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Research Article

Research on the production of noni (*Morinda citrifolia* L) fruit powder and application of noni fruit powder to make syrup

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Abstract

Noni syrup has became a popular product in the health and beauty industry thanks to its numerous potential benefits. First, noni syrup contains high levels of antioxidants, which help neutralize free radicals in the body, thereby preventing aging and protecting cells from damage. The study tested different ratios of dissolving the Noni fruit powder in water (1:99, 2:98, 3:97, 4:96 g/mL). Noni fruit extract was mixed with different sugar concentrations (50, 55, 60° Brix) and citric acid levels 0.3, 0.35, 0.4% (w/v). Additionally, Carboxymethyl Cellulose (CMC) was added at concentrations of 0.1, 0.15, and 0.2% (w/v). The results indicated that the best ratio for producing noni syrup was 3 g of Noni powder dissolved in 97 mL of water. For optimal sensory value, a sugar concentration of 55%, citric acid concentration of 0.35%, and CMC concentration of 0.15% were recommended. Overall, the study concluded that the noni syrup had an appealing sweet and tangy flavor, as well as an attractive color.

Keywords: *Noni fruit, syrup, noni powder, Carboxymethyl Cellulose (CMC)*

1. INTRODUCTION

In recent years, there has been a growing trend toward the widespread popularity of natural products, and concurrently, the techniques for utilizing natural herbal remedies have shown remarkable advancements. Among the medicinal plants discovered by the ancient Polynesians, noni stands out as a significant traditional botanical remedy that has been employed for over two millennia in the region of Polynesia. Noni holds a distinguished position among the most favored plants utilized for herbal treatments, ranking as the second most sought-after botanical in the field of medicinal herbs for addressing a myriad of typical ailments and promoting well-being [1, 2]. The noni fruit contains over 200 biologically active compounds, including organic acids, alcohols, triterpenoids, flavonoids, glycosides, phenols, saccharides, anthraquinones, carotenoids, esters, lactones, iridoids, ketones, lactones, lignans, nucleosides, triterpenoids, sterols, and aromatics compounds [3]. In the field of medicine, noni has antibacterial, analgesic, antioxidant, anti-inflammatory, astringent, laxative, sedative, and hypotensive effects [4]. Noni is gaining popularity as a dietary supplement, functional ingredient, or natural health enhancer worldwide. Noni fruit is advantageous to health because it contains high levels of phenolic compounds that help reduce stress. These properties have spurred increased interest in researching the composition and antioxidant function of noni [5]. A previous clinical trial involving a limited sample of healthy adults indicated that daily consumption of up to 750 mL (25 fl oz) of noni juice was generally well-tolerated, with no significant adverse effects reported in the majority of participants [6]. Studies have shown that noni juice can improve health for osteoarthritis, increase physical endurance, boost immune activity, inhibit protein glycation, support weight management, help preserve bone health in women, and help stabilize blood

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pressure [7]. Additionally, noni juice has been found to have more notable antioxidant activity than other fruit juices. One of the unique components of noni juice is a phytochemical known as xeronine, which enhances enzyme activity and protein structure [8]. Xeronine is known for its ability to reduce pain in the body [9].

Noni-derived products have been historically overlooked, with noni fruits typically being harvested fresh or sold at low prices, resulting in limited consumption and short shelf life. Agricultural products often have limited value in their raw state and gain worth when processed into high-quality goods with extended shelf lives. Generally, noni syrup can be used by adults seeking natural wellness options, particularly those looking to support their immune system or improve digestion. However, caution is advised for certain groups. Pregnant or nursing women should consult their healthcare provider before using noni syrup due to limited research on its effects during pregnancy and lactation. Building on these insights, this research on producing noni fruit powder and its application in syrup production aims to utilize the abundance of raw materials and leverage the medicinal properties of this valuable plant. This effort not only diversifies syrup products but also enhances the value of noni by preserving its natural medicinal properties, potentially leading to increased economic returns. Moreover, the syrup can be marketed as a tasty addition to beverages and as a functional product with immune-boosting and anti-inflammatory properties, aligning with the growing trend toward natural remedies and holistic health solutions. The resulting noni fruit powder can be a versatile ingredient suitable for various applications in health and wellness formulations.

