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Development of spray-dried yogurt with addition of cinnamon extract as a functional drink

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Abstract

The addition of cinnamon extract was done to improve the functional properties of yogurt. The limiting factor of yogurt is the difficulty of maintaining the quality in the distribution process. Spray drying technology is suitable for maintaining the quality of yogurt during distribution. This study aimed to evaluate the characteristics and antioxidant activity of yogurt with the addition of cinnamon extract before and after spray drying process. Research was conducted using factorial pattern of complete randomize design 2×3 (levels of extract and type of yogurt). The samples were evaluated for its pH, water activity, viscosity, titratable acidity, total lactic acid bacteria, antioxidant activity by DPPH inhibition, total phenolic compound (TPC), nutrient content and sensory properties. Yogurt powder obtained from spray drying process were analyzed for its visual appearance using scanning electron microscopy. Results showed that pH, viscosity, titratable acidity, viable lactic acid bacteria, protein and ash content were significantly affected by spray drying process, while moisture content and TPC were significantly affected by both spray drying and type of yogurt. Overall, after spray drying process, rehydrated cinnamon-yogurt still had antioxidant capacity and quality that met the requirement according to Indonesian Standard and CODEX.

1. Introduction

In the last two years, a lot of people evaluate their views on health, diet and wellness due to COVID-19. Consumers are now more than ever associating their eating patterns with their health. As a result, the market for functional foods, which are foods with improved nutritional qualities and offer health advantages including boosted immunity and decrease weariness, is constantly rising. Functional foods are, in many ways, the food of the future, and this trend will continue to grow as new food technologies evolve. In the current condition, food intake that has functional properties, such as antioxidants is needed for consumption. Antioxidant-rich foods can combat oxidative stress and may function as immunomodulators (Winarsi *et al.,* 2022).

Yogurt as one of the popular functional drinks in the world has been recommended by nutritionist due to its high nutritional value, especially due to the breakdown of lactose, increased calcium concentration, and the existence of bioactive compound produced through the role of prebiotics and probiotics bacteria (Batista *et al.,* 2015; Heydari *et al.,* 2018). Studies show that consumption of yogurt can provide health benefits by preventing obesity, diabetes and cardiovascular (Panahi and Tremblay, 2016; Rezaei *et al.,* 2017). The addition of herbal ingredients to yogurt is currently one of the most promising innovations developed by researchers. Herbal ingredients are rich in bioactive compounds with high of antioxidants capacity. *Cinnamomum burmanii* as Indonesia's leading spice commodity has the potential as a phytopharmaceutical material. Cinnamon bark has active substances such as flavonoids, glycosides, saponins, tannins, triterpenoids, phenols and alkaloids which are play a significant role as antioxidants agent (Rahadian *et al.,* 2017; Wihansah *et al.,* 2022). Thus, the addition of cinnamon extract may enhance the functional properties of yogurt.

On the other hand, storage conditions become a critical point during the distribution process of yogurt. Yogurt may lose its ability to promote health due to a number of circumstances, including improper storage

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temperature, post acidification, oxygen exposure, decreased proteolytic activity and interactions between starting culture. Processing yogurt into powder form is an alternative for conservation of yogurt for a longer period. Converting yogurt into powder through spray drying can prevent yogurt from spoilage during transportation and storage by slow down chemical process, reduces microbial and enzymatic activities, and extent product shelf life. Water reduction in yogurt contributes to greater preservation and facilities transport and packaging due to the reduced wight of product (Jafari *et al.,* 2019). Another major advantage is that low storage temperatures are not required, as those used in the conservation of traditional product, thus eliminating the need for cold chain during distribution and sale, which represents an economic advantage (Santos *et al.,* 2018). After buying yogurt powder, consumers can practically add water into yogurt powder to produce a yogurt drink. During the drying process, the viability of heat-sensitive lactic acid bacteria can decrease. Thus, microencapsulation techniques are needed to protect bacteria during the drying process. Microencapsulation is the process of forming microcapsules from the active ingredient in the form of solid, liquid or a dispersion with a thin layer of encapsulation so that prevent bacterial cell damage from environmental influences. Encapsulation through spray drying is a simple, continuous and cheap commercial process, used for heat-sensitive materials (Assadpour and Jafari, 2019). The main goal of this research was to produce yogurt powder with addition of cinnamon extract and study the characteristic and antioxidant activity of rehydrated cinnamon-yogurt powder.

