Ảnh hưởng bao bì bảo quản đến chất lượng kẹo dẻo bổ sung phụ phẩm chà thịt quả mãng cầu xiêm (*Annona muricata* L.)

TÓM TẮT

Bao bì hiệu quả có tác dụng mang lại lợi ích sức khỏe và lợi ích cho người tiêu dùng sản phẩm, an toàn hơn với thời hạn sử dụng dài hơn. Bao bì và thời gian bảo quản ảnh hưởng đến chất lượng kẹo dẻo, vì vậy nghiên cứu hiện tại nhằm mục đích khảo sát ảnh hưởng loại bao bì và thời gian bảo quản đến chất lượng kẹo dẻo bổ sung thịt quả mãng cầu xiêm. Trong số 3 loại bao bì, bao bì polyethylene (PE) duy trì đặc tính cấu trúc và hạn chế sự tăng trưởng vi sinh vật hiếu khí và nấm mốc, nấm men trong sản phẩm khi so sánh với bao bì polyamide (PA) hoặc polypropylene (PP). Ngoài ra, bao bì PE còn giữ được chất lượng màu sắc, hàm lượng vitamin C, hàm lượng đường tổng, hàm lượng acid tổng, chỉ tiêu cảm quan của sản phẩm sau 6 ngày khảo sát. Hơn nữa, khảo sát thời gian bảo quản kẹo dẻo với bao bì PE trong 5 tuần chỉ ra rằng sản phẩm kẹo dẻo mãng cầu xiêm có màu sắc và hương vị đặc trưng, chất lượng tốt khi được bảo quản trong bao bì PE ở nhiệt độ mát. Bao bì PE có thể là một tùy chọn thích hợp để góp phần duy trì và nâng cao chất lượng sản phẩm kẹo dẻo trong thời gian bảo quản kéo dài.

Từ khóa: *Bao bì, kẹo dẻo, mãng cầu xiêm, polyethylene, thịt quả*

The effect of packaging material on the quality of gummy candy supplemented with soursop (*Annona muricata* L.) pulp by-product extract

ABSTRACT

The effective packaging material offers health benefits and enhances customer welfare with safer and prolonged usage. Packaging and storage time may affect the quality of gummy candy; thus, the current study aims to investigate the effect of packaging material and prolonged storage time on the quality properties of gummy candy supplemented with soursop (*Annona muricata* L.) pulp by-product extract. The results indicated that the polyethylene (PE) package both maintained the structural characteristics and inhibited the growth of aerobic bacteria, as well as yeast and mold, in the gummy candy, when compared with those of polyamide (PA) or polypropylene (PP). In addition, PE also retained its color, nutritional components such as vitamin C, total acid, total sugar contents, and sensory properties after six investigated days. Moreover, the PE package not only extended the storage time up to five weeks but also sustained the soursop pulp extract-supplemented gummy candy with its typical good quality, color, and taste. Therefore, the PE package may be a suitable option for the quality of the gummy candy product in a prolonged storage period.

Keywords: *Gummy candy, packaging, polyethylene, pulp, Soursop*

1. INTRODUCTION

Soursop (*Annona muricata* L.) is a tropical plant grown in the tropical region of Southeast Asia, South America, Central America, and some Pacific Ocean Islands[1,2]. Soursop has been widely cultivated in the South and Central regions of Vietnam due to favorable soil and climate conditions for its growth[3,4]. It has been known to have a strong flavor and high nutritional content, and to possess health benefits such as anticancer, antimicrobial, antiparasitic, anti-inflammatory, and antidiabetic activities[5,6]. Soursop fruits contain a variety of bioactive compounds with high antioxidant and biological activities, such as phenolic, flavonoid, alkaloid, cyclopeptide, and acetogenin[7,8,2,4]. Moreover, its vitamins and amino acids, such as proline and aminobutyric acid, are comparable to those of bananas, pears, apples, grapes, and pineapples[9,4]. The soursop fruit's vitamin and mineral contents further boost the immune and digestive systems[2]. The pulp contains 29% ascorbic acid, which is higher than in its peels, and abundantly harbors phenolic acids, including gallic acid, benzoic acid, coumaric acid, ferulic acid, and hesperidin[10]. As the soursop fruit is highly perishable and has a short post-harvest life of 3-4 days[1], it is widely used in the preparation of jams, jellies, dried fruits, syrups, beverages, and wine to generate various nutritious products and increase the economically effective utilization of natural material sources[1,3,11]. However, it is known that a considerable quantity of material sources is underused in its processing; thus, the utilization of the soursop fruit's by-product from the processing can create value-added products, contributing to economic effectiveness and health benefits.