2. MATERIALS AND METHODS

2.1 Additives and Materials

Noni (*Morinda citrifolia L*) was harvested from the noni orchard in Can Tho. Uniformly ripe noni fruits suitable for syrup production were selected. The ingredients used include citric acid (99.0%) (Merck, Germany); Sodium Carboxymethyl Cellulose (SINOCMC Chemical *Co., Ltd*, China); and sucrose (Bien Hoa, Vietnam).

2.2. Equipment

The following equipment was used: Pasteurization equipment (100 L, Vietnam), Spectroscopy equipment (Pharo 100, Merck, Germany), Colorimeter (CR-400, Japan), Handheld refractometer (HR-Models, Germany), Viscosity meter (DVE, USA), pH meter (HI2020-02, Hanna), Analytical balance (Shimadzu 300, Japan), Oven (Memmert UN55plus, Germany), and Powder grinder DH-1500 (Southern Co., Ltd, Vietnam).

2.3. Methods

2.3.1. Procedure for producing noni powder

Noni fruits were harvested, washed with water, drained, and then cut into pieces. The non-pieces were subsequently dried in an oven at 60℃ for 48 hours until reaching a moisture content of 14 - 15%. Following this, the dried noni was ground into powder and sifted through a 2 mm sieve to achieve a uniform powder size. The powder obtained was then labeled and stored at room temperature for later use [10].

2.3.2. Experiment 1: investigating the impact of the ratio of noni powder to water on product quality

Noni powder was dissolved with filtered water at 80℃ for 5 minutes according to the following experimental ratios A1(1:99), A2 (2:98), A3 (3:97), A4 (4:96) (g:mL). Then the treatments were filtered through filter paper and the resulting solution was analyzed for parameters such as absorbance Abs, L, a*, b.

2.3.3. Experiment 2: Investigating the effects of sugar and acid concentrations on noni syrup products

Noni powder was dissolved with hot water at the ratio selected in experiment 1. The filtrate was then mixed with sugar concentrations 50, 55, 60^o Brix and citric acid 0.3, 0.35, 0.4%, (w/v). After mixing, the syrup mixture was poured into sterilized glass bottles, sealed with caps, and then pasteurized at 85℃ for 2 minutes in a pasteurization unit [23]. Then, the finished product was obtained and analyzed for pH, Brix, and viscosity and subjected to sensory evaluation.

2.3.4. Experiment 3: The impact of Carboxymethyl Cellulose (CMC) concentration on the quality of noni syrup products

Noni powder was dissolved in water according to the selected ratio in experiment 1. The filtrate was then mixed with citric acid and sugar based on the ratios determined in experiment 2, followed by the addition of Carboxymethyl Cellulose (CMC) at concentrations of 0.1%, 0.15%, and 0.2% (w/v). After mixing thoroughly, the mixture was poured into sterilized glass bottles and sealed with caps. The syrup was then pasteurized at a

temperature of 85°C for 2 minutes in a pasteurization pot [23]. The finished noni syrup product was then subjected to viscosity analysis and sensory evaluation.

2.3.5. Analytical method

** Method for determining color (L, a*, b)*

The colour measurements were conducted using the Hunter Lab Color Quest II Minolta CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan). The colour measurements were determined according to the CIELab colour space system. Colour is represented as L (indicating lightness); a+ (green) and a- (red); b+ (blue) and b- (yellow).