2. Materials and methods

This research was performed in the Post-harvest Laboratory and Quality Assurance Laboratory, Department of Animal Husbandry, Bogor Agricultural Development Polytechnic, Integrated Laboratory, Faculty of Animal Science, IPB University, and Indonesian Agency for Agricultural Research and Development. Whole milk, skim milk, *Cinnamon burmanii*, starter culture (*Streptococcus thermophilus* ENCC 0040, *Lactobacillus bulgaricus* ENCC 0041, *Lactobacillus casei* FNCC 0090 dan *Bifidobacterium longum* ATCC 15707), sugar, were used for yogurt production. Other chemicals including phenolptalein, NaOH, DPPH (1,1-diphenyl-2-picrylhydrazyl) solution, deMann Rogosa Sharpe Agar (MRSA), akuades, ethanol 70% were purchased from international brands.

2.1 Cinnamon extraction

Cinnamon was finely ground and filtered with a mesh size of 40. Extract preparation was done by maceration using 70% ethanol (1:5) for 48 hrs. The separation of the ethanol solvent was carried out with a Rotary vacuum evaporator under reduced pressure at approximately 40°C (Salehi *et al.,* 2013).

2.2 Yogurt production

Manufacture of yogurt start with preparing bulk culture containing *Streptococcus thermophilus* ENCC 0040, *Lactobacillus bulgaricus* ENCC 0041, *Lactobacillus case*i FNCC 0090 and *Bifidobacterium longum* ATCC 15707. Those culture were added into heated milk with temperature of 70-80°C for 30 mins after cooled up to a temperature of 40°C an amount of 4%. Incubation performed at room temperature for 24 hrs. After yogurt has been formed, cinnamon extract with 1 and 2% level were added and stirred well. Product stored at cold temperatures (~4^{o}C) before further assay (Wihansah *et al.,* 2022).

2.3 Manufacture of yogurt powder

Fresh yogurt that has been formed was added with skim milk as encapsulation material with a concentration of 20% each. Sterile distilled water was added to the solution, and the mixture was stirred until homogeneous. Next, the mixture was dried using a spray dryer (LabPlant type SD-05) with an inlet temperature of 160°C and an outlet of 65-70°C according to the method described by Juniawati *et al*. (2020). Morphology properties were observed by a scanning electron microscope (SEM) Carl Zeiss type EVO MA 10.

2.4 Yogurt powder rehydration

Rehydration is done to determine the effectiveness of spray drying method in maintaining the quality of yogurt, especially the viability of bacteria. The rehydration process was carried out by adding sterile water to 5% yogurt powder and 3% skim milk, then incubated at 37°C for 10 hrs. The rehydrated yogurt was then tested for characteristics, total lactic acid bacteria, antioxidant activity and sensory properties (Juniawati *et al.,* 2020).

2.5 Physical, chemical, microbiological evaluation of yogurt

Samples of fresh yogurt and rehydrated yogurt were evaluated for pH value using pH meter Schoot Instrument Lab 850 (Deutschland), titratable acidity, viscosity using Viscotester Rion VT-04F (Japan), water activity using aw meter Novasiana (Swiss), nutrient content consisting of moisture, protein, fat and ash content (AOAC, 2005), and lactic acid bacteria according to method described by Food and Drug Administration (2001).

