***JKPK (JURNAL KIMIA DAN PENDIDIKAN KIMIA)**, Vol. 9, No.2, 2024* *pp. 275-287*
Chemistry Education Study Program, Universitas Sebelas Maret *ISSN 2503-4146*
https://jurnal.uns.ac.id/jkpk *ISSN 2503-4154 (online)*

THE EFFECT OF VARIATION CONCENTRATION OF SIMPLEX SYRUP ON THE PHYSICOCHEMICAL STABILITY OF NANOSILVER SYRUP

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ARTICLE INFO

Keywords:
inulin nanosilver;
simplex syrupus;
immunostimulant;
supplement

Article History:
Received: 2024-01-27
Accepted: 2024-07-01
Published: 2024-07-13
*d*oi:10.20961/jkpk.v9i2.84012

ABSTRACT

Inulin from Gembili has been identified as an effective bioreactor for forming nanosilver with a size of 481.4 nm, stable for 30 days when stored at 4°C. Inulin nanosilver exhibits immunomodulatory properties and has been proven safe through acute toxicity evaluation at 4 mg/kgBB. A drug delivery system needs to be developed for its use as a supplement. Syrup was chosen due to its alcohol-free nature, better taste, and ease of measuring the active substance compared to elixirs, solutions, and suspensions. Simplex syrupus, used as a syrup base, influences stability by potentially forming crystals during storage. This research aims to determine how varying concentrations of simplex syrups affect the physicochemical properties of inulin nanosilver syrup. The study involved biosynthesis using Gembili's inulin, nanosilver characterisation, formulation, and stability testing. Inulin nanosilver syrup was prepared with simplex syrupus concentrations of 20%, 40%, and 60%. The physicochemical stability of the syrup, including organoleptic properties, pH, and viscosity, was tested before and after storage at 4°C and 40°C over six cycles. The selected formula was evaluated for sugar reduction content and FT-IR profile. Data analysis was performed using SPSS 21.0 for Windows with One-way ANOVA and Paired T-Test. Results indicated that higher concentrations of simplex syrupus led to increased consistency, pH, and viscosity. A 60% concentration of simplex syrups met the physicochemical stability requirements, with a medium-thick consistency, pH of 5.25±0.03, and viscosity of 92±2.6 cps. The reducing sugar content was 20.59% ±0.002, and the FT-IR profile confirmed the presence of inulin nanosilver, indicated by Ag-N groups compared to silver nitrate solution. This product has the potential to be developed as a health supplement.

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How to cite: D. E. Ermawati, Y. Hanuriansyah, N. C. A. Susanto, S. Rohmani, D. T. Utami, M. F. Zulpadly, H. Sasongko, U. A. Darojati, A. D. Meitasari, and M. K. Untari, "The effect of variation concentration of simplex syrup on the physicochemical stability of nanosilver syrup," *Jurnal Kimia dan Pendidikan Kimia (JKPK),* vol. 9, no. 2, pp. 275-287, 2024. Available: http://dx.doi.org/10.20961/jkpk.v9i2.84012

INTRODUCTION

Nanosilver is a nanotechnology-based product developed as a medical agent and tested for various applications. Silver ions can be toxic to body tissues due to their high affinity for thiols in the liver and other organs [1]. When silver is converted into nanoparticles, the increased contact area with bacteria enhances its antibacterial activity and reduces toxicity [2]. Besides antibacterial properties, nanosilver also has antiviral effects [3]. It catalyses the body's immune system to combat viruses, pathogens, and bacteria in humans, with a

maximum concentration of 10 mg/kg BW being safe [3].

Biosynthesis of silver nanoparticles using plant extracts is environmentally safer compared to physical and chemical methods. Most plant extracts contain secondary metabolites such as terpenoids, phenolics, flavonoids, and other components with carboxylic acid, amide, and aldehyde functional groups, which act as bioreductive agents by converting Ag^+ to Ag^o [4]. Polysaccharides can serve as reducing and nanosilver-capping agents [5]. Gembili tubers, rich in inulin oligosaccharides, enhance the body's defence mechanism (immunomodulator) [6]. Inulin, a plant-derived carbohydrate fibre, is widely used in health as a prebiotic to boost immunity [7]. During synthesis, the –OH group in inulin acts as a capping agent, reducing Ag^+ to Ag^o, resulting in a stable nanosilver with antibacterial activity [8]. Gembili's inulin, acting as a silver ion bioreductor, shows immunomodulatory activity and synergistically increases the solubility of the inulin [8].