Gummy candy is a popular and favorable food for all people[12]. It is a combination of sugars, gelatin, acid, food coloring, and flavorings[13]. The use of natural juices or purees of orange, strawberry, and other fruits, or even fruit by-products, has been considered for the manufacture of gummy candy. This utilization not only improves sensory properties (color, flavor, texture) of gummies, but also creates high antioxidant and healthier formulation[14]. Several previous studies have demonstrated the effectiveness of utilizing the skins and peels of fruits as grapes, pineapples, papayas, and lemon peels in the production of gummies[15,16]. Recent group work has utilized soursop pulp by-product from wine production processing to produce gummy candy with highly appreciated texture, color, flavor, and sensory value, meeting the requirements of microbiological safety standards[17]. The present study examines the effects of packaging materials and storage time on the quality of gummy candy supplemented with soursop by-product pulp extract in order to propose measures to contribute to maintaining

and improving the quality during the storage period of gummy candy products.

2. CONTENTS

2.1. Materials and Methods

2.1.1. Materials

The fruit pulp used is a by-product of soursop wine production. The pulp had a bright white color and good quality.

Saccharose sugar (>99,8%) was originated from TTC Bien Hoa - Dong Nai Sugar One Member Limited Company. Gelatin (bloom 250) and pectin were from TNHH ICFOOD Viet Nam.

Citric acid, ($Pb(CH_3COO)$), 3,5-dinitrosalicylic acid (DNS), hydrochloric acid (HCl), saturated sodium sulfate (Na_2SO_4), pectin, and sodium hydroxide (NaOH) were obtained from Xilong Scientific Company, China.

2.1.2. Preparation of gummy candy supplemented with soursop pulp by-product extract.

The qualified soursop pulp (50 g) was added to 100 mL of water in a ratio of pulp:water (1:2, w/w). The mixture was minced to obtain the pulp extract, and subsequently, a solution mixture of 150% sugar, 4% citric acid, 0,6 % pectin was added. The mixture was heated to 90°C for 7 min, and then 35% gelatin was added and heated for an additional 3 min to form a uniform mixture. Gelatin was soaked in water for 30 minutes with a ratio of 1:1 (w/w) to fully hydrate and swell prior to use. Next, the mixture was then further heated with the addition of 20% prepared soursop pulp extract for 3 min. The cooked mixture was poured into a mold and left at room temperature for 1 hour, and then cooled at 2-4 °C for 24 hours to stabilize the structure of the gummy candy mass. Once the candy structure was stabilized after cooling, the mold was removed, and the gummy candy product was obtained[17].

2.1.3. Investigation of the packaging materials on the quality of gummy candy supplemented with the soursop pulp by-product

The experiment was laid out following a completely randomized design with triplicate for each treatment. Six samples were stored in three different packaging treatments, including polypropylene (PP), polyamide (PA), and polyethylene (PE). Afterward, samples were stored in a plastic box and placed at room temperature with natural light. Samples were tested and evaluated for humidity, vitamin C, total sugar content, total acid content, texture, color, and total microorganisms at two-day intervals. Gummy candy samples stored in each corresponding package without sealing were considered the control treatment.

2.1.4. Investigation of storage time on the quality of gummy candy supplemented with the soursop pulp by-product

From the experiment described in the sub-section 2.1.3, we selected the best optimal packaging material and increased the investigation up to five weeks. The changes of the product during storage time were evaluated once a week, including color, total acid and total sugar content, vitamin C, and total microorganisms, yeast, and mold.