** Method for sensory evaluation*

Sensory evaluation was conducted using the 9-point hedonic scale [11]. There were 100 raters, with 10 being evaluated at each time. The 9-point hedonic scale: (1) dislike very much; (2) dislike much; (3) dislike moderately; (4) dislike slightly; (5) neither like nor dislike; (6) like slightly; (7) like moderately; (8) like much; (9) like very much.

** Chemical and microbiological analysis methods*

Heavy metals (Cadmium, Lead, Arsenic, and Mercury) were tested using the AOAC 2015.01 method [12]. Measure the absorbance of noni syrup using a spectrophotometer (Cary 100, Merck Germany). The sample was poured into a cuvette and then measured at 560 nm. After obtaining the baseline absorbance with a blank sample, the noni syrup was carefully placed in the spectrophotometer's sample chamber. The viscosity was measured using Brookfield-DVE (USA) equipment, with spindle s61 (LV 01), measuring speed 3 rpm. Ensure that the sample was properly prepared and at a consistent temperature. Determination of microbiological indicators according to TCVN 4991:2005 (ISO 7937: 2004) [13], TCVN 6848:2007 (ISO 4832: 2006) [14], TCVN 7924-2:2008 (ISO 16649-2: 2001) [15], AOAC 3003.08 [16], TCVN 6189-2:2009 (ISO 7899-2: 2000) [17], ISO 16266:2006 [18], TCVN 4884-1:2015 (ISO 4833-1: 2013) [19], TCVN 8275-1:2010 (ISO 21527-1: 2008) [20].

2.3.6. Data processing methods

Data was collected and processed using the statistical software SPSS 20.0. Each treatment has 3 repetitions. Analysis of variance ANOVA and Duncan test were used to assess the mean differences among treatments at a 95% confidence level. Analysis of variance showed the difference between the treatment means at a significance level of 0.05.

3. RESULTS AND DISCUSSION

3.1. The result investigated the impact of the ratio of noni powder and water on product quality

This study aims to determine how the ratio of noni powder to water affects the quality of noni syrup. The results in **Table 1** indicate that the color of the product was impacted by this ratio. The absorbance (Abs) of noni fluid shows a gradual increase, and there was a significant difference between treatments at the 95% confidence level. In treatment A1, the lowest color absorption was 0.06 ± 0.00, while in treatment A4, the highest was 0.28 ± 0.00. This proves that color absorption was proportional to the ratio of noni powder and inversely related to the amount of water added. Substances such as sugar, acid, anthocyanin and caramel color dissolve well in water [21], so as more water is added, light absorption decreases gradually, and conversely, as less water is added, absorption increases. Similar to the results of this study, as the amount of water decreased, the absorption increased.

Based on the statistical analysis presented in **Table 1**, it was evident that as the noni powder content increased and water content decreased, the brightness value (L) and b value of the treatments decreased, while the a value increased. Specifically, brightness (L) decreased from A1 (15.2 ± 0.58) to A4 (10.2 ± 0.12), showing a statistically significant difference ($P < 0.001$). This could be explained by the increase in soluble substances such as sugar, acid, anthocyanin and caramel color pigments with the higher noni powder amount, which leads to a reduction in brightness. Simultaneously, the b value decreased from treatment A1 (4.89 ± 0.09) to treatment A4 (3.01 ± 0.32), with a statistically significant difference ($P < 0.001$). On the other hand, the value increased from treatment A1 (0.38 ± 0.16) to A5 (1.65 ± 0.62), which was also significantly significant ($P < 0.001$). This confirms that as the noni powder amount increases, the brightness value (L) decreases, and the a value increases due to the natural color of the noni powder.