Short-chain inulin generally improves mouthfeel due to its good solubility and sweet taste. In contrast, long-chain inulin from Gembili tubers can act as a fat substitute or texture modifier due to its poor solubility but good stability and viscosity [5]. The silver biosynthesis process with inulin as a reductant enhances inulin solubility since both are nanoparticles. Gembili's inulin, as a silver bioreactor, produces nanoparticles in the range of 12.4−48.0 nm with a spherical shape and shows strong antibacterial activity against gram-positive bacteria and weaker activity against gram-negative bacteria [8]. The optimal pH value for Gembili's inulin nanosilver is 8.0. Even when the pH is increased to 10 and 12, the optimal absorption at the maximum wavelength of nanosilver in the SPR range remains unchanged over a 30-day observation period [9].

The immunomodulatory effect test of Gembili's inulin nanosilver involved evaluating the Immunoglobulin G (IgG) profile in the serum of test animals induced with a vaccine. Using the ELISA reader method at a dose of 4 mg/kg BW, the highest Optical Density (OD) value was observed compared to other doses. Compared with synthetic immunostimulants, the result showed a significance level of 0.13 ($p>0.05$), indicating no significant difference and demonstrating effective immunomodulating activity.

This product, derived from a tuber plant, is an immunity supplement. Herbal immunostimulant products known in the community categorised as phytopharmaca (equivalent to synthetic drugs), serve as a comparison. The nano silver solution remained stable for 30 days at an optimal pH of 8 [9]. Acute toxicity tests of Gembili's inulin nanosilver revealed no toxicity symptoms within the first 4 hours and up to 24 hours of observation, with no LD50 value reached.

This research aims to formulate an immunity supplement suitable for patients ranging from children to the elderly. Inulin nanosilver has proven antibacterial and immunostimulant properties and is safe up to 256 mg/kg BW based on acute toxicity tests. Observations of the semiquantitative histological profile of the kidneys and liver

showed reversible damage, including congestion and intratubular bleeding, at 254 mg/kg BW [10].

Based on previous research, Gembili's inulin nanosilver will be developed as a supplement product. The syrup was chosen due to its alcohol-free nature, better taste, ease of dose measurement, and stability of the active substance compared to elixirs, solutions, and suspensions. Simplex syrupus, used as a syrup base, affects stability due to its potential to form crystals during storage. Research on the effect of sugar concentration on the characteristics of red dragon fruit syrup, with added sugar concentrations of 50%, 55%, and 65%, showed that syrup with 50% sugar met the SNI syrup quality standard, with a reduced sugar content of 65.7% [11] [12]. The quality requirement for making syrup includes a maximum sugar solution concentration of 65% at room temperature to prevent crystallisation and a minimum of 60% to avoid microbial contamination [13].

Previous formulations of nanosilver syrup, such as those given to honeybees at 25 ppm (25 mg/L), have shown health benefits for bees [14]. This study will incorporate Gembili's inulin nanosilver into syrup preparations. The nanosilver syrup was made by adding 4 mg/kg BW of Gembili's inulin and varying the concentration of syrups simplex to 20%, 40%, and 60%, followed by evaluating the physicochemical properties. This study examines the impact of varying concentrations of syrups simplex on the stability of nanosilver syrup to develop a versatile immunomodulatory supplement for patients of different age groups.

METHODS

1. Materials

The study utilised Gembili tubers from Cepogo, Central Java, Indonesia; silver nitrate ($AgNO_3$, Merck KgaA, Germany); 96% ethanol (pharma grade, Merck); simplex syrup (Apomix PKH Pharmazeutisches Labor); propylene glycol (USP /EP / Food grade); sodium benzoate (Food grade, Khoser); and distilled water (Trade Chemicals). Additional materials included anhydrous glucose pro analysis specification 1.08337.11000 (Merck); Nelson reagent (Katayama Chemical Industries Co.); and arsenomolybdate reagent (Oxford Lab Fine Chem LPP).