2.1.5. Analysis of physicochemical properties

The product color was analyzed using the ColorLite sph870 portable spectrophotometer to determine to determine the CIE (Commission Internationale de I'Esclairage) color space coordinates through the L*, a*, b* values, in which L* indicates the darkness/lightness of the sample, a* is the measurement of green to red, and b* is the measurement of blue to yellow. The product structure, including hardness, flexibility, toughness, and elasticity, was analyzed by a TMS-Pro texture analyzer using the one-cycle compression method with maximum compression force parameters of 90 N, height of 15 mm, speed of 60 seconds, and compression depth of 50% of the sample. Total acid content was determined by a saturated method according to the Vietnamese standard TCVN 4589:1988. Moisture content was measured by the drying method according to the Vietnamese standard TCVN 1867:2001. Reducing sugar content was evaluated by the DNS method[18]. Vitamin C content was determined by the titration method with iodine as described previously[19].

2.1.6. Analysis of total microorganisms, yeast, and mold (CFU/g)

Aerobic microbial density was measured by the agar-plate counting method. The minced sample (10 g) was added to 9 mL pepton buffer. The sample was thoroughly shaken for 2-3 min to obtain a stock solution of 10^{-1} and diluted to various concentrations. A serial diluted sample (1 mL) was plated on a petri dish, and then 10 mL of medium was added. After the sample was incubated at 37°C for 72 hours, the colonies were counted, and the number of colonies was calculated using the formula as follows: N = C/n.d.v, in which N: total colony number in 1 mL sample (CFU: colony forming units), C: number of colonies counted, n: number of plates for one

diluted sample, d: dilution factor, and v: volume plated (mL).

2.1.7. Data analysis

Data was analyzed using Statgraphics Centurion XV (Statpoint Technologies Inc., USA). Statistical significance was analyzed by One-way ANOVA. The Least Significant Difference (LSD) was used to test the mean difference between treatments at 5% significance level.

2.2. Results and Discussion

2.2.1. Effect of package material on the quality of gummy candy supplemented with soursop pulp by-product extract

Packaging material not only contains the food, but also protects it from the impact of the environment; thus, it is essential in food storage. The effective package offers consumer health benefits, as well as high-quality food with increased safety and a longer usage life[20]. The selection of appropriate packaging material plays an important role in maintaining the texture, quality, nutritional composition, and sensory properties of the food. The polyester packaging has been popularly used and provides a barrier against oxygen and carbon dioxide while also regulating humidity in food storage. Moreover, the polyethylene and polypropylene packaging have also been used in food storage due to simplicity, low cost, flexibility, strength, lightness, moisture and chemical resistance, and ease of handling[21]. High-density polyethylene is rigid, gas permeable, advantageous process and shape[22,23].

Table 1. Effect of packaging on the texture of gummy candy supplemented with soursop pulp by-product extract

Day	Packaging material	Texture			
		Hardness (N)	Elasticity (mm)	Flexibility (N)	Toughness (mJ)
2	PA	0.38^{bc}	0.25^{ab}	0.35^{b}	0.14^{c}
	PE	0.39^{ab}	0.23^{b}	0.35^{b}	0.17^{b}
	PP	0.35^{c}	0.26^{a}	0.27^{c}	0.15^{c}
	F	*14.56*	*95.88*	*69.87*	*62.07*
	P	*0.001*	*0.000*	*0.000*	*0.000*
4	PA	0.37^{c}	0.24^{a}	0.33^{b}	0.16^{c}
	PE	0.39^{b}	0.23^{a}	0.35^{b}	0.19^{b}
	PP	0.33^{d}	0.26^{a}	0.26^{c}	0.15^{c}
	F	*449.00*	*19.56*	*120.31*	*30.00*
	P	*0.000*	*0.000*	*0.000*	*0.000*
6	PA	0.36^{b}	0.23^{c}	0.32^{b}	0.18^{b}
	PE	0.39^{a}	0.23^{b}	0.31^{b}	0.21^{a}
	PP	0.31^{c}	0.25^{ab}	0.24^{c}	0.16^{b}
	F	*100.25*	*12.47*	*130.33*	*31.76*
	P	*0.000*	*0.002*	*0.000*	*0.000*

Data are the mean of three replicates in each treatment. Different letters in the same column indicate the statistically significant difference between treatments at 5% significance level by the LSD test.

