



Utilization of Local By-products for Functional Dairy Products: A Review

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Abstract. Changes in people's lifestyles through the implementation of a good food diet are carried out by consuming foods containing bioactive compounds. Functional milk products contain bioactive components to improve metabolism, the immune system and digestion. Optimization of functional milk products can be enriched through fortification of by-products such as mangosteen peel and dragon fruit peel that are rarely utilized, even though it has natural antioxidant content to be expanded and utilized. Although it possess the potential to be investigated and advanced as natural antioxidants, the inclusion of dragon fruit peel extract at a concentration of 5% produces the finest red bean sprout milk yogurt with pH (4.34), viscosity (4006 mPas), antioxidants (26.17%RSA), and sensory (4.02). The yogurt drink enriched with 3% mangosteen peel extract has a viscosity of 74.65 cp, lightness (L) of 79.89, redness (a*) of 0.14, and yellowness (b*) of 2.32. In the organoleptic tests, viscosity was rated at 2.84 (slightly thick), color was scored 3.52 (brownish white), and texture was rated 2.12 (rather smooth). Based on several research results, it shows that the potential of local by-products can provide significant results for use in functional milk products.

Keywords: by-products, functional dairy products, quality

1 Introduction

Healthy living awareness encourages people to understand and implement a food diet by consuming foods containing bioactive compounds [1]. Functional dairy products contain bioactive components to improve metabolism, the immune system and digestion [2]. Optimization of functional dairy products can be enriched through fortification of by-products that are rarely used, even though it has natural antioxidant content to be expanded and utilized [3]. By-products with high potential, if not utilized properly will cause environmental pollution [4]. The results of the study showed that testing Antioxidant potential of apple peel by-product extract by applying maceration

combination method and Microwave Assisted Extraction (MAE) methods with 50% methanol, 12 minutes of radiation time gave the highest percentage of antioxidants and total flavonoids of 95.09% and 29.62 ppm [5]. Cocoa bean hulls (CBS) are the main by-product of cocoa beans, accounting for approximately 10 to 20% of the total weight of cocoa beans [6]. Therefore, its disposal can cause environmental and economic problems., By-product Cocoa pod hull has nutraceutical character [7]. source of phenolic acids which are useful as antioxidants ranging from 4.6-6.9 g GAE/100g and high fiber content around 50% w/w. Cocoa bean hulls (CBS) are one of the main types of solid waste from the chocolate industry. This residual biomass has the potential to be an interesting source of nutrients and bioactive compounds [8, 9], due to its high content of dietary fiber, polyphenols and methylxanthines, making it a valuable ingredient or additive for innovative and functional food products [10]. Several research data show that Dragon fruit peel (*Hylocereus S*) contains bioactive compounds, including vitamin C, in higher amounts when compared to the levels of vitamin C in the fruit flesh, as well as antioxidant activity, several studies show better activity in dragon fruit peel. Fresh dragon fruit peel showed antioxidant activity of 140.12 ± 5.76 mg/ml, with a vitamin C content of 252 mg per 100 g [11]. The bioactive characteristics and antioxidant activity of several by-products with the extraction method are listed in Table 1.

Exploration of the ability of fruit waste (FBP) as a prebiotic component containing a large amount of dietary fiber and polyphenols can be utilized for anti-inflammatory activity, reducing Dysbiosis or microbiota imbalance is indicated by changes in the composition and function of the intestinal microbiota, which can reduce the possibility of the onset or development of various health disorders [18]. Of the various food products, fermented milk is the main choice for increasing prebiotics for the optimization of FBP prebiotics and anti-inflammatory activity. and provide unique contributions, to improve the nutritional and functional value of fermented milk, probiotic viability, and physical and sensory characteristics of fermented milk.

The development of consumption of processed milk products in society shows an increasing trend along with public awareness of healthy living [19]. Fermented yogurt milk not only has a good nutritional composition and an attractive appearance and taste, but also has certain physiological functions for the body, so it is called a functional food ingredient [20]. Yogurt is described as a dairy product made by introducing yogurt bacteria like *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* into standardized milk [21]. Yogurt is a fermented milk product that is highly sought after due to its nutritional composition, microbial activity, and diverse product range in terms of flavor and texture [22]. Dairy products, particularly yogurt, offer numerous sensory benefits due to the straightforward formulation variations that ensure desirable taste preferences.

Yogurt contains several health-enhancing components, including beneficial bacteria and bioactive peptides. Plain yogurt is a rich source of phenolic compounds, vitamin C, and other substances that, through HPLC analysis, provide potent antioxidant properties to the product. Yogurt is a source of bioactive peptides that develop during the fermentation process. In addition, yogurt contains other health-promoting components such as beneficial lactic acid bacteria (LAB), especially as probiotics [23].

Table 1. The bioactive characteristics and antioxidant activity of several by-products with the extraction method.