2. Instruments:

The instruments used were an oven (Mermmet UN110, Germany); a pH meter Eutech CyberScan pH 300 (OHAUS Starter 300); a viscometer Rion VT-04F (Japan); a UV-Visible spectrophotometer (Genesys 150, USA); an FTIR (Shimadzu); and a centrifuge (Thermo Scientific, Germany).

3. Gembili's Inulin Preparation:

Gembili tubers were processed at the Biology Laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Surakarta, Indonesia. The tubers were dried in an oven at 40°C and dissolved in hot water for 30 minutes. The filtrate volume was measured, and 30% ethanol was added to 30% of the total filtrate volume. The solution was stored in a freezer at -10°C for 18 hours to obtain a precipitate, which was then dried in an oven [15].

4. Biosynthesis and Characterization of Nanosilver

Ten grams of Gembili inulin were dissolved in 250 mL of distilled water at 40°C and stirred until fully dissolved. The solution was filtered using the Whatman No. 1 paper (solution a). 85 mg of silver nitrate was dissolved in 500 mL of distilled water at 40°C (solution b). Seven millilitres of solution a were added to 36 mL of solution b and mixed at 60°C for 15 minutes. The mixture was left to stand for 24 hours to maximise the biosynthesis process. The resulting solution was measured at the maximum wavelength using a UV-Vis spectrophotometer, with distilled water as the blank [8]. Particle Size Analyzer (PSA) was used for nanosilver characterisation to determine particle size distribution and uniformity, providing data on Z-average, polydispersity index (PI), and zeta potential.

5. Nanosilver Syrup Preparation:

The ingredients were carefully weighed (**Table 1**). Sodium benzoate was dissolved in half of the propylene glycol. Nanosilver was dissolved in the remaining propylene glycol and mixed with simplex syrup until all ingredients were dissolved. Distilled water was added to make up a total volume of 60 mL.

Table 1. Formula of Inulin Nanosilver Syrup with Variation of Simplex Syrup Concentration

Ingredients	Function	Weight (gram)		
		Formula 1 (20% of syrup base)	Formula 2 (40% of syrup base)	Formula 3 (60% of syrup base)
Gembili's inulin nanosilver	Immunomodulator agent	0.40	0.40	0.40
Simplex syrup	Syrup base	12.0	24.0	36.0
Propylene glycol	Co-solvent	4.81	4.81	4.81
Na benzoate	preservative	0.059	0.059	0.059
Distilled water	solvent	add 60 mL	add 60 mL	add 60 mL

6. Stability Test

The stability test was accelerated using the cycling test method. Syrup preparations were evaluated on day 0 and after six cycles, with each cycle consisting of storage at 4±2 °C and 40±2 °C for 24 hours each. Physicochemical evaluations included organoleptic tests, pH, F value, and viscosity of the syrup preparations [16].

Organoleptic observations assessed changes in colour, aroma, consistency, and the presence of gas or crystals. pH measurements were taken using a calibrated pH meter with standard pH solutions 4 and 10. The pH meter was placed in a nanosilver syrup bottle until the pH value stabilised. Results were recorded and replicated three times. Viscosity was measured by dipping the spindle into the syrup preparation and turning on the viscometer until the spindle was fully submerged and the reading stabilised. The syrup was also placed in a centrifugation tube and centrifuged at 3000 rpm for 10 minutes to observe phase separation. The F value was calculated by dividing the separation height by the total phase height [17].

7. Reduction Glucose Test

A standard glucose solution with a 0.04 mg/mL concentration was prepared. One millilitre of this solution was added to 1.0 mL of Nelson's reagent and heated at 100 °C for 20 minutes. After cooling, 1.0 mL of

arsenomolybdate reagent and 7.0 mL of distilled water were added and vortexed until homogeneous. The absorbance of the resulting mixture was measured at wavelengths ranging from 640-840 nm [18].

1.0 mL of glucose standard solutions with concentrations of 0.012, 0.021, 0.0248, 0.029, 0.0349, 0.041, and 0.052 mg/mL were added to volumetric flasks to create a standard curve. Each was mixed with 1.0 mL of Nelson's reagent, heated at 100 °C for 20 minutes, and then cooled. One millilitre of arsenomolybdate reagent was added and vortexed until all precipitate dissolved. Subsequently, 7.0 mL of distilled water was added and shaken until homogeneous. Absorption of each solution was measured at the maximum wavelength. A standard curve was constructed showing the relationship between standard glucose concentration and absorbance. For the syrup analysis, 1.0 mL of syrup with a concentration of 1.0 mg/mL was prepared and placed in a volumetric flask, mixed with 1.0 mL of Nelson's reagent, heated at 100 °C for 20 minutes, and cooled following the procedure for determining the maximum wavelength.