2.6 Antioxidant activity measurement

Antioxidant activity was measured according to Apostolidis *et al*. (2006). Samples of fresh yogurt and rehydrated yogurt were determined for its antioxidant activity using 1,1-diphenyl-2-picryl-hydrazyl (DPPH) radical inhibition test. Samples of 250 µL from each treatment was added to 3 mL of 60 µM DPPH in ethanol. A UV Vis spectrophotometer was used to measure the decrease in absorbance at the wavelength (λ) of 517 nm. The readings were compared with 250 µL control (dH_2O). The inhibitory activity was calculated using the following formula:

$$\% \text{ inhibition} = \left(\frac{\text{control} - \text{extract}}{\text{control}}\right) \times 100\%$$

2.7 Total phenolic content assay

Total phenol assay was calculated using the method of Shetty *et al*. (2006). Yogurt extract (1 mL) was transferred into a tube and mixed with 1 mL 95% ethanol and 5 mL dH_2O. Folin-Ciocalteu reagent (50% v/v; 0.5 mL) was added to each of the sample and then homogenized with a vortex. After 5 mins, 1 mL of 5% Na_2CO_3 was added and allowed to stand for 60 mins at room temperature. The absorbance was read at a wavelength (λ) of 725 nm. Absorbance value converted to total phenol and expressed in micrograms equivalent to -acid error per military (mL) of sample.

2.8 Sensory evaluation

Sensory evaluation of the product is carried out by twenty-five semi-trained panelists using a 5 hedonic scale system for different parameters such as color, aroma, texture, taste and overall acceptability. The hedonic scale starts from very disliked, disliked, rather like, liked and very liked.

2.9 Data analysis

Factorial pattern of complete randomized design was used in this research. First factor is drying process (before spray drying and after spray drying), and the second factor is cinnamon extract levels (0, 1 and 2%). Each treatment was repeated 4 times, there were 24 experiments units. Data were analyzed with Analysis of Variance, followed by Duncan Test at 5% level of significance using SPSS version 2.5.

3. Results and discussion

3.1 Characteristics of fresh yogurt and rehydrated yogurt powder

Fresh yogurt and rehydrated yogurt powder were evaluated for its characteristics including viability of lactic acid bacteria, pH, titratable acid, water activity and viscosity. Results showed that population of lactic acid bacteria were significantly affected by spray drying process. Total lactic acid bacteria of rehydrated yogurt powder were lower than those in fresh yogurt as presented in Table 1. The population of lactic acid bacteria was influenced by a number of factors during spray drying, including the inlet and outlet temperatures, nozzle pressure, material concentration and encapsulation material. Inactivation is brought on by a decrease in moisture content and exposure to high temperatures, which harms the DNA, RNA, proteins, lipids, membranes and ribosomes (Dos Santos *et al.,* 2018). Loss of bound water at the cell surface is also blamed for harming bacteria during spray drying. The cytoplasmic membrane is one of the areas of cells most vulnerable to damage, and spray drying exacerbates this. Other dehydration stress targets include ribosomes and

Table 1. Characteristics of fresh yogurt and rehydrated yogurt powder.

Variables	Type of Yogurt	Level of Extracts (%)			Average
		0	1	2	
Lactic acid bacteria (log CFU/ml)	Fresh Yogurt	8.69±0.16	8.70±0.27	8.64±0.11	8.68±0.18^a
	Rehydrated Yogurt	7.80±0.15	8.10±0.07	8.13±0.17	8.01±0.13^b
	Average	8.25±0.15	8.40±0.17	8.38±0.14	
pH	Fresh Yogurt	3.84±0.05	3.82±0.01	3.83±0.01	3.83±0.02^a
	Rehydrated Yogurt	4.14±0.27	4.09±0.04	4.05±0.08	4.09±0.12^b
	Average	3.99±0.15	3.95±0.02	3.93±0.04	
Titratable acidity (%)	Fresh Yogurt	1.35±0.13	1.38±0.04	1.40±0.09	1.37±0.08^a
	Rehydrated Yogurt	1.25±0.41	1.31±0.22	1.31±0.21	1.29±0.28^b
	Average	1.30±0.27	1.34±0.13	1.35±0.15	
a_W	Fresh Yogurt	0.85±0.00	0.87±0.01	0.87±0.00	0.86±0.00
	Rehydrated Yogurt	0.85±0.01	0.86±0.00	0.86±0.00	0.85±0.00
	Average	0.85±0.00^a	0.86±0.01^b	0.86±0.00^b	
Viscosity (cPas)	Fresh Yogurt	3.95±0.40	3.83±0.22	3.33±0.28	3.7±0.30^a
	Rehydrated Yogurt	3.67±0.62	2.92±0.43	3.3±0.57	3.3±0.54^b
	Average	3.81±0.51^a	3.37±0.32^{ab}	3.31±0.42^b	