***Table 1**. Survey results on the influence of the ratio of noni powder and water on product quality*

Treatments	Abs	L	a	B	The average score for sensory evaluation
A_1	0.06 ± 0.00^a	15.2 ± 0.58^d	0.38 ± 0.16^a	4.89 ± 0.09^d	5.20 ± 0.20^b
A_2	0.17 ± 0.00^b	12.9 ± 0.56^c	1.16 ± 0.23^b	3.94 ± 0.08^c	6.13 ± 0.25^c
A_3	0.19 ± 0.00^c	11.3 ± 0.24^b	1.48 ± 0.81^c	3.64 ± 0.13^b	7.10 ± 0.26^d
A_4	0.28 ± 0.00^d	10.2 ± 0.12^a	1.65 ± 0.62^d	3.01 ± 0.32^a	4.43 ± 0.40^a

Note: The data in the table are the average values of 3 repetitions. Different letters in the same column indicate the significant difference in the treatments survey according to the Duncan test at the 95% confidence level. A1: 1:99, A2: 2:98, A3: 3:97, A4:4: 96 (g:mL).

The proportion of noni powder significantly affected the sensory quality of the products. Therefore, determining the appropriate proportion of noni powder is crucial for creating products with desirable sensory properties and improving overall product quality. In this experiment, the proportions of noni powder added were A1: 1:99, A2: 2:98, A3: 3:97, and A4:4:96 (g: mL) The sensory evaluation results in **Table 1** show the liking scores of the four average treatments of products as evaluated using a nine-point scale. Overall, the treatments had different liking scores. Treatment A4 was the least preferred. Treatment A1 was less favorable than treatments A2 and A3. Treatment A2 had a lower liking score than treatment A3 and a higher liking score than the remaining treatments. The sensory score of noni powder added to noni syrup in treatment A3 was the most favorite. Sample and achieved the highest score of 7.1 points compared to the remaining treatments this recipe has a noni smell that was the most favorite.

3.2. Results of surveying the effects of sugar and acid citric concentrations on noni syrup products

The purpose of this study was to determine the most suitable concentration of sugar and citric acid for noni syrup production. Sugar and citric acid were commonly added to juices to enhance flavor, color, and consistency. The product should have the characteristic aroma of the raw material and a balanced sweet and sour taste. Typically, the product has an acidity range of (0.2% to 0.5%) [22]. The results in **Figure 1** show that the concentration of added sugar and citric acid impacts the Brix, pH, and viscosity of noni syrup products.

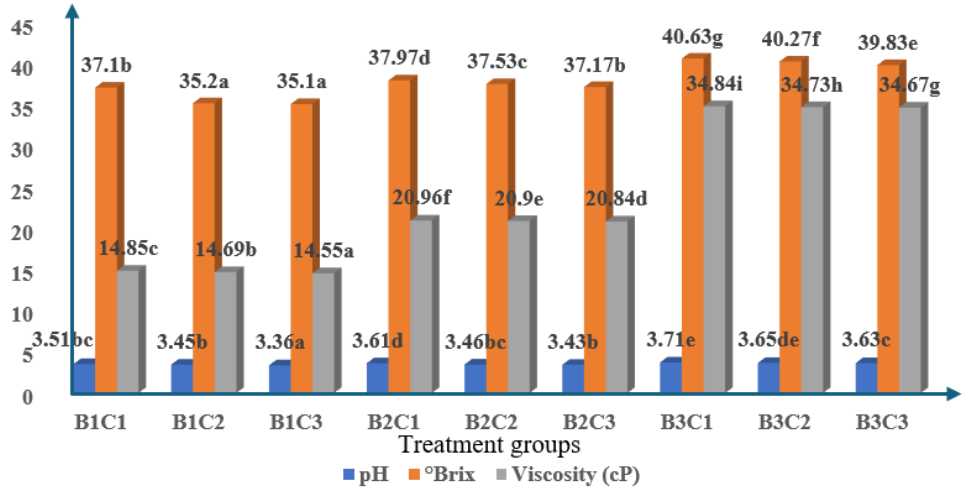

***Figure 1**. Results of surveying the effects of sugar and acid citric concentrations on pH, Brix and viscosity of noni syrup products. Note: The data in the table are the average values of 3 repetitions. Different letters in the same column indicate the significant difference in the treatments survey according to the Duncan test at the 95% confidence level. B1: 50% B2: 55% B3: 60% (w/v) C1: 0.3% C2: 0.35% C3: 0.4% (w/v)*

The results indicate that when the additional citric acid ratio was changed while keeping the sugar ratio constant, there were intense significant differences in pH, Brix, and viscosity. This suggests that adding citric

acid affects the Brix level, pH, and viscosity of the noni syrup product. In contrast, maintaining a constant acid ratio while increasing sugar led to notable differences in pH, Brix, and viscosity.

