INTEREST

All authors declared that there was no conflict of interest.

REFERENCES

Arimond, M., Zeilani, M., dan Jungjohann, S. (2015). Considerations in developing lipid-based nutrient supplements for prevention of undernutrition: experience from the international lipid-based nutrient supplements (ilins) project. *Maternal and Child Nutrition*, 11 (4): pp.31-61. https://doi.org/10.1111/mcn.12049.

Badrya, L., Gunarti, D.R., dan Wulandari, Y. (2024). Superoxide dismutase (sod) activity in stunted children: review article. *Science Midwifery*, 12(2): pp.983-991. https://doi.org/10.35335/midwifery.v12i2.1581.

Cizmarova, B., Hubkova, B., & Birkova, A. (2023). Quercetin as an effective antioxidant against superoxide radical. *Functional Food Science*, 3(3): pp.15–25. https://doi.org/10.31989/ffs.v3i3.1076.

Hasrini, R.F., Zakaria, F.R., dan Suparto, I.H. (2017). Mikroenkapsulasi minyak sawit mentah dengan penyalut maltodekstrin dan isolat protein kedelai. *Jurnal Teknologi dan Industri Pangan*, 28(1): pp.10-19. https://doi.org/10.6066/jtip.2017.28.1.10.

Kanchana, K. (2016). A review on Glycine max (l.) merr. (soybean). *Journal of Pharmacy and Pharmaceutical Science*, 5(1): pp.356-371. https://doi.org/10.21107/agrointek.v14i1.6311.

Kementerian Kesehatan Republik Indonesia. (1995). *Farmakope Indonesia Edisi IV*. Jakarta, Kementerian Kesehatan Republik Indonesia.

Kementerian Kesehatan Republik Indonesia. (2014). *Farmakope Indonesia Edisi V*. Jakarta, Kementerian Kesehatan Republik Indonesia.

Kementerian Kesehatan Republik Indonesia. (2020). *Farmakope Indonesia Edisi VI*. Jakarta, Kementerian Kesehatan Republik Indonesia.

Kementerian Kesehatan Republik Indonesia. (2023). Prevalensi stunting di indonesia turun ke 21,6% dari 24,4%. Available from: https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20230125/3142280/prevalensi-stunting-di-indonesia-turun-ke-216-dari-244/ [Accessed 14th January 2024].

Khamidah, S.Z., Hastarini, E., Fardiaz, D., dan Budijanto, S. (2017). Mikroenkapsulasi konsentrat asam lemak tak jenuh dari minyak ikan patin, *Jurnal Teknologi dan Industri Pangan*. 30(2): pp.143-151. https://doi.org/10.6066/jtip.2019.30.2.143.

Khatri, P., Katikaneni, P., Desai, D., dan Minko, T. (2018). Affinisol HPMC polymers for direct compression process applications. *Journal of Drug Delivery Science and Technology.* 47(1): pp.461-467. https://doi.org/10.1016/j.jddst.2018.08.018.

Ningsih, T.E., Siswanto, dan Winarsa, R. (2018). Aktivitas antioksidan kedelai edamame hasil fermentasi kultur campuran oleh Rhizopus oligosporus dan Bacillus subtilis. *Berkala Saintek*, 6(1): pp.17-21. https://doi.org/10.19184/bst.v6i1.7556.

Parcheta, M., Świsłocka, R., Orzechowska, S., Akimowicz, M., Choińska, R., Lewandowski, W. (2021). Recent Developments in Effective Antioxidants: The Structure and Antioxidant Properties. *Materials (Basel)*, 14(8): pp.1984. https://doi.org/10.3390/ma14081984.

Peng, Q., Meng, Z., Luo, Z., Duan, H., Ramaswamy, H.S., dan Wang, C. (2023). Effect of emulsion particle size on the encapsulation behavior and oxidative stability of spray microencapsulated sweet orange oil (Citrus aurantium Var. dulcis). *Foods*, 12(1): pp.116-129. https://doi.org/10.3390/foods12010116.

Purnamayati, L., Dewi, E.N., dan Kurniasih, R.A. (2016). Karakteristik fisik mikrokapsul fikosianin spirulina pada konsentrasi bahan penyalut yang berbeda. *Jurnal Teknologi Hasil Pertanian*, 9(1): pp. 1-8. https://doi.org/10.20961/jthp.v9i2.12844.

Rizzo, J., Min, M., Adnan, S., Afzal, N., Maloh, J., Chambers, C.J., Fam, V., and Sivamani, R.K. (2023). Soy protein containing isoflavones improves facial signs of photoaging and skin hydration in postmenopausal women: results of a prospective randomized double-blind controlled trial. *Nutrients*, 15(19):1-15. https://doi.org/10.3390/nu15194113.