8. FT-IR Analysis

FTIR analysis was conducted to identify the chemical bonds in the base syrup, nanosilver, and selected nanosilver syrup preparations. This can be determined by observing the wave numbers that indicate the presence of functional groups. A typical infrared scan is produced in the mid-infrared region of the light spectrum, which ranges from 400-4000 cm-1, corresponding to wavelengths of 2.5-25 microns (10-3 mm) [19]. Wave numbers below 900 cm-1 are characteristic of inulin carbohydrates [20].

9. Data Analysis

Data from the physicochemical properties test of the nanosilver syrup formulations were analysed using SPSS 21 software, starting with the Shapiro-Wilk test for normality. If the data were normally distributed, a One-Way ANOVA test was conducted to identify significant differences between the three formulations. Significant differences found in the One-Way ANOVA test were further analysed using the Post Hoc test. The physicochemical properties of each formulation after the stability test were analysed using the Paired Samples T-Test to identify significant differences. Statistical analysis was essential to evaluate the effect of syrups simplex concentration on the physicochemical stability of nanosilver inulin syrup, including viscosity, pH, and sugar reduction.

RESULTS AND DISCUSSION

reaction *Dioscorea rotundata* (brown-skinned white uwi), *Dioscorea alata* (white uwi), *Dioscorea bulbifera* (gembolo), *Dioscorea opposita* (yellow-skinned white uwi), *Dioscorea alata* (yellow fruit uwi with purple skin), and the lowest in *Dioscorea pinthaphyla* (uwi katak) [21].

Biosynthesis, also known as green synthesis, is an environmentally friendly and safe method for synthesising silver nitrate using biological materials, microorganisms, and plants. This method is safer, more cost-effective, and environmentally friendly than physical and chemical methods. Chemical methods for NP-Ag synthesis typically involve

toxic chemicals and high-temperature conditions. Exposure to NP-Ag has been shown to cause oxidative stress, damage cell membranes and DNA, and interact with proteins and enzymes [29]. Using plant extracts for biosynthesis is easier than using microorganisms as bioreactors because it does not require the preparation of microorganism media or cell culture [3]. The physical method of silver metal synthesis involves breaking metal solids into small nano-sized particles, while the chemical method forms nanoparticles through chemical reactions [22]. Chemical-reducing agents have disadvantages such as producing hazardous waste, being expensive, and being toxic. Additionally, the nanosilver formed is often unstable due to the lack of a capping agent to prevent agglomeration [1]. Developing bioreduction methods using plant extracts provides an alternative to these two methods [23].

1. Characteristic of Gembili's Inulin Nanosilver

The biosynthesis process was conducted at 60°C for 15 minutes, a temperature that optimises the size of the resulting nanosilver particles [8]. The reaction completes more quickly at this temperature, producing smaller particles than biosynthesis at room temperature. Previous studies have shown that varying the solubility temperature of inulin (40 ± 2°C and 60 ± 2°C) in the biosynthesis of inulin-silver nitrate results in nanoparticles sized between 12.44 and 47.9 nm with a spherical shape. No significant difference was observed in the antimicrobial activity against *S. aureus* and *E. coli* between the two temperature variations [8]. The –OH groups in inulin act as capping agents, reducing Ag+ to Ag°, thus creating a stable nanosilver. The synthesis process produces a brownish solution, indicating the reduction of Ag+ when bound to the –OH functional group in inulin from Gembili tubers (**Figure 1**). The ability of plant compounds to reduce Ag+ to Ag° nanoparticles is fundamental to the biosynthesis process. The maximum wavelength obtained from UV-Vis spectrophotometric characterisation is 440 nm, indicating the formation of nanosilver, as it produces absorbance peaks in the SPR (Surface Plasmon Resonance) range of 400-500 nm [24].

