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Characterization of baked egg custard formulated using suji leaf juice

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Abstract: The purpose of this study was to find out the physicochemical characteristics of baked egg custard adding 1%, 2%, and 3% of suji leaf juice with a control sample that had no addition. Four treatments and five replications were used in a fully randomized design. Standard laboratory techniques were used to examine the following: texture, pH, yield, color (L, a*, b*), proximate composition, and crude fiber. Data of baked egg custard were processed using ANOVA and Duncan's Multiple Range Test to identify significant differences. The addition of suji leaf juice had a substantial impact on all measured parameters, according to the results ($P<0.01$). In terms of protein, fat, and crude fiber content, as well as improved texture and color qualities, the custard made with 3% suji leaf juice was highest quality. Improved product stability and sensory appeal were also demonstrated by the pH, yield, and moisture content. According to the results, suji leaf juice optimally improves the physicochemical quality of baked egg custard when added at a rate of 3%. This makes it a promising ingredient for dessert goods that are both functional and aesthetically pleasing.

Keywords: Egg; Custard; Natural Colorant; Suji Leaf Juice

Introduction

Baked egg custard is a dessert favored by many cultures both east and west. Basically, baked egg custard is a mixture of milk, eggs and sugar that forms a soft texture and good flavor when baked. Its high nutritional value, versatile functions and dessert appeal have made baked egg custard a culinary mainstay around the world. However, the traditional formulation of baked egg custard still prioritizes taste and texture over its functional use for the body, which creates an opportunity to innovate the product (Ngamlerst et al., 2023). Consumer preferences for healthier, natural and functional food products can incorporate plant-based ingredients with bioactive properties into products (Khatun et al., 2018).

In recent years, the exploration of the discovery and addition of natural additives in food science is growing due to the goal of increasing nutritional value and consumer demand for benefits for the body. Among them, suji leaf juice (*Dracaena angustifola*) is a natural extract that contains green pigments sourced from bioactive compounds as promising ingredients (Koja et al., 2024). Suji leaves are a source of chlorophyll compounds and are rich in phenolics and flavonoids (Rahayuningsih et al., 2018). Chlorophyll content can contribute to increased visual appeal which is an important factor in product acceptance by consumers (Indrasti et al., 2018).

The addition of suji leaf juice to baked egg custard is in line with trends in food product innovation. Previous research has found that plants with bioactive

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content added to food products can improve nutritional profiles and consumer appeal (Hiolle et al., 2020). Research on pandan leaves, spirulina, jackfruit seed, and matcha used for natural additives can improve health benefits (Fadlilla et al., 2023; Kent et al., 2022; Nirmalawaty et al., 2023). Research is still very limited regarding the utilization of suji leaf juice, especially added in food formulations, so there is still a significant gap.

Previous studies have used gelatin, agar, and other stabilizers to optimize texture in custard (Abdo Qasem et al., 2017; Choobkar et al., 2022). However, the addition of plant-based additives is yet to be done. Traditional egg custard formulations are favored for their texture and flavor, but they pose a challenge in maintaining storage stability when reformulated (Kurnia et al., 2023; Oliveira et al., 2019). The addition of suji leaves can lead to potential changes in flavor profile, gel structure, and visual appeal. The main scientific research lies in characterizing and evaluating the effect of suji leaves on the physicochemical properties of baked egg custard.

This study was conducted as an attempt to address the gap by evaluating the effect of adding suji leaf juice to baked egg custard. Specifically, this study aims to characterize baked egg custard against changes in physicochemical content including pH value, yield, texture, Lab color profile, proximate, and crude fiber.

Method

Research Material

The research materials used in making baked egg custard were fresh chicken egg (collected within 24 hours of laying) from the Teaching Farm of the Faculty of Animal Science Universitas Brawijaya, suji leaves from the Malang traditional market and other supporting ingredients such as fresh milk purchased at KUD Dau (3.5% fat, sourced from a local dairy supplier), cane sugar, and cornstarch of food-grade quality was used as a stabilizer to ensure consistency in the custard's texture.