Values are presented as mean±SD. Values with different superscripts within the same row or column are statistically significantly different ($p<0.05$).

nucleic acids, which are likely damaged as a result of Mg^{2+} leaking out of the heat-damaged cell membrane (Huang *et al.,* 2017). Viability of lactic acid bacteria in this research was only 0.48-0.89 log reduction, lower compared to works by Koc *et al*. (2010) and Rascón-Díaz *et al*. (2012), who showed 10^2 CFU/g reduction after spray drying. This work is in accordance with Gul and Atalar (2019) who showed 0.43-1.62 log loss in probiotic viability after spray drying. Based on Juniawati *et al*. (2020), skimmed milk has better ability to maintain viability of total lactic acid bacteria during the drying process compared to maltodextrin and gum arabic. Skim as a component of milk is a material that can be used as an encapsulant. Skim is also a good choice in probiotics microencapsulation. Protein as an encapsulation material has a better probiotic microencapsulation ability compared to carbohydrate-based encapsulation because protein is a material that is naturally needed by probiotics and has good gelation properties. Rehydrated yogurt powder in this work met Indonesian National Standard SNI 2981:2009 (Badan Standardasi Nasional, 2009) and Codex Alimentarius (2018) which require minimum 10^7 CFU/g culture.

Spray drying process was also significantly affects the pH and titratable acidity of yogurt. Fresh yogurt pH value ranged from 3.82 to 3.84, while rehydrated yogurt pH value ranged from 4.05 to 4.14 (Table 1). The pH value is closely related to the count of lactic acid bacteria, as count of bacteria decreases, the pH value increases. After spray drying process, pH of yogurt in this research was slightly lower than those in research conducted by Malik and Sharma (2021) with 4.42 value, and incomparable with Koc *et al.* (2010) who obtained 4.17. In line with pH value, titratable acidity of fresh yogurt was higher than rehydrated yogurt. Titratable acidity of fresh yogurt was 1.35-1.40, while rehydrated yogurt has titratable acidity of 1.25-1.31% (Table 1). According to Indonesian National Standard, yogurt should contain 0.5-2.0% titratable acidity, also according to Codex Alimentarius, yogurt should contain a minimum of 0.6% titratable acidity.

Water activity of yogurt was significantly affected by level of cinnamon extract, but all value indicates good condition of product (Table 1). Water activity in this research were slightly higher than those reported by Wihansah *et al.* (2018), who found water activity of yogurt in the range of 0.80-0.83. Water activity value is important because it may be used to control stability and quantity of foodstuffs. Foods with low water activity contributes to the extended shelf life of the food product which is often desirable to the consumer. The minimum water activity for all microbial growth is 0.60 and spoilage of foods would not be of a microbiological nature below this value (Ijabadeniyi and Pillay, 2017). Water activity is the availability of the water contained in the product for microbes. Water activity indicates the availability of water's medium for chemical reactions, biochemical transfer or exchange though semi permeable membrane. Microorganisms can keep their viability regardless of the water activity, but for growth bacteria requires >0.8 and yeast and molds >0.6 (Vesterlund *et al.,* 2012). Meanwhile, viscosity of yogurt was significantly affected by spray drying process and level of cinnamon extract. The higher the extract level, the lower the viscosity obtained. This might due to the addition of cinnamon extract increases moisture content of yogurt. Rehydrated yogurt powder has a lower viscosity. Rehydrated yogurt may have less viscosity since the spray-drying technique disrupted its microstructure. Spray drying at a high shear rate damages yogurt's fragile gel structure and causes protein denaturation, which leads to a low viscosity end product when it is rehydrated (Rascón-Díaz *et al.,* 2012).