As shown in Table 1, there was a statistically significant difference between packaging treatments that were used to store gummy candy supplemented with soursop pulp by-product extract at six days of investigation. Hardness is one of the important criteria to evaluate the quality of gummy candy, and it has a direct relationship with the moisture content of the product in the inverse direction. Toughness reflects the product's flexibility and elasticity. In this investigation, hardness was reduced gradually, and this decrease was found in PA and PP when compared to PE. As for other texture parameters, the elasticity of the product stored in PE packaging did not show a significant difference after 6 days, remaining at 0.23 N, while those in PA and PP packaging tended to decrease slightly, to 0.25 mm and 0.26 mm on day 2 and to 0.23 mm and 0.25 mm on day 6. Nhi and colleagues indicate considerable factors in the production of gummy candy from the soursop pulp, such as toughness and browning, which affect the product life cycle[24]. In general, three packaging materials, PA, PP, and PE, increased toughness, especially in PE packaging. In terms of the flexibility characteristic, PE and PA packaging showed higher stability than PA packaging over the 6-day investigation. In addition, the evaluated packaging type did not significantly affect the color quality, vitamin C

content, total sugar content, total acid content, and sensory indicators of the product over the 6-day time period. After 6 days of storage, the density of aerobic microorganisms in PA and PP packaging exceeded the allowable standards with densities of 1.9 x 10^4 and 1.8 x 10^4, respectively, while the density of aerobic microorganisms in PE packaging was 4.0 x 10^3 within the allowable standard (The Ministry of Health, 2007). In all three packaging materials, after 6 days of storage, the total number of yeast and mold spores was limited within the allowable level according to microbial standards, according to Decision 46/2007/QD-BYT.

Table 2. Effect of packaging on the microbial parameter after gummy candy's six-day storage.

Day	Parameter	Ministry of Health, 2007	Packaging material		
			PA	PP	PE
2	Total aerobic microorganism	≤10^4	2.2 x 10^2	2.4 x10^2	2.0 x 10^2
	Total yeast and mold	≤10^2	ND	ND	ND
4	Total aerobic microorganism	≤10^4	5.5 x 10^3	3.7 x 10^3	1.4 x 10^3
	Total yeast and mold	≤10^2	ND	ND	ND
6	Total aerobic bacteria	≤10^4	1.9 x 10^4	1.8 x 10^4	4.0 x 10^3
	Total aerobic microorganism	≤10^2	<10	<10	<10

Data are the mean of three replicates in each treatment. Different letters in the same column indicate the statistically significant difference between treatments at 5% significance level by the LSD test. PA: polyamide, PE: polyethylene, PP: polypropylene. ND: not detected.

2.2.2. Effect of storage time on the quality of gummy candy supplemented with soursop pulp by-product extract

Because PE packaging maintained the stability of structure, color, and quality of gummy candy products better than PA and PP packaging after 6 days. Therefore, we continued to study the impact of PE packaging on the quality of gummy candy products during longer storage periods of up to 5 weeks. Color is one of the important characteristics of foods, including candy. It is a parameter that represents the quality and sensory characteristics of consumer tastes. However, it is affected by storage time due to environmental conditions and the type of packaging used. The analysis results showed that the L* value increased after 5 weeks, from 51.34 in week 1 to 55.50 in week 5. The a* value also increased after 5 weeks, from 3.21 in week 1 to 4.97 in week 5. The b* value decreased after 5 weeks, from -1.48 in week 1 to -1.90 in week 5 (Table 3). The findings showed that the L* and a* values were directly proportional to each other and inversely proportional to b*. If L* and a* increase, b* decreases, and vice versa.