The sensory evaluation results in **Figure 2** show the average liking scores of the nine treatments of products as evaluated using a nine-point scale. Overall, the treatments had different liking scores. Treatments B3B3, B1C1, B1C3, B3C2, B2C1 were the least favorite. Treatments B3C1, B2C3, and B1C2 were less popular than treatments B2C2 and had a higher liking score than the remaining treatments. The sensory score of noni powder added to noni syrup in treatment B2C2 was the most favorite sample and achieved the highest score of 7.6 points compared to the remaining treatments this recipe has a noni smell, harmonious sweet and sour taste that was the most favorite.

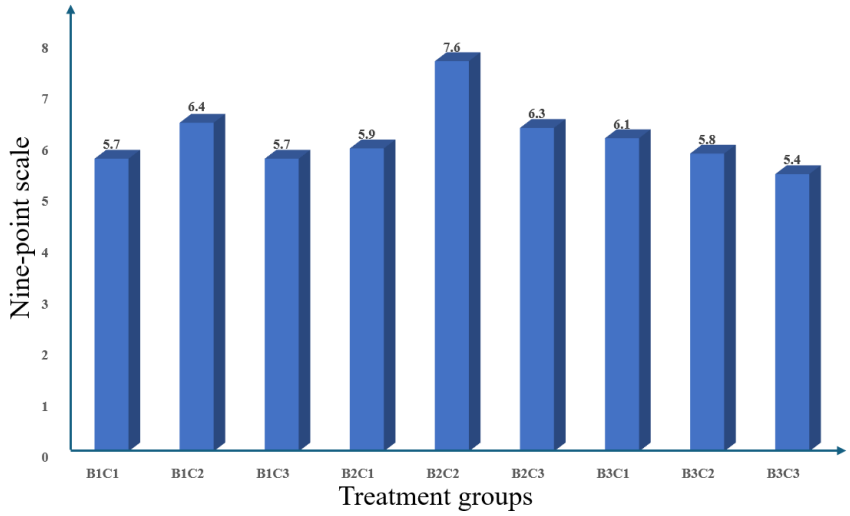

***Figure 2**. Results of sensory evaluation investigating the effects of sugar and acid concentrations on noni syrup products. Note: The data in the table are the average values of 3 repetitions. Different letters in the same column indicate the significant difference in the treatments survey according to the Duncan test at the 95% confidence level. B1: 50% B2: 55% B3: 60% (w/v) C1: 0.3% C2: 0.35% C3: 0.4% (w/v)*

3.3. Effect of the concentration of carboxymethyl cellulose (CMC) used on the state of noni syrup products

The viscosity of treatments D1, D2 and D3 were presented in **Table 2**. As the CMC content increases, the viscosity value of the treatments gradually increases from D1 (30.84 ± 0.26) to D3 (54.63 ± 0.35) and this difference was compressed significantly ($P < 0.001$). In general, the additional CMC content gradually increases, causing the visibility of the product to also increase. CMC was linear polymers for non-Newtonian fluids and has a high molecular weight so when added to a solution they increase the viscosity of the solution. This result was consistent with the research on syrup production from wild myrtle fruits by Nguyen Minh Thuy (2010) [23], showing that when CMC content increases, viscosity also increases.