Table 2. Proximate analysis of yogurt and rehydrated yogurt powder.

Variables	Type of Yogurt	Level of Extracts (%)			Average
		0	1	2	
Moisture content	Fresh Yogurt	78.22±0.17	79.01±0.15	79.34±0.15	78.86±0.16^a
	Rehydrated Yogurt	84.74±0.18	85.20±0.11	84.88±0.39	84.94±0.23^b
	Average	81.48±0.17^a	82.10±0.13^b	82.11±0.27^b	
Protein content	Fresh Yogurt	2.54±0.08	2.79±0.07	2.79±0.13	2.70±0.09^a
	Rehydrated Yogurt	4.05±0.30	4.60±0.16	4.41±0.11	4.35±0.19^b
	Average	3.29±0.19^a	3.69±0.11^b	3.60±0.12^b	
Ash content	Fresh Yogurt	0.90±0.01	0.85±0.04	0.88±0.02	0.88±0.02^a
	Rehydrated Yogurt	1.1±0.00	1.08±0.02	1.07±0.02	1.08±0.01^b
	Average	1.00±0.01	0.97±0.03	0.98±0.02	
Fat content	Fresh Yogurt	2.98±0.50	3.19±0.29	3.10±0.40	3.09±0.40
	Rehydrated Yogurt	2.72±0.14	2.88±1.76	3.45±0.37	3.01±0.23
	Average	2.85±0.32^a	3.03±0.23^{ab}	3.27±0.39^b	

Values are presented as mean±SD. Values with different superscripts within the same row or column are statistically significantly different (p<0.05).

3.2 Proximate analysis of fresh yogurt and rehydrated yogurt powder

As presented in Table 2, moisture content of rehydrated yogurt was significantly higher than fresh yogurt. The addition of cinnamon extract increases moisture content of yogurt. Moisture content of fresh yogurt obtained in this work were ranged from 78.22 to 79.34%, while after drying process, rehydrated yogurt had 84.74-85.20% moisture content. Those finding were similar with Za *et al*. (2019) who reported 85.59-88.03% moisture content of yogurt, and Mbaeyi-Nwaoha *et al*. (2017) who reported 85.28-87.14%. The results of the moisture content are also in accordance with the viscosity value obtained in this work, where rehydrated yogurt had a lower viscosity and higher moisture content. Consistency in reconstituted yogurt powder, shows an irreversible weakening of the gel network structure, most likely as a result of mechanical energy needed to incorporate water for rehydration (Santos *et al.,* 2018). Protein content of fresh yogurt was ranged from 2.54 to 2.79%, while rehydrated yogurt powder had protein content ranged from 4.05 to 4.60%. Protein content was significantly affected by spray drying process and addition of cinnamon extract. After rehydration of yogurt powder, the product found to had a higher protein content since skim milk was used as encapsulant material. It has been described by Juniawati *et al*. (2020) that skim is a protein-based encapsulant. The higher the addition of skim milk as an encapsulant, the protein content of yogurt powder will be higher. Skimmed milk is a highly concentrated product that is fractionated using ultra filtration to make it concentrated and lactose-reduced. During this process, milk components are separated based on their molecular size. The milk then passes through a membrane that allows some lactose, minerals, and water to pass through but prevents casein and protein due to their large molecular sizes (Oladipo *et al.,* 2014). Addition of cinnamon extract increases protein content of yogurt due to the existing of protein in cinnamon extract. This finding was within the recommended value by the Indonesian National Standard and Codex Alimentarius which establishes minimum protein in yogurt to be 2.7%. Ash content of yogurt was significantly affected by spray drying process. After rehydration yogurt powder, ash content was increases which correspond to the used of skim as encapsulant. Ash content of yogurt in this study were in accordance with the Indonesia National Standard with maximum value of 1%. Santos *et al*. (2018) also found that ash content and protein were higher in the rehydrated yogurt when compared to the traditional yogurt. Fat content of fresh yogurt obtained in this work ranged from 2.98 to 3.19%, while rehydrated yogurt ranged from 2.72 to 3.45%. The percentage of fat content increased as the extract level increased. It was related to the presence of fat in cinnamon.