Research Methods

The study was conducted in a lab setting utilizing experimental techniques. There were four treatments and five replications in the fully randomized experimental design. The formulation for making baked egg custard is fresh milk (74%); egg yolk (14.50%); cornstarch (5%); vanilla (0.50%); and sugar (11%). The addition of suji leaf juice according to the treatment (1%; 2%; 3% of the total mixture weight). Each formulation was designed to yield a total mixture weight of 250 mL.

Suji leaf juice preparation

Clean suji leaves were combined with distilled water in a 1:3 (weight to volume) ratio, and the combination was filtered through a muslin cloth to extract the suji leaf juice. To maintain its natural chlorophyll content and beneficial components, the extract was made fresh for every batch.

Baked egg custard preparation

The preparation process began with the slight beating of eggs to break their structure before mixing with milk, sugar, and other ingredients. Separate the yolks and whites using an egg separator. Put the egg yolks in a bowl with the sugar and stir until evenly mixed. Heat liquid milk over low heat for ± one minute, and add vanilla flavoring, after the milk reaches a temperature of 72 ± 2°C for 15 seconds. Pour the milk slowly into a basin containing a mixture of egg yolks and sugar while stirring and add suji leaf juice according to the specified percentage. For baking, the custard was poured into aluminum molds (50 mL each) and baked in a water bath at a consistent temperature of 140 ± 2°C for 45 minutes, ensuring uniform cooking.

Physicochemical Analysis

pH value

Each custard sample's pH was determined using a digital pH meter that had been calibrated (Hanna Instruments, USA). Measurements were made at room temperature after homogenizing the samples to guarantee consistency. To evaluate the effect of suji leaf juice on the acidity and stability of the custard over time, the pH was measured both immediately and after baking (Apriliyani et al., 2022).

Yield

Weighing the custard samples both before and after baking allowed us to calculate the yield. The weight ratio of the finished baked custard to the weight of the original mixture, expressed as a percentage, was used to compute the percentage yield. Next, use the following formula to determine the baked egg custard yield: Yield = (final weight/initial weight) × 100% (AOAC, 2005).

Texture

A texture profile analyzer (TPA) fitted with a cylindrical probe was used to examine the cooked custard's texture characteristics. To determine the force necessary for deformation, each sample (20 mm in diameter and 20 mm in height) was crushed at a rate of 1 mm/s. To evaluate how the concentration of suji leaf juice affected the gel's strength and rigidity, the results were expressed in Newtons (N). The mean ± standard deviation was used to record the results (Susilo et al., 2023).

Lab color profile

A calibrated colorimeter was used to assess the custard samples' color (Konica Minolta, Japan). Lightness (L*), redness/greenness (a*), and yellowness/blueness (b*) readings were provided by the instrument. Because of its chlorophyll content, it was anticipated that the addition of suji leaf juice would have a major impact on the a* and b* values. On the cooked custard's surface, measurements were made three times, and averages were recorded (Apriliyani et al., 2022).

Proximate composition

The custard samples' proximate composition—which includes their moisture, protein, fat, and carbohydrate content—was ascertained. The samples were dried to constant weight at 105°C in order to determine the moisture content (Mahrus et al., 2023; Setyaji & Monica, 2023). The Kjeldahl method was used to assess the protein content, and total protein was calculated using a nitrogen conversion factor of 6.25 (Yanqoritha, 2023). Petroleum ether was used as the solvent in Soxhlet extraction to measure the fat content (Mukhlisah et al., 2024). By deducting the total weight of the sample from the sum of the moisture, protein, fat, and ash, the amount of carbohydrates was determined by difference (Andayani et al., 2022).