A Particle Size Analyzer (PSA) was used to determine particle size distribution and uniformity, providing data on Z-average, PDI (Polydisperse Index), and zeta potential. Z-average represents the average particle diameter, and PDI indicates the particle size distribution's breadth. The PSA analysis's advantage lies in its ability to assess particle size distribution and uniformity, which affects the active substance's uniformity at the action target. A high PDI value suggests a wide distribution distance and heterogeneous particle sizes [25]. Zeta potential measures the electric charge between colloidal particles [26].

The Z-average for Gembili's inulin nanosilver ranges from 108.93 to 127.9 nm. Nanoparticles are solid colloidal particles with diameters between 1 and 1000 nm [24]. The results indicate that Gembili's inulin nanosilver size falls within this range. A PI value of less than 0.5 indicates a homogeneous particle size distribution. The zeta potential values obtained were -28.91 to

-27.94 mV, suggesting strong repulsion between particles, which results in a stable dispersion. A zeta potential value of more than +25 mV or less than -25 mV indicates a stable preparation. The values obtained in this study, less than -25 mV, confirm the stability of the resulting nanosilver. The uniformity of particle size on the nanometer scale helps prevent instability, such as condensation.

Figure 1. Gembili's inulin powder (a); gembili's inulin solution (b); silver nitrate solution (c); and gembili's inulin nanosilver (d).

2. Inulin Nanosilver Effective Dose

This study converted a 4 mg/KgBW dose into an appropriate dose for a 70 kg human. The 4.0 mg/KgBW dose was based on previous research, which identified this amount as effective for inulin nanosilver as an immunostimulator [9]. For a 70 kg human, the effective dose as an immunostimulant is 4 mg/KgBW. When converting this dose for animal tests (20 g mice), the equivalent dose is 0.08 mg. An acute toxicity test was performed at this dose to determine the LD50 value using the Thompson-Weil method. Observations made 24 hours post-administration showed no 50% mortality in the test animals, indicating the LD50 value could not be calculated and confirming the safety of this dose when taken orally.

Nanosilver syrup is formulated as a health supplement designed to supplement nutritional needs, maintain health, and provide nutritional value and physiological effects. These supplements can include vitamins, minerals, amino acids, and other non-plant ingredients combined with plant extracts [12]. The recommended usage for this nanosilver syrup preparation is 5 mL once daily. The minimum effective nanosilver dose is 10 mg/KgBW, equivalent to 78 mg for a 70 kg human. Previous studies demonstrated that feeding honeybees nanosilver syrup containing 25 mg/L nanosilver improved their health [14]. Based on stability tests, the best formulation was identified as F3, with a 60% simplex syrup concentration.

Simplex syrupus, used as a sweetener, is added to enhance the syrup's taste. Stabilisers, including antioxidants, buffers, and complexes, are incorporated to maintain the syrup's stability [13]. Increasing the concentration of simplex syrup enhances the consistency of the preparation without affecting the colour of the nanosilver syrup, though it may influence the clarity. The odour of the nanosilver syrup primarily derives from the simplex syrup, which is strong and characteristic, and its concentration does not alter the odour. Similarly, the taste, attributed to the sweetness of the simplex syrup,

remains unaffected by varying concentrations.

Stability evaluation of syrup preparations includes physical, chemical, and microbiological aspects. Physical changes can involve phase separation, precipitation, colour alteration, or texture modification. Chemical stability is influenced by temperature, humidity, pH, oxidation, or interactions between syrup components. Microbiological stability concerns the presence of microorganisms like bacteria, mould, or yeast, which can degrade active ingredients, cause physical changes, or pose toxicity risks.

The recommended pH value for syrup preparations ranges from 5 to 8 [12]. Monitoring pH is essential because an overly acidic syrup can irritate the stomach, while an overly alkaline syrup can taste bitter. Simplex syrups have a pH of around 7, and formula 3's pH is higher than that of formulas 1 and 2 (**Table 2**). Despite slight pH changes during storage, all three formulas maintained values within the acceptable range. The pH values remained stable, decreasing by no more than 50% during storage [31]. Stability tests at storage temperatures of 4°C and 25°C showed that the pH values of all three formulas remained within the recommended range according to the Republic of Indonesia Ministry of Health, which specifies a pH of 5 to 8 [27]. These results suggest that increasing the concentration of simplex syrup does not significantly impact the pH of the nanosilver syrup.