3.3 Antioxidant activity of fresh yogurt and rehydrated yogurt powder

Antioxidant activity of yogurt in this work was described as DPPH inhibition and total phenolic compound. As shown in Figures 1 and 2, in fresh yogurt, increasing levels of cinnamon extract increased the DPPH - inhibitory activity. Fresh yogurt without addition of cinnamon extract was found to has 28.42% inhibition, with the addition of 1% cinnamon extract has 29.45%, and with the addition of 2% cinnamon extract has 32.22%. Samples in this research has antioxidant capacity of 30.56, 31.78, and 35.05 mg EVC/100 g for yogurt, yogurt with 1% cinnamon extract and 2% cinnamon extract, respectively. The highest activity obtained by fresh yogurt was with the addition of 2% cinnamon extract. This finding are higher compare to the findings of Purwati *et al*. (2018), who reported a 10.98-24.89% inhibition. Cinnamon bark contains compounds sinamaldehid which is the principal ingredient in cinnamon bark that act as antioxidant (Purwati *et al.,* 2018). Thus, the more cinnamon bark extract, the higher the cinnamaldehyde in yogurt resulting in an increase of its antioxidant activity. Cinnamon is a plant source of antioxidants. Its phytochemical compound makes cinnamon's potential as an antioxidant. Sinamaldehid is

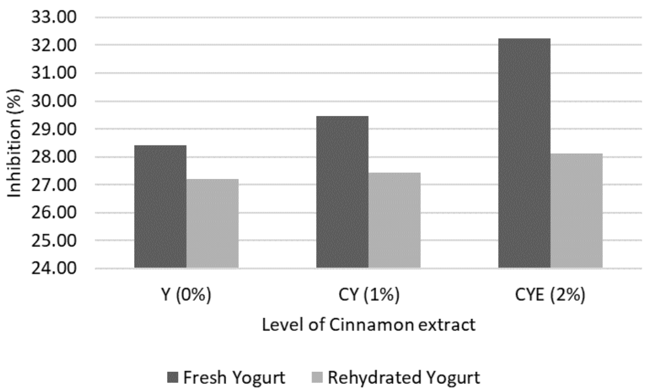

Figure 1. DPPH Inhibition of fresh yogurt and rehydrated yogurt.

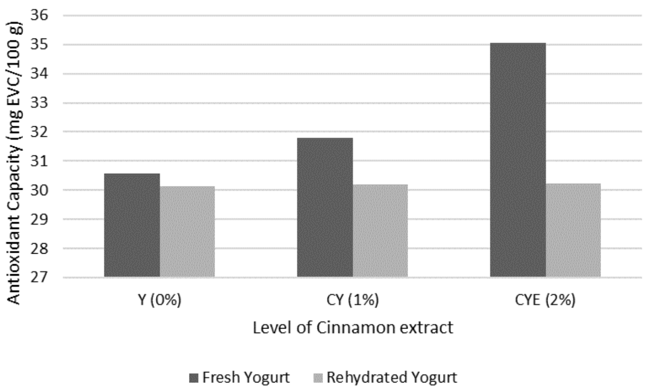

Figure 2. Antioxidant capacity of fresh yogurt and rehydrated yogurt.