Table 3. Effect of storage time on color parameters of the gummy candy supplemented with soursop pulp by-product extract.

Time (weeks)	Color values		
	L*	a*	b*
1	51.34^e	3.21^e	-1.48^a
2	52.47^d	4.84^d	-1.56^a
3	53.31^c	4.25^c	-1.68^b
4	54.24^b	4.74^b	-1.77^c
5	55.50^a	4.97^a	-1.90^d
F	*563.72*	*229.04*	*96.68*
P	*0.000*	*0.000*	*0.000*

Data are the mean of three replicates in each treatment. Different letters in the same column indicate the statistically significant difference between treatments at 5% significance level by the LSD test.

Table 4. Effect of storage time on nutritional composition of the gummy candy supplemented with soursop pulp by-product extract.

Week	Vitamin C (%mg)	Total acid (%)	Total sugar (%)	Humidity (%)
1	16.28^a	1.30^c	43.60^a	14.47^a
2	15.84^b	1.31^c	43.35^b	13.33^b

3	15.40^{c}	1.33^{b}	42.92^{c}	12.20^{c}
4	14.96^{d}	1.34^{b}	42.02^{d}	12.13^{c}
5	14.52^{e}	1.38^{a}	41.15^{e}	11.50^{d}
F	*698.08*	*145.50*	*30776.1*	*1023.64*
P	*0.000*	*0.000*	*0.000*	*0.000*

Data are the mean of three replicates in each treatment. Different letters in the same column indicate the statistically significant difference between treatments at 5% significance level by the LSD test.

The vitamin C content slightly decreased from 14.52 mg/% to 16.28 mg/%, while the total acid increased slightly from 1,.% to 1,.38% during 5 weeks of storage (Table 4). In addition, the sugar content decreased from 43.6% to 41.15%. The plausible explanation can be due to browning reactions, such as the Maillard reaction, that occurred during storage[25]. This reaction not only reduces the sugar content but can also affect the flavor and color of the gummy candy. Although the total sugar content decreased after 6 days, it was higher than the allowable limit of 40% in accordance with National Standard TCVN 5908:200928. The results also showed that there was an increase in the density of total aerobic microorganisms from 2.0.10^{2} to 4.0 x 10^{3} after 5 weeks; however, this value was within the allowable limit on microbiological indicator standard according to Decision 46/2007/QĐ-BYT. No yeast and mold spores were detected for 5 weeks (Table 5). Thus, the soursop gummy candy product was guaranteed with PE packaging after 5 weeks of storage.

Hình 1. The product

Table 5. Effect of storage time on microbial parameters of the gummy candy supplemented with soursop pulp by-product extract.

Week	Total aerobic microorganism		Total yeast and mold	
	Ministry of Health, 2007	This study	Ministry of Health, 2007	This study
1	≤10^{4}	2.0 x 10^{2}	≤10^{2}	ND
2	≤10^{4}	2.7 x 10^{2}	≤10^{2}	ND
3	≤10^{4}	3.1 x 10^{3}	≤10^{2}	ND
4	≤10^{4}	3.5 x 10^{3}	≤10^{2}	ND
5	≤10^{4}	4.0 x 10^{3}	≤10^{2}	ND

Data are the mean of three replicates in each treatment. Different letters in the same column indicate the statistically significant difference between treatments at 5% significance level by the LSD test. ND: not detected.