Data Analysis

SPSS (version 25.0) statistical software was used to examine all of the data. The effects of the concentration of suji leaf juice on each parameter were compared using one-way analysis of variance (ANOVA). When significant differences were found in pairwise comparisons, Duncan's test was used. A significant threshold of $p < 0.05$ was established. A mean ± standard deviation was used to present the results.

Result and Discussion

The physical quality of baked egg custard was significantly affected ($p<0.01$) by the addition of suji leaf juice in varying percentages. Data on Physical Quality of Baked Egg Custard with Suji Leaf are shown in Table 1.

Table 1. Physical Quality of Baked Egg Custard with Suji Leaf Juice Addition

Parameter	P0	P1	P2	P3
Texture (N)	0.68±0.02^{d}	0.61±0.01^{c}	0.59±0.00^{b}	0.57±0.00^{a}
pH value	6.33±0.05^{a}	6.38±0.03^{b}	6.42±0.05^{c}	6.49±0.13^{d}
Yield (%)	85.59 ± 0.28^{b}	85.03 ± 1.06^{b}	83.77 ± 4.17^{ab}	75.10 ± 0.21^{a}

Note: $^{a, b, c, d}$ Different superscripts in the same row indicate very significant differences ($p<0.01$)

Texture

The average value shows the texture of baked egg custard with the addition of suji leaf juice ranges from 0.68-0.57N. P0 had the highest average value, measuring 0.68N, while P3 treatment, which added 3% suji leaf juice, had the lowest texture, measuring 0.57N. The addition of suji leaf juice to baked egg custard can reduce the texture value. The texture value decreases because the suji leaves have a lot of water content. Suji leaves contain chlorophyll which has quite a high moisture content (Aryanti et al., 2016).

pH value

The average value shows the pH of baked egg custard with the addition of suji leaf juice. ranged from 6.33-6.49. P0 treatment yielded the lowest pH of 6.33, while P3 achieved the highest average value of 6.49. Adding suji leaf juice to baked egg custard can increase the pH. The increase in pH occurs because suji leaves contain a pH of 6.95 (Putri et al., 2003).

Yield

The average yield value for baked egg custard ranged from 75.10-85.59%. With a yield of 75.10%, the P3 treatment's addition of 3% suji leaf juice produced the lowest average value, whereas the P0 treatment—which did not include suji leaf juice—produced the highest average yield value, 85.59%. The decrease in the yield of baked egg custard was due to the increasing addition of suji leaf juice. This is by research conducted by Sulistyowati et al. (2019) that the greater the percentage of addition of gerga orange juice in liquid form can reduce the yield of the resulting product. The increasing addition of suji leaf juice to baked egg custard resulted in a decreasing yield. According to Rosida et al. (2018), yield is a comparison of the amount of a product produced from the procedure carried out in percent units. The yield value is obtained from the comparison between the final weight of the product and the total material before processing which is expressed in percent. Raisanti et al. (2022) stated that factors that can influence the yield are the composition of the materials used and the handling during the processing of a product.

The La*b* color profile of baked egg custard was significantly affected ($p<0.01$) by the addition of suji leaf juice in varying percentages. Data on La*b* color profile of Baked Egg Custard with Suji Leaf are shown in Table 2.

Table 2. La*b* Color of Baked Egg Custard with Suji Leaf Juice Addition

Parameter	P0	P1	P2	P3
Lightness (L)	75.82 ± 0.69^{c}	73.99 ± 0.90^{bc}	72.15 ± 0.68^{b}	68.38 ± 1.21^{a}
Redness (a*)	1.65 ± 0.16^{d}	0.51 ± 0.13^{c}	-4.04 ± 0.31^{b}	-5.91 ± 0.56^{a}
Yellowness (b*)	54.50 ± 0.79^{d}	52.53 ± 0.80^{c}	35.96 ± 1.00^{b}	34.17 ± 0.41^{a}

Note: $^{a, b, c, d}$ Different superscripts in the same row indicate very significant differences ($p<0.01$)

L, a, b* color*

The decrease