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the largest component ranges from 60-70% as the main antioxidant compound. Sinamaldehid compounds in cinnamon works by preventing the DPPH (Diphenylpicryl-hidrazil) from oxidizing (Tisnadjaja *et al.,* 2020). The structure of cinnamon polyphenol compounds displays antioxidant activity, especially type A polyphenols. Numerous phenolic substances are included in cinnamon, including phenol polymers, epicatechin, procyanidin B2, and catechin, all showed notable inhibitory effects on the production of advanced glycation end products. Their antiglycation activities are influenced by their antioxidant functions as well as the capacity of reactive carbonyl species to be trapped (Qin *et al.,* 2010).

After rehydration process of yogurt powder, inhibition was decreased to 27.19, 27.43 and 28.13% for yogurt, yogurt with 1% cinnamon extract and 2% cinnamon extract, respectively. After rehydration process of yogurt powder, antioxidant capacity of all treatments was found to decrease to 30.14, 30.19, and 30.21 mg EVC/100 for yogurt, yogurt with 1% cinnamon extract and 2% cinnamon extract, respectively. Value obtained for DPPH-inhibition and antioxidant capacity also correlated well with the total phenolic compound (Table 3). Before spray drying process, fresh yogurt has 4.33, 5.47, and 6.37% total phenolic compound for yogurt, yogurt with 1% cinnamon extract, and yogurt with 2% cinnamon extract, which means increases along with the increasing extract level. After spray drying process, total phenolic compound decreased to 1.81-1.95%. Reduction in the anthocyanidin value and total phenolic after spray drying process were also observed by Lim *et al.* (2011), who reported amount of 5.66-69.66% and 8.22-17.51% depending on the ratio of the encapsulation. Anthocyanins is one of the phenolic compounds in cinnamon that is unstable and susceptible to heat and light. The combination of heat and oxygen causes the most detrimental effects on anthocyanins (Lim *et al.,* 2011). Degradation of encapsulated phenolic compounds (gallic acid) after spray drying and during storage has been shown by Ramírez *et al*. (2015), but according to Assadpour and Jafari (2019), compared with freeze drying, retention of bioactive phenolics is generally lower when using spray drying. It is interesting that spray drying has been shown to be more effective at retaining phenolic chemicals. One of the essential biological functions for life is antioxidant activity. Even a low level of antioxidants could prevent oxidative damage to various biomolecules linked to diseases such as cancer, liver, ageing, arthritis, inflammation and diabetes. Yogurt with a high antioxidant activity can reduce oxidative stress and prevent its effects. Additionally, probiotic bacteria in yogurt, like *Lactobacillus acidophilus* and *Bifidobacterium* can increase the antioxidant level in patient with type 2 Diabetes Mellitus (Arkan *et al.,* 2022).

3.4 Morphology of yogurt powder

By using SEM, the yogurt powder particles were mostly seen as spherical. Figure 3 displays yogurt powder scanning electron microscopy images that were created under optimum spray drying circumstances. The magnification level was set to 1000x. Images showed a smooth surface, but there were also minor depressions and cracks. It showed that spray-dried yogurt in this research is generally spherical in shape. The spherical shape indicates successful encapsulation. Few cracks in some parts might due to ballooning phenomenon during spray drying process. Ballooning is a microcapsule particle bubble event due to the formation of water vapor in the microcapsule structure during the spray drying process (Juniawati *et al.,* 2020). All treatment showed a similar particle size and shapes.

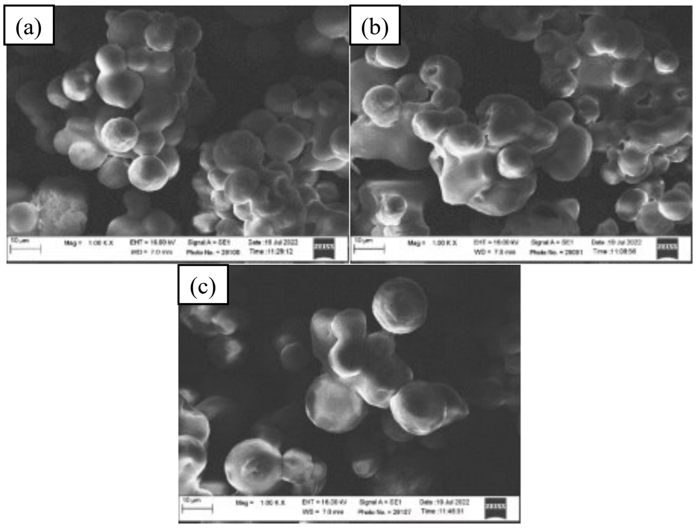

Figure 3. SEM analysis of spray dried yogurt (a), spray dried yogurt with 1% cinnamon extract (b), and spray dried yogurt with 1% cinnamon extract (c).