3. CONCLUSIONS

Generating food products supplemented with natural by-products is a circular strategy, increasing economic efficiency and creating nutritional value-added products. In this study, the soursop pulp by-product from the wine-making process with high fiber, ascorbic acid, and phenolic acid contents will be utilized and supplemented for the gummy candy production. To search for further optimal solutions, the study investigated the packaging material and storage time affecting the quality of soursop gummy candy. Among the three packaging types evaluated, polyethylene (PE) packaging maintained the quality of the gummy candy product with stable structure, texture, and nutritional content and limited the growth of aerobic microorganisms, molds, and yeasts compared to polyamide (PA) and polypropylene (PP) packaging. Furthermore, the gummy candy has color and flavor, quality characteristics when stored in PE packaging for up to 5 weeks at a cool temperature. PE packaging could be a suitable option in maintaining and improving the quality of gummy candy products during long-term storage. At the same time, the research results provide scientific values to evaluate and forecast the product's change trend. Further studies should be conducted to determine other factors, such as humidity, light intensity, and others, that can affect the product quality; thereby, diversifying the forms of preservation and circulation of products on the market.

REFERENCES

1. H.X. Phong, H.V. Kiet, L.T. Hung, T.K. Ai, L.M. Chau, N.N. Thanh, T.H. Hiep, L.T. An, D.T.K. Tien. Optimization of fermentation conditions in wine production from soursop (*Annona muricata* L.) using *Saccharomyces cerevisiae* FBY015, *TNU Journal of Science and Technology*, **2021**, *226*(5), 95-103.
2. L.T.N. Huynh, D.Y. Vy, N.N. Quy, T.T.Y. Nhi, H.B. Long, B.L. Giang, B.T.T. Thao, D.T. Phat. Assessment of changes in product quality and antioxidant activity of dried soursop (*Annona muricata* L.) during product storage, *Food Chemistry: X*, **2023**, *21*, 101062.
3. D.T.K. Tien, D.T.T. Nhung, L.T. An, T.H. Hiep, H.T.N. My, N.N. Thanh, H.X. Phong. Isolation and selection of yeasts from soursop *Annona muricata* for wine fermentation, Vietnam Journal of Science and Technology, **2021,** *63*(11), 53-57.
4. D.Y. Vy, L.T.Q. Nhu, N.H.Nghia, V.N. Duc, T.N.Y. Nhi, N.T. Bay, T.T. Tuu, B.L. Giang, D.T. Phat. Assessment of the changes in product characteristics, total ascorbic acid, total flavonoid content, total polyphenol content and antioxidant activity of dried soursop fruit tea (*Annona muricata* L.) during product storage, *Food Science & Nutrition*, **2023**, *12*(4), 2679-2691.
5. S.M.A. Wahab, I. Jantan, Md.A. Haque, L. Arshad. Exploring the leaves of *Annona muricata* L. as a source of potential anti-inflammatory and anticancer agents, *Frontiers in Pharmacology*, **2018**, *9*, 661.
6. M.Mutakin, R. Fauziati, F.N. Fadhilah, A. Zuhrotun, R. Amalia, Y.E. Hadisaputri. Pharmacological activities of soursop (*Annona muricata* Lin.), *Molecules*, **2022**, *27*(4), 1201.
7. S.Z. Moghadamtousi, M. Fadaeinasab, S. Nikzad, G. Mohan, H.M. Ali, H.A. Kadir. *Annona muricata* (Annonaceae): A Review of Its Traditional Uses, Isolated Acetogenins and Biological Activities, *International Journal of Molecular Sciences*, **2015**, *16*, 15625-15658.
8. S. Ilango, D.K. Sahoo, B. Paital, K. Kathirvel, J.I. Gabriel, K. Subramaniam, P. Jayachandran, R.K. Dash, A.K. Hati, T.R. Behera, P. Mishra, R. Nirmaladevi. A Review on *Annona muricata* and Its Anticancer Activity, *Cancers*, **2022**, *14*(18), 4539.