Table 2. Formula of Inulin Nanosilver Syrup with Variation of Simplex Syrup Concentration

Physicochemical test	Cycling test at 4±2°C and 40±2°C for six cycle					
	Formula 1 (20% of syrup base)		Formula 2 (40% of syrup base)		Formula 3 (60% of syrup base)	
	before	after	before	after	before	after
pH	5.17±0.01	4.84±0.03[a]	4.97±0.01	5.05±0.02[b]	5.15±0.03	5.07±0.05
Viscosity (cps)	67±2.0	62±1.2[c]	77±2.2	73±1.1	94±1.6	85±1.6[d]
Reduction glucose (%)	13.80±0.001	12.20±0.001	11.64±0.002	16.40±0.001[e]	13.78±0.002	21.19±0.002[f]

*mean±SD, replication three times; [letter] significantly different

The homogeneity of variance test indicated a significance value greater than 0.05 (p-value = 0.763), suggesting variance similarity between groups. The One-way ANOVA test showed a significance value of less than 0.05 (p-value = 0.000), indicating a significant difference in the pH stability of the preparation across different groups.

The viscosity of the preparation is influenced by factors such as mixing and stirring during formulation. Continuous stirring causes droplet particles to move freely and collide, increasing the tendency to combine. This combination results in weaker contact areas between droplet particles, decreasing consistency and viscosity during storage [26]. The difference in viscosity values can be affected by the amount of solid particles, such as sugar, added to the medium. A higher number of sugar particles increases the viscosity of the syrup [26]. Viscosity is directly proportional to the total amount of dissolved sugar, with stronger bonds between particles resulting in higher viscosity values. Hydrogen bonds between hydroxyl groups (OH) on sugar molecules

and water molecules contribute to the high viscosity of the syrup [28]. These results align with the standard syrup preparation viscosity range of 27 cPs to 396 cPs, as defined by the Indonesian Pharmacopoeia V (1995). Nanosilver syrup with a greater concentration of simplex syrup exhibits higher viscosity. The homogeneity of variance test analysis showed a significance value greater than 0.05 (p-value = 0.876), indicating similar variance between groups. The One-Way ANOVA test revealed a significance value of less than 0.05 (p-value = 0.000), indicating a significant difference in viscosity between the formulas. This demonstrates that variations in the concentration of simplex syrup affect the viscosity of nanosilver syrup preparations.

3. Reduction of Glucose of Inulin Nanosilver Syrup

The reducing sugar test for inulin nanosilver syrup was performed using the Nelson-Somogyi method and UV-VIS spectrophotometry. This method involves oxidising glucose with a Nelson reagent to form a blue-green molybdenum complex after adding an arsenomolybdate reagent [29]. The intensity of the colour formed indicates the amount of reducing sugar present in the sample, as the concentration of reduced arsenomolybdate is proportional to the concentration of copper(I) oxide (Cu2O), which in turn is proportional to the concentration of reducing sugar [18]. The test was carried out in the 400-800 nm wavelength range. The standard glucose solution showed a maximum wavelength of 758 nm, which was used to determine the standard glucose curve and analyse the concentration of the inulin nanosilver syrup. Previous research found a maximum wavelength of 761 nm, which falls within the acceptable tolerance limit of 1-3 nm [30] [12].

The standard curve equation obtained was y = 0.0309x - 0.097, where (y) is the absorbance value and (x) is the reducing sugar content in the sample. The correlation coefficient (r^2) was 0.9465, indicating a strong linear relationship between concentration and absorbance. An r^2 value close to 1 confirms a good linear correlation. The increase in reducing sugar levels is attributed to the hydrolysis of sucrose into reducing sugars (glucose and fructose) during heating, as well as the conversion of sucrose into reducing sugar, which increases with higher sucrose content (**Table 2**) [27] [32].

4. FT-IR Analysis

Fourier Transform Infrared (FTIR) spectroscopy detects the functional groups within a compound. The working principle involves collecting infrared light spread across the sample surface to determine the frequency of the absorbed waves. This can then be interpreted to identify specific groups within the sample. This study evaluated the chemical interaction between inulin and $AgNO_3$ using FTIR spectroscopy at 500 to 4000 cm^{-1} wavenumbers. FTIR analysis was performed on biosynthetic inulin-AgNO3 (nanosilver) samples, selected nanosilver syrup preparations, and syrup preparations without nanosilver. The FTIR spectrum results were interpreted using a correlation table (**Table 3** and **Figure 2**) to identify the types of functional groups based on their wavenumber ranges.