Table 3. Total phenolic compound of yogurt and rehydrated yogurt powder.

Variables	Type of Yogurt	Level of Extracts (%)			Average
		0	1	2	
Total Phenolic compound	Fresh Yogurt	4.33±0.10	5.47±0.07	6.37±0.24	5.39±0.13[a]
	Rehydrated Yogurt	1.95±0.39	1.81±0.10	1.82±0.05	1.86±0.18[b]
	Average	3.14±0.24[a]	3.64±0.08[b]	4.10±0.15[c]	

Values are presented as mean±SD. Values with different superscripts within the same row or column are statistically significantly different ($p<0.05$).

Table 4. Sensory evaluation of yogurt and rehydrated yogurt powder.

Variables	Fresh yogurt			Rehydrated yogurt		
	Level of extracts (%)					
	0	1	2	0	1	2
Color	3.62±0.61	4.00±1.09	4.06±0.99	3.75±0.57[a]	3.68±0.60[a]	3.37±0.71[b]
Aroma	3.37±0.80[a]	3.62±1.02[b]	3.75±1.00[b]	4.00±0.63[a]	3.81±0.83[b]	3.50±0.89[c]
Texture	4.12±0.50[a]	3.75±0.57[ab]	3.93±0.57[b]	3.93±0.92[a]	3.75±0.68[b]	2.50±0.73[c]
Taste	3.18±0.75[a]	3.12±0.95[a]	4.43±0.81[b]	2.87±0.71[a]	3.12±0.80[b]	2.93±0.85[ab]
Overall acceptability	3.43±0.72[a]	3.43±1.03[a]	4.12±0.95[b]	3.43±0.96[a]	3.50±0.81[a]	3.06±0.77[b]

Values are presented as mean±SD. Values with different superscripts within the same row or column are statistically significantly different ($p<0.05$).

3.5 Sensory evaluation of fresh yogurt and rehydrated yogurt powder

Sensory properties of yogurt in this research were evaluated, including color, aroma, texture, taste, and overall acceptability. Results presented in Table 4 shows that panelist like the color and aroma of all types of yogurts both fresh yogurt and rehydrated yogurt, and with or without the addition of cinnamon extract. In the term of texture, the panelists like all samples except for rehydrated yogurt with the addition of 2% cinnamon extract, the score was rather like. Significant changes were observed in the taste of yogurt, before spray drying process, the panelists like fresh yogurt with the addition of 2% cinnamon extract, and rather like other fresh yogurt, but in rehydrated yogurt, the panelist rather like all the samples. As well as in overall acceptability, the panelist like fresh yogurt with the addition of 2% cinnamon extract, and rather like another fresh yogurt, but rather like all rehydrated yogurt. According to Wihansah *et al.* (2022) adding cinnamon extract into yogurt can enhance the likeness of consumer due to unique aroma and enhance of flavor.

4. Conclusion

Addition of cinnamon extract significantly improved antioxidant activity of fresh yogurt. After rehydration, spray-dried yogurt has physical, chemical, microbiological properties that met Indonesian National Standard and Codex Alimentarius for yogurt. Rehydrated yogurt also still has antioxidant activity through inhibition of DPPH and phenolic content, making it a potential functional drink. The development of yogurt powder makes the distribution and storage process easier and is effective because it produces yogurt with properties similar to fresh yogurt.

Conflict of interest

The authors declare no conflicts of interest.

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