No	By-product	Extraction methods	Bioactive compound	Antioxidant activity	References
1	Avocado peel	Autohydrolysis	43 Bioactive compounds identified; Quercetin Quercetin-hexose Quercetin (C ₁₅ H ₁₀ O ₇) Quercetin-dihexose Quercetin-O-arabinosylglucoside Glucuronide Antioxidant phenolics	DPPH, ABTS, FRAP UHPLC-TOF MS analysis	[12]
2	Cupuassu Seeds	Maceration	The largest flavonoid components identified are: epicatechin dan glycosylated quercetin.	ABTS DPPH	[13]
3	Apple peel (<i>Idared apple</i>)	Ultrasonication-assisted solvent methanol 0%, 0.01%, 0.1%, 1%, 2%	Highest Quercetin identified (36.3 mg/100 g DW with concentration 1.0%. Methanol Quercetin: 1.3. Total Quercetin & Glycosides: 94.6		[14]
4	Mango waste	Ultrasound assisted extraction (UAE): (% ethanol, amplitude and time)	Bioactive compound components identified 45	HPLC-QTOF-MS/MS	[15]
5	Avocado seed	MAE (ethanol solvent)	Identified 10 phenolic components with the largest amounts in rutin (71.67), TPC=82.36; TFC=19.93.	DPPH, ABTS, DPPH=73.61 and ABTS=80.20 HPLC analysis	[16]
6	Apple and pomegranate peel	Combination of maceration and innovative (sonication) techniques	Sonication technique produced higher amounts of polyphenols than maceration	DPPH Radical scavenging assay.	[17]

Several studies have shown that the free radical scavenger properties of dairy products can be altered through the incorporation of natural plant-based materials (produce, plant matter, spices) that show rich in phenolics and carotenoid compound con-

tent during production [24, 25, 26, 27]. These additives influence the sensory characteristics of the final product and help prolong its shelf life by preventing lipid oxidation during storage in the refrigerator [28]. The role of yogurt as a functional food enriched with bioactive components from several other compounds by utilizing by-products has been studied such as by fortification of carotenoid extraction from carrot waste [29] and camu-camu seed extract (*Myrciaria dubia*) is able to increase antioxidant activity [30].

2 Materials and Methods

2.1 By-product extraction

Extraction is the process of separating the desired components from raw materials using solvents or certain methods. The method of bioactive compounds from by-products can be extracted using both traditional and modern methods. Traditional methods are commonly employed in the extraction process, typically involving solvents and elevated temperatures, but they are time-consuming. The benefits of non-traditional methods are eco-friendly and highly effective, encompassing membrane technology, ultrasound, microwave extraction, and high hydrostatic pressure [12-17].

Apple peel extraction. The powder of *Malus sylvestris* was combined with 50% methanol in a 5 g powder to 100 mL methanol ratio and left to macerate for 24 h. Afterward, the solution was extracted using microwave radiation. The obtained crude extract was filtered using Whatman no. 4 filter paper, and ethanol was evaporated with a rotary evaporator at 55mmHg pressure and 50°C temperature. The filtrate was subsequently concentrated further using a rotary evaporator (IKA RV 10) to remove the solvent [5]

2.2 Production of fortified yoghurt by-product extract

Yogurt is made with milk added with pasteurized fruit by-product extract and then left to warm. Then, the BAL starter inoculation is inserted and the yogurt is fermented until the yogurt pH is reached. Yogurt quality test is based on physico-chemical characteristics and acidity levels [29, 30]. The process of fortified yoghurt by-product extract production can be seen in Figure 2.

3 Results and Discussion

Improving the quality of yogurt drink can be done by adding mangosteen peel extract [31]. Mangosteen peel contains xanthone compounds and its derivatives which are compounds that can play a role in maintaining health. Yogurt drink with the addition of 3% mangosteen peel extract produced a viscosity value of 74.65 cp, lightness (L) 79.89, redness (a *) 0.14 yellowness (b *) 2.32, organoleptic test of viscosity with a

score of 2.84 (slightly thick), organoleptic test of color 3.52 (brownish white) and organoleptic test of texture with a score of 2.12 (slightly smooth). Based on the results of the study, it can be concluded that the addition of mangosteen peel extract can improve the physical quality, color, and organoleptic of yogurt drink. The use of mangosteen peel extract will increase the economic value and product diversification.

Frozen yogurt fermented by *Streptococcus thermophilus* and *Lactobacillus* bacteria with UHT milk as the main ingredient with variations in the addition of red dragon fruit peel extract produced the best organoleptic in terms of texture, color, taste, aroma and overall acceptance was the addition of 25% dragon fruit peel extract with an average level of panelist preference for a slightly soft texture (3-4), white - red color (2-4). The yogurt has the criteria of a slightly soft texture, pink color, distinctive yogurt aroma and sour taste. Total acid 0.73-1.14% [32].