***Table 2**. Results of surveying the influence of the concentration of carboxymethyl cellulose (CMC) used on the state of noni syrup products*

Treatments	Viscosity (cP)	The average score for sensory evaluation
D_1	30.84 ± 0.26^a	5.6 ± 0.20
D_2	42.93 ± 0.38^b	7.3 ± 0.17
D_3	54.63 ± 0.35^c	6.2 ± 0.25

Note: The data in the table are the average values of 3 repetitions. Different letters in the same column indicate the significant difference in the treatments survey according to the Duncan test at the 95% confidence level. D_1: 0.1%; D_2: 0.15%; D_3: 0.2%, (w/v)

Sensory evaluation results **Table 2** shows that treatment D1 was the least favorite. Treatment D1 was less favorable than treatments D2 and D3. Treatment D2 had a lower liking score than treatment D3 and a higher liking score than the remaining treatment. The sensory score of CMC added to noni syrup in treatment D3 was

the most favourite sample and achieved the highest score of 7.3 points compared to the remaining treatments this recipe has the consistency that is the most.

3.4. Analysis of chemical and microbiological indicators of noni syrup products

The noni syrup product was processed and analyzed for chemical and microbiological criteria, showing that the content of heavy metals Cd, Pb, As, Hg, and microorganisms was undetectable (**Table 3**). indicated that the noni syrup maintained its chemical integrity and microbiological safety. Overall, the analytical results affirm the noni syrup's quality and safety for consumption, positioning it favorably within the growing natural health supplements market.

***Table 3**. Results of analysis of chemical and microbiological indicators of noni syrup products*

Parameter	Content
pH	3.45 ± 0.02
Viscosity (cP)	42.90 ± 0.10
Brix (%Brix)	37.52 ± 0.10
Cadimi (mg/L)	ND (LOD = 0.02)
Lead (mg/L	ND (LOD = 0.02)
Arsen (mg/L)	ND (LOD = 0.004)
Mercury (mg/L)	ND (LOD = 0.03)
Clostridium perfingens (cfu/mL)	ND (LOD = 1)
Coliforms (cfu/mL)	ND (LOD = 1)
Escherichia coli (cfu/mL)	ND (LOD = 1)
Staphylococus aureus (cfu/mL)	ND (LOD = 1)
Faecal streptococci (cfu/mL)	ND (LOD = 1)
Pseudomonas aeruginosa (cfu/mL)	ND (LOD = 1)
Total number of *aerobic microorganisms* (cfu/mL)	ND (LOD = 1)
Total number of *yeast* and *mold* spores (cfu/mL)	ND (LOD = 1)

Note: the data in the table are the average values of 3 repetitions
ND: not detected

As the demand for clean and natural products continues to rise, noni syrup was well-positioned to capture the attention of health-conscious consumers. Its proven quality, safety parameters, and naturally derived components make it an attractive addition to the burgeoning market of health supplements, offering both efficacy and sensory satisfaction to those looking for holistic alternatives in their wellness journey 3.4.1. Specificity of the method.

4. CONCLUSION

In conclusion, this study has successfully developed and optimized a formulation for noni syrup production. The results demonstrate that a ratio of 3 grams of noni powder dissolved in 97 mL of water yields a product with superior color and sensory attributes. To achieve a balanced sweet-sour taste profile, attractive color, and appropriate syrup consistency, the most appropriate formulation includes 55% sugar concentration and 0.35% citric acid concentration. Furthermore, the addition of 0.15% Carboxymethyl Cellulose (CMC) enhanced the sensory qualities of the final product. Future research could explore the optimization of the noni syrup formulation by varying the concentrations of sugar, citric acid, and CMC to assess their effects on overall flavor profile and consumer preference. Investigating alternative natural sweeteners could provide insights into healthier formulations that maintain sensory appeal while appealing to health-conscious consumers. Additionally, expanding the study to include sensory evaluations with a larger demographic might elucidate cultural preferences for flavor and texture, thereby enhancing marketability.

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