Table 3. The result of the functional group of silver nitrate solution, syrup base and nanosilver syrup by FT-IR analysis

Functional group	Wave Number (cm^{-1})		
	Silver nitrate Solution	Syrup base	Gembili's Inulin Nanosilver Syrup
Ag-N	451.326; 412.78		447.50; 425.32
Pyranose ring	552.63		535.27
C-C vibration	702.12	717.55	716.59
OH- bending	-	1384.95	1385.91
C-O-C	1169.88	-	922.98; 841.00
OH-bending	-	-	1082.11; 1042.57; 994.35
NO_2	-	-	1268.25; 1205.56
C=C	1616.42	1637.64	1628.95
O=C=O stretching	2374.47; 2306.00	2356.15	2355.19; 2312.75; 2108.29
C-H stretching	2939.64; 2868.27	-	2924.21; 2886.60; 2854.77
O-H stretching	3396.79; 3249.23	3451.76	3534.71; 3421.8

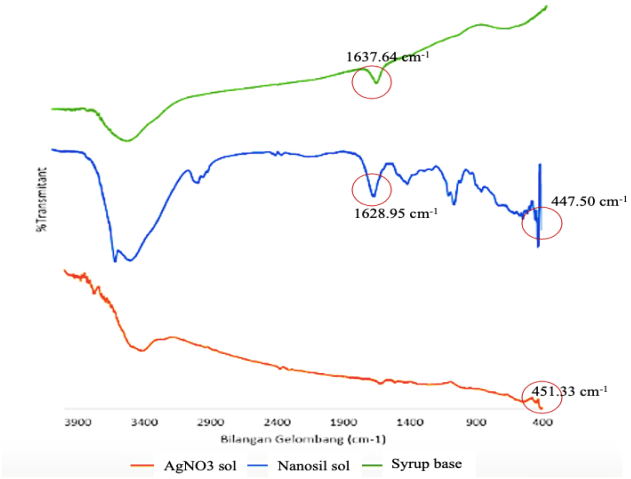

Figure 2. The FT-IR spectra of silver nitrate solution, syrup base and nanosilver syrup where x= wave number (cm^{-1}) and y= % transmittance

The FTIR spectra of the silver nitrate solution, syrup base, and nanosilver syrup show similarities in absorption peaks. In the nanosilver inulin solution, an absorption peak at 1616.42 cm^{-1} (C=C) is also present in the nanosilver syrup at 1628.95 cm^{-1} (C=C). Inulin derived from dahlia tubers has been shown to have FTIR spectra identical to those of chicory and artichoke inulin, characterised by an O−H stretching absorption peak at 3300 cm^{-1}, a signature feature of inulin. The nanosilver syrup sample displayed absorption peaks at 425.32 and 447.50 cm^{-1} (Ag-N) and 535.27 cm^{-1} (pyranose ring), similar to the inulin nanosilver solution's peaks at 412.78 and 451.32 cm^{-1} (Ag-N) and 552.63 cm^{-1} (pyranose ring).

The presence of Ag-N groups (silver ions) in the nanosilver solution and the nanosilver syrup confirms that the nanosilver syrup contains nanosilver particles. In the biosynthesis of nanosilver, reducing agents such as organic compounds or plant extracts interact with silver ions (Ag^+) to form Ag-N groups, reducing silver ions to nanosilver particles. Wave shifts in the nanosilver solution and nanosilver syrup samples indicate interactions between functional

groups and silver nanoparticles. This suggests that adding ingredients results in new properties distinct from those of the original materials.

CONCLUSION

The study demonstrated that a higher concentration of simplex syrup increases consistency, pH, and viscosity. The syrup with 60% simplex syrup concentration met the physicochemical stability requirements, exhibiting a medium-thick consistency, a pH of 5.25±0.03, a viscosity of 92±2.6 cps, and a reducing sugar content of 20.59% ±0.002. The FTIR profile confirmed the presence of nanosilver, indicated by the Ag-N groups compared to the silver nitrate solution.

ACKNOWLEDGMENT

This research was funded by RKAT PTNBH Universitas Sebelas Maret for the 2024 Fiscal Year through the Research Grant Scheme HGR-UNS with Agreement Letter Number: 194/UN27.22/PT.01.03/2024

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