Ravi, D., Usha, G., & Parthasarathy, R. (2013). Microencapsulation technique for selected probiotics and prebiotics. *Malaysian Journal of Science*, 32(2): pp.33–38. https://doi.org/10.22452/mjs.vol32no1.2.

Shahidi, F., & Han, X.-Q. (1993). Encapsulation of food ingredients. *Critical Reviews in Food Science and Nutrition*, 33(6): pp.501–547. https://doi.org/10.1080/10408399309527645.

Sucianti, S., Nurhaeni, N., dan Hardi, J. (2020). Mikroenkapsulasi ekstrak kulit buah naga super merah (Hylocereus costaricensis) pada berbagai massa maltodekstrin dan aplikasinya sebagai antioksidan. *KOVALEN*, 6(3): pp.191-197. https://doi.org/10.22487/kovalen.2020.v6.i3.9889.

Sulistyowati, E., Martono, S., Riyanto, S., Lukitaningsih, E. (2018). Analisis Daidzein dan Genistein pada Kedelai (glycine max l. Merril) Varietas Anjasmoro, Argomulyo dan Dena 2 Menggunakan Metode KCKT. Media Farmasi Indonesia, 13(1): pp.1299–1304. https://mfi.stifar.ac.id/MFI/article/view/40.

Sumardi, Anastasya, D.A., Tarigan, S.T., Insyara, K., dan Yufita, U.M. (2024). Uji aktivitas antioksidan noda klt preparatif dari ekstrak tumbuhan nyirih (Xylocarpus granatum). *Forte Journal*, 4(1): pp.51-162. https://doi.org/10.51771/fj.v4i1.764.

Supriyadi, dan Rujita, A.S. (2013). Karakteristik mikrokapsul minyak atsiri lengkuas dengan maltodekstrin sebagai enkapsulan. *Jurnal Teknologi dan Industri Pangan*, 24(2): pp.201-208. https://doi.org/10.6066/jtip.2013.24.2.201.

Syukri, Y. (2018). *Teknologi Sediaan Obat dalam Bentuk Solid*. Yogyakarta, Universitas Islam Indonesia.

Thomas, N.A., Abdulkadir, W.S., Taupik, M., dan Oktaviana, N. (2021). Pengaruh konsentrasi hydroxypropyl methylcellulose (HPMC) sebagai bahan pengikat pada sediaan tablet ekstrak rimpang jahe merah (Zingiber officinale var. rubrum.). *Indonesian Journal of Pharmaceutical Education,* 1(3): pp.158-167. https://doi.org/10.37311/ijpe.v1i3.11667.

Tolve, R., Galgano, F., Caruso, M. C., Tchuenbou-Magaia, F. L., Condelli, N., Favati, F., & Zhang, Z. (2016). Encapsulation of health-promoting ingredients: Applications in foodstuffs. *International Journal of Food Sciences and Nutrition*, 67: pp.1-131. https://doi.org/10.1080/09637486.2016.1205552.

United States Pharmacopeial Convention. (2024). *United States Pharmacopeia and National Formulary (USP 43–NF 38), General Chapter <1174> Powder Flow.* United States Pharmacopeial Convention.

Wardani, M.A., dan Dewi, L. (2021). Pemanfaatan probiotik dalam cookies labu kuning sebagai strategi pengembangan produk biskuit fungsional. *Teknologi Pangan: Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian*, 12(2): pp.239-249. https://doi.org/10.35891/tp.v12i2.2574.

Waliansyah, R.R. (2020). Identifikasi Jenis Biji Kedelai (Glycine max L) Menggunakan Gray Level Co-occurrence Matrix (GLCM) dan K-Means Clustering. *Jurnal Teknologi Informasi dan Ilmu Komputer,* 7(1): pp.17-26. https://doi.org/10.25126/JTIIK202071066.

World Health Organization. (2015). Guideline: Stunting in a nutshell. Available from: https://www.who.int/news/item/19-11-2015-stunting-in-a-nutshell [Accessed January 28, 2024].

Yuliantini, E., Kamsiah, K., dan Maigoda, T.C. (2022). Food intake with stunting events in fisherman family in bengkulu city. *Aceh Nutrition Journal*, 7(1): pp.79-88. http://dx.doi.org/10.30867/action.v7i1.579.

Zarmpi, P., Flanagan, T., Meehan, E., Mann, J., and Fotaki, N. (2017). Biopharmaceutical aspects and implications of excipient variability in drug product performance. *European Journal of Pharmaceutics and Biopharmaceutics*, 111(1): pp.1-15. https://doi.org/10.1016/j.ejpb.2016.11.004.

Zegzulka, J., Gelnar, D., Jezerska, L., Prokes, R., and Rozbroj, J. (2020). Characterization and flowability methods for metal powders. *Scientific Reports*, 10(2): pp.1-19. https://doi.org/10.1007/s40964-023-00484-x.