9. M. Afzaal, F. Saeed, A. Asghar, Y. A. Shah, A. Ikram, H. Ateeq, M. Hussain, C. E. Ofoedu, J. S. Chacha. Nutritional and therapeutic potential of soursop, *Journal of Food Quality*, **2022**, *2022*, 828358.
10. Y.O. Domingues, G.A.Lemes, F.L. de Oliveira, T.R. de Souza, B. Silva, J.A.C. Bento, M.C. Morzelle. In vitro simulated gastrointestinal digestion and bioaccessibility of phenolic compounds and antioxidants of soursop (*Annona muricata* L.) peel and pulp, *LWT - Food Science and Technology*, **2024**, *208*, 116694.
11. B. Olas. The antioxidant potential of graviola and its potential medicinal application, *Nutrients*, **2023**, *15*, 402.
12. R. Delgado-Durán, A. Antonio-Pérez, J. Esperón-Carreón, O.E. Méndez-Guerrero, S.V. Saucedo, R.E. Rivero-Aranda, A.L. Torres-Huerta. Formulating chayote-enriched gummy candies: Balancing nutrition and taste for a delightful alternative, *Food Chemistry Advances*, **2025**, *6*, 100902.
13. A. Periche, A. Heredia, I. Escriche, A. Andrés, M.L. Castelló. Potential use of isomaltulose to produce healthier marshmallows, *LWT - Food Science and Technology*, **2015**, *62*(1), 605–612.
14. E. Teixeira-Lemos, A.R. Almeida, B. Vouga, C. Morais, I. Correia, P. Pereira, R.P.F. Guiné. Development and characterization of healthy gummy jellies containing natural fruits, *Open Agriculture*, **2021,** *6*, 466-478.
15. K.F. Romo-Zamarrón, L.E. Pérez-Cabrera, A. Tecante. Physicochemical and sensory properties of gummy candies enriched with pineapple and papaya peel powders, *Food and Nutrition Sciences*, **2019**, *10*, 1300-1312.
16. F. Aiello, P. Caputo, C.O. Rossi, D. Restuccia, U.G. Spizzirri. Formulation of antioxidant gummies based on gelatin enriched with citrus fruit peels extract, *Foods*, **2024**, *13*, 320.
17. D.T.K. Tien, T.T.T. Linh, N.T.T Kim, D.H Dang, H.T.N. Mi. Utilizing the by-product of the soursop winemaking process to make gummy candy, *TNU Journal of Science and Technology*, **2024**, *229*(14), 321-330.
18. G.L. Miller. Use of dinitrosalicylic acid reagent for determination of reducing sugar, *Analytical Chemistry,* **1959**, *31*(3), 426-428.
19. N.M. Tri, D.K. Quyen. Effects of ingredients on texture, anthocyanin and vitamin C contents of strawberry gel candy, *Can Tho University Journal of Science*, **2014,** *14*(1), 50-60.
20. S.S.H. Aly, M.A. El-Gendy. The Effect of Packaging Materials on The Quality of Children's Jelly Candies with Artificial and Natural Color, *Food Technology Research Journal*, **2023**, *1*(3), 66-80.
21. P.R. Lozano, E.R. Miracle, A.J. Krause, M. Drake, K.R. Cadwallader. Effect of cold storage and packaging material on the major aroma components of sweet cream butter, *Journal of Agricultural and Food Chemistry*, **2007**, *55*(19), 7840-7846.
22. R.W.G.V. Willige, J.P.H. Linssen, M.B.J. Meinders, H.J Van der Steger, A.G.J. Oragen. Influence of flavor absorption on oxygen permeation through LDPE, PP, PC and PET

plastics food packaging, *Food Additives and Contaminants*, **2002**, *19*(3), 303-313.

23. K. Marsh, B. Bugusu. Food Packaging-Roles, Materials, and Environmental Issues, *Journal of Food Science*, **2007**, *72*(3), 39-55.
24. T.T.Y Nhi, N.D. Vu, N.N. Quyen, P.V. Thinh, N.T.M. Tho, T.T. Truc. The effect of malt, pectin, and gelatin concentrations on elasticity, color and sensory evaluation of soursop (*Annona muricata* L.) jelly candy, *IOP Conference Series: Materials Science and Engineering*, **2020**, *991*, 012013.
25. A.M. Durrani, P.K. Srivastava, S. Verma. Development and quality evaluation of honey based carrot candy, *Journal of Food Science and Technology*, **2011**, *48*(4), 502-505.