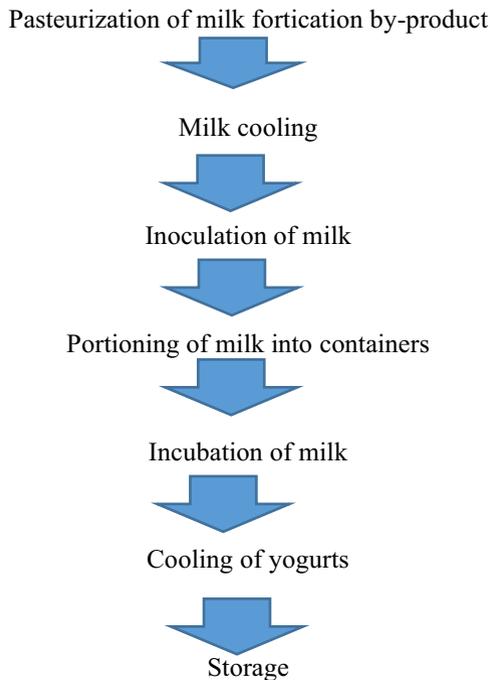


Fig. 2. Production of fortified yoghurt by-product extract

The use of Red dragon fruit peel in the preparation of frozen yogurt can also be used as a natural coloring agent. Its advantage is that it contains polyphenols. Red dragon fruit peel contains greater antioxidants than the fruit flesh. Variations in the addition of dragon fruit peel extract in the manufacture of red bean sprout frozen yogurt affect the antioxidant activity, pH, and viscosity of the frozen yogurt obtained. The addition of dragon fruit peel extract does not affect the sensory properties (color, aroma, taste, consistency) of the resulting yogurt. The addition of dragon fruit peel extract at a concentration of 5% produces the best red bean sprout milk yogurt with pH (4.34),

viscosity (4006 mPas), and antioxidants (26.17%RSA), and sensory (4.02). The total acidity of frozen yogurt shows that it is in accordance with the quality requirements for probiotic drinks that have been set by the Indonesian National Standard, namely between 0.5% -2.0% [33].

Synbiotic yogurt with red dragon fruit peel extract is a blend of probiotics and prebiotics, and the inclusion of stevia sweetener enhances its physical properties. The analysis results indicated that the concentration of stevia sweetener caused a highly significant difference (T0.05) on the water holding capacity. The optimal treatment for physical quality was T1, which involved adding 0.5% stevia sweetener, resulting in an average pH of 4.15, syneresis of 27.11%, water holding capacity of 71.33%, and color values of $L = 38.38$, $a = 13.46$, and $b = 4.60$. The physical characteristics of synbiotic yogurt with 0.5% stevia sweetener meet the SNI 2981:2009 standard, and the 0.5% stevia concentration proved to be more efficient than other variations [34].

This research was carried out to assess the quality characteristics, antioxidant potential, microbiological properties, and sensory attributes of yogurt enriched with 2%, 5%, and 7% red dragon fruit peel (RD) powder. The yogurt was prepared using traditional methods modified to fit laboratory conditions. The physicochemical analysis revealed significant differences in pH (4.73–4.36), acidity (0.18–0.16 g lactic acid/100 g), and ascorbic acid (1.17–1.34 mg/100 g) across various yogurt formulations ($P < 0.05$). Furthermore, fortification with RD peel powder resulted in an increasing trend in crude fiber (1.53–3.34 g/100 g), ash content (5.19–5.29 g/100 g), and moisture (76.70–80.19 g/100 g), while a decrease was observed in fat content (3.48–2.36 g/100 g) and crude protein (4.49–4.07 g/100 g) [35].

Consumption of fermented milk drink from red dragon fruit peel (*Hylocereus polyrhizus*) with Fe fortification (NaFeEDTA) as much as 100 ml/day for 3 weeks has the potential to significantly raise hemoglobin levels and improve nutritional status in the treatment group, but not in the control group (red dragon fruit juice as much as 100 ml/day). Fermented milk drink is a low-fat milk drink added with 6% granulated sugar which is then fermented with *Lactobacillus bulgaricus* starter, *Lactobacillus acidophilus*, *Streptococcus thermophilus*, *Bifidobacterium* as much as 106-108 cfu/ml which is added with 6% pureed red dragon fruit peel and fortified with Fe (NaFeEDTA) as much as 20 mg. Sodium Iron Ethylene Diamine Tetraacetic Acid (NaFeEDTA) is a type of fortification that is stable, has a long shelf life and bioavailability 2-3 times higher than ferrous sulfate and ferrous fumarate [36]

4 Conclusion

Utilization of local by-products for the manufacture of functional milk has great potential in increasing the added value and sustainability of the dairy industry. Local by-products, such as agricultural waste, food processing by-products, and other local ingredients, can be utilized as additives that function to increase the nutritional content, health, and functional benefits of dairy products. Some examples of their utilization include the use of ingredients such as fiber, vegetable oil, or plant extracts that have probiotic, antioxidant, or metabolic regulating effects. In addition to providing

functional benefits, the utilization of these by-products can also reduce waste and increase the efficiency of natural resources, in line with the principles of a circular economy. This can reduce dependence on imported raw materials and provide opportunities for the development of more affordable and environmentally friendly dairy products.

In the future, the development of functional milk that uses local by-products has the potential to support food product innovation, optimize local agricultural and livestock products, and increase the competitiveness of the dairy industry in the global market. However, it is important to ensure the safety, quality, and sustainability in the use of these by-product raw materials, by involving more in-depth research and strict regulations.

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