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Physicochemicals, Organoleptic Properties, and Nutritional Adequacy Rates of Supplementary Food Cookies with the Addition of Whey Protein Powder, a By-Product of Making Dangke

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ABSTRACT

The purpose of this research is to develop a supplementary meal for breast milk (CF) using whey protein derived from the byproduct of *dangke* manufacture, a typical Enrekang dish. The research involved spray drying whey protein powder and making CF cookies with four different whey protein powder addition treatments (0, 10, 20, and 30%). The physicochemical parameters of whey protein powder were studied, and the sensory and nutritional properties of CF cookies were evaluated. A sensory evaluation of the CF cookies found that 20% whey protein powder produced the best results in terms of color, flavor, and texture. Cookies made with 20% whey protein contained 6.80% protein, 22.25% total fat, 65.98% carbohydrate, and a total energy value of 490.73 Kcal/100g. While whey protein cookies contain protein and energy benefits that are comparable with WHO recommendations for CF, some concerns require attention. The total sugar level (24.625%) and salt content (453.67 mg/100 g) were relatively high, necessitating modifications to meet the sugar and sodium limits in CF. This work demonstrates the potential use of whey protein obtained from *dangke* by-products as a CF ingredient; nevertheless, more refinement is required to optimize its compliance with infant nutritional requirements.

Keywords: complementary food, Enrekang, local food, milk, whey protein

INTRODUCTION

Nutrition issues are extremely complex and must be addressed urgently in Indonesia. Especially since Indonesia is one of the countries with the most widespread nutritional issues. According to various studies, nutrition problems in Indonesia are on the rise, which is not the case in other ASEAN countries like Malaysia, Singapore, and Thailand. Stunting is a long-standing nutritional issue in Indonesia. Stunting is a chronic malnutrition condition caused by insufficient nutritional intake over time, usually owing to feeding that does not meet nutritional requirements. Stunting begins in the womb and is only visible when the child is two years old (Sampe *et al.* 2020). In Indonesia, cases of stunting or failure to grow in children under the age of five remain high and have not improved significantly. According to the World Health Organization (WHO), Indonesia has the third most incidences in Asia (Sugianto 2021). According to the 2013 and 2018 Riskesdas reports, the prevalence of stunting in Indonesia was 37.2% in 2013 and dropped to 30.1% in 2018. Furthermore, the 2021 Indonesian Nutrition Status Study (SSGI) showed a further fall to 24.4% in 2021 (Ministry of Health, Republic of Indonesia 2021). However, the pace of decline is lower than the 19% target set by the 2024 National Medium-Term Development Plan (Bappenas 2019). According to SSGI data for 2021, the prevalence of stunting in Enrekang Regency was 31.9%, ranking eighth highest in South Sulawesi Province. According to data from the Enrekang Health Office (Dinkes), the proportion of stunted toddlers in Enrekang district in 2021 was 22.8%, or 3,277 out of a total of 15,275 toddlers (Riyadh 2023). Although the stunting rate in Indonesia has been successfully lowered year after year via various measures, the Ministry of Health of the Republic of Indonesia believes that it will continue to fall by 3% per year, allowing the target of 19% by 2024 to be met (April 2018).

Dangke, a traditional delicacy prepared from cow or buffalo milk, is popular in Enrekang. The milk processing procedure into *dangke* creates a high-quality byproduct in the form of whey protein (70–76%, Ardat 2022). This whey protein has potential as a supplemental food product due to its nutritional content, which includes α-lactalbumin (α-LA, 20%), β-lactoglobulin (βLg, 50%), serum albumin (BSA, 10%), and immunoglobulins (10%). Whey protein has a high protein quality score and a high proportion of branched-chain amino acids (BCAA) and fat, but its usage has yet to be optimal (Harna 2017). Whey protein contains α-LA and β-LA, which are highly digestible and

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absorbable, contributing to its nutritional value (Soltani 2017). A study conducted in the United States on the effect of adding whey protein to the diet of malnourished or undernourished children found that it resulted in faster nutritional recovery than the addition of vegetable protein (Stobaugh 2016).

METHODS

This was an experimental study with a complete random design, conducted in Bogor in August 2024. This study was carried out in two stages: the production of whey protein powder using the spray dry method and the production of whey protein cookies. The raw ingredient for whey protein powder was liquid whey protein collected as a byproduct of *dangke* production. *Dangke* is made by boiling milk to 100.15 °C and then adding papaya fruit papain enzyme at a concentration of up to 0.8% by volume. After adding the enzyme, the milk coagulates, separating solid casein from liquid whey. The filtered liquid whey protein was then blended with 8% maltodextrin, 5% skim milk, and 3% egg yolk before being dried in a spray dryer with an inlet temperature of 130–140°C and an exit temperature of 70–80°C (Monasdir *et al.* 2023). The generated whey protein powder was tested for physicochemical parameters such as yield, pH, moisture content, ash, protein, fat, and carbohydrate content. CF whey protein cookies were prepared with four different amounts of whey powder, namely 0, 10, 20, and 30%. The CF cookie products were sensorially tested to determine the panelists' degree of approval, and the findings of the sensory test were utilized as a guide to choose CF cookie products for nutritional adequacy analysis. The collected whey protein powder data were analyzed using multiple fingerprint analysis (ANOVA), whilst organoleptic test data were examined using the non-parametric Kruskal-Wallis test with Minitab statistics.

RESULTS AND DISCUSSION

Physicochemical Properties of Whey Protein Powder

The physical and chemical properties of spray-dried whey protein powder were analyzed. The whey protein powder value was measured and found to be 5.96 (Table 1). The pH of the whey protein powder generated is somewhat acidic. This matches the features of whey in general. According to Agarwal *et al.* (2022), the pH of whey protein concentrates ranged from 5.5 to 6.5. This slightly acidic pH has the potential to impact protein stability and functionality in culinary applications. The yield of dried whey protein was 19.8%, suggesting that the drying procedure was efficient, meaning that approximately one-fifth of the total liquid raw ingredients are obtained in the powder form. Given the high moisture content of liquid whey, this is to be expected. Using maltodextrin as a filler may assist to boost yield (Carvalho *et al.* 2020).

The moisture level in whey protein powder was 1.84%, indicates the efficacy of the spray drying procedure in eliminating water from the material. Moisture levels of less than 5% is often preferred for powdered products since it inhibits microbiological growth, extending shelf life (Tontul and Topuz 2020). The fat content of whey protein powder was 1.32%. This low-fat content is due to the properties of whey protein in general. Edda *et al.* (2024) discovered that the protein isolate (WPI) comprises more than 90% protein and has a very low-fat content, typically less than 1%. The 3% addition of egg yolks does not considerably alter the final product's fat content.

The protein concentration in whey powder was 16.69%, lower than that found in commercial whey protein concentrates, which normally contains at least 80%. This is due to the addition of maltodextrin, which enhances the carbohydrate content. Proximate analysis is a way of quantifying the major components of materials, which include water, ash, proteins, lipids, and carbohydrates, which account for 100% of the total weight of the sample. As a result, an increase in one component, whether caused by manipulation or natural material changes, will influence the relative decrease in the other component. This event exemplifies the nature of mass equilibrium in a closed system, in which the proportion distribution of each component influences the other.

The ash percentage in whey protein powder was 4.43%, showing the product's mineral composition. This amount is significantly greater than commercial whey protein concentrates, which normally ranges between 3–4% (Agarwal *et al.* 2022). Whey protein powder has a carbohydrate content of 75.69%. Whey protein powder has a high carbohydrate content due to the addition of maltodextrin (8%). Maltodextrin acts as

Table 1 Physicochemical properties of whey protein powder

Parameter	Value
pH	5.96 ± 0.01
Yield (%)	19.8 ± 0.20
Moisture (%)	1.84 ± 0.13
Fat (%)	1.32 ± 0.12
Protein (%)	16.69 ± 0.37
Ash (%)	4.43 ± 0.93
Carbohydrate (%)	75.69 ± 1.08

a filler, increasing yield and improving the functional qualities of the finished product (Carvalho *et al.* 2020).

Organoleptic Test of Cookies from Whey Protein

The spray-dried whey protein powder was used as a raw material for flour substitution in the production of CF cookies. Cookies with four different levels of whey protein powder added were organoleptically tested using hedonic quality tests (Table 2). Adding whey protein powder dramatically improves the color of cookies. P2 (20% whey) and P3 (30% whey) showed the highest scores, indicating a yellow/golden tint when compared to P0 and P1. This is due to the Maillard process that occurs when whey protein and sugar are baked together. According to Gani *et al.* (2021), the inclusion of whey protein can boost the intensity of brown in baked items via the Maillard reaction. The flavor value increases with the addition of whey protein. P2 (20% whey) has the highest rating, indicates a preferred flavor, and ranges from slightly sweet to sweet. Banach *et al.* (2019) discovered that moderate doses of whey protein can improve the taste acceptance of bread products.

There was no significant change in aroma values between the treatments. All treatments exhibited values ranging from 2.4 to 2.8, indicating that the cookies were largely flavored with a little scent of whey protein powder. P2 and P3 showed higher texture values, indicating a crisper texture compared to P0 and P1. The inclusion of whey protein can improve the crispness of bread items by forming strong protein networks during baking (Zhou *et al.* 2020). The product similarity characteristics to CF revealed no significant differences across treatments. All treatments had a score of 3.45–3.70, indicating that these cookies are acceptable for CF. According to the results of the hedonic quality test, adding 20% whey protein powder (P2) produced the greatest outcomes in terms of color, flavor, and texture (Figure 1).

Analysis of Nutritional Adequacy Figures of Whey Protein Cookies

The hedonic quality organoleptic test findings indicated that P2 (20% whey protein) was the best formulation, thus the addition of 20% whey protein to the cookie was tested for nutritional adequacy (Table 3). Protein is required for the growth and development of the newborn. The WHO recommends that CF for babies aged 6–23 months have 6–15% protein-based

Table 2 Hedonic quality test of whey protein cookies

Parameter	Treatment			
	P0 (0%)	P1 (10%)	P2 (20%)	P3 (30%)
Color	3.37 ± 0.68^{b}	3.13 ± 0.91^{b}	4.48 ± 0.69^{a}	4.21 ± 0.58^{a}
Taste	2.94 ± 0.81^{b}	3.27 ± 0.76^{ab}	3.56 ± 0.86^{a}	3.48 ± 0.73^{a}
Aroma	2.81 ± 1.19	2.40 ± 1.14	2.45 ± 1.01	2.43 ± 0.89
Texture	3.35 ± 0.75^{b}	3.40 ± 0.83^{b}	4.21 ± 0.85^{a}	4.24 ± 0.92^{a}
Similarities to CF	3.70 ± 0.81	3.70 ± 0.77	3.50 ± 0.95	3.45 ± 1.19

: 1 = Very pale/white, 2 = Pale/white, 3 = slightly yellow/golden 4 = golden yellow, 5 = Very yellow/golden
Taste : 1 = Very bland, 2 = Bland, 3 = A bit sweet, 4 = Sweet, 5 = Very sweet
Aroma : 1 = Smell like ordinary cookies, 2 = Dominant smell of cookies with a slight smell of whey protein powder, 3 = Smells of cookies and balanced whey protein powder aroma, 4 = Slightly smells of cookies and dominant smell of whey protein powder, 5 = Does not smell like cookies and dominant smell of whey protein powder
Texture : 1 = Very chewy, 2 = chewy, 3 = A bit crispy, 4 = Crispy, 5 = Very crispy
Similarity to CF : 1 = very unsimilar, 2 = Not similar, 3 = Somewhat similar, 4 = Similar, 5 = Very similar

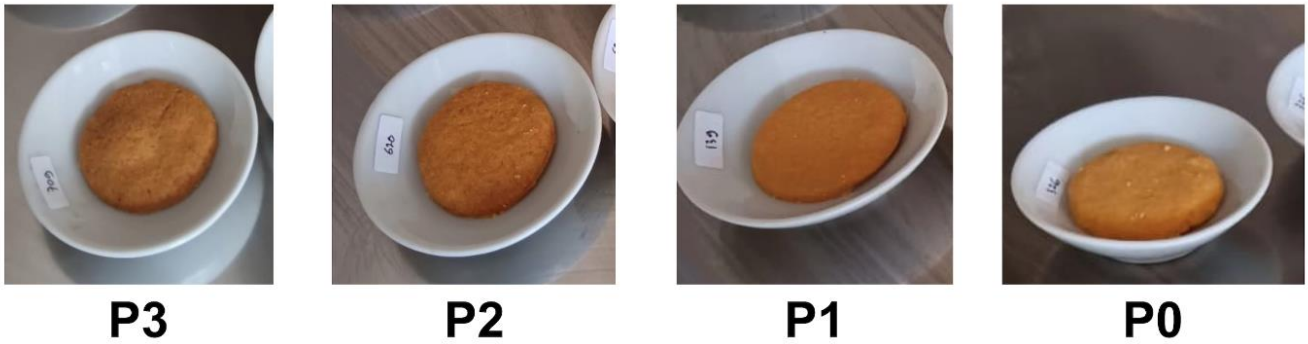

Figure 1 Cookies fortified with whey protein at different concentration levels. P3 = 30% whey protein, P2 = 20% whey protein, P1 = 10% whey protein, P0 = 0% whey protein

Table 3 Nutritional adequacy of cookies with the addition of 20% whey protein

Composition	Value
Ash (%)	2.11
Energy from fat (Kcal/100 g)	200.25
Total fat (%)	22.25
Moisture (%)	3.02
Total energy (kcal/100 g)	490.73
Carbohydrate (%)	65.98
Protein (%)	6.80
Sodium (mg/100 g)	453.67
Total sugar (%)	24.625
Saturated fat (%)	8.85

energy. With a protein value of 6.80%, this cookie falls to the lower end of the recommended. Michaelsen *et al.* (2020) noted that CF with a high protein content is essential for the baby's optimal growth. The whey protein cookies have a total fat content of 22.25% and energy from fat of 200.25 kcal/100 g. The WHO recommends that 30–45% of CF energy comes from fat. With a total energy of 490.73 kcal/100 g, the energy from fat in this cookie is around 40.8%, which falls within the acceptable range. Fewtrell *et al.* (2019) stressed the role of fats in cystic fibrosis for brain development and fat-soluble vitamin absorption.

Carbohydrates were 65.98%, with sugar accounting for 24.625% of the total. Carbohydrates are the primary source of energy. Protein whey cookies include a significant amount of sugar. The WHO recommends limiting additional sugars in CF. Paglia *et al.* (2020) demonstrated that sugar restriction in CF is important for preventing obesity and dental caries in children. The moisture content of cookies was 3.02 percent. Low moisture content improves cookie shelf life but can impair cookie texture, therefore it must be tailored to the baby's needs. The salt concentration of the cookies was 453.67 mg/100 g, which is relatively high for CF. The WHO recommends minimizing sodium in baby diets to avoid excessive salty taste preferences. Venter *et al.* (2020) stated the necessity of reducing sodium.

CONCLUSION

This study effectively exploited whey protein, a byproduct of *dangke* production, to give a supplemental diet for breast milk. The physicochemical features of the resulting whey protein powder make it suitable for usage in food items. When up to 20% whey protein powder is added to the CF cookie recipe, the sensory outcomes (color, taste, and texture) improve significantly. The nutritional content of CF cookies containing 20% whey protein is reasonable, particularly in terms of protein (6.80%) and total energy (490.73 kcal/100 g), which is consistent with WHO standards for CF. The best results were obtained with CF cookies with 20% whey protein powder. This composition can serve as the foundation for creating the next whey protein-based CF product. To continue the research, several aspects must be optimized, such as lowering the total sugar and sodium content in cookie formulations to meet WHO recommendations regarding the restriction of sugar and sodium in CF, increasing the protein content of cookies, for example by increasing the concentration of whey protein or adding other protein sources that are suitable for babies, and conducting product acceptance tests on target consumers (infants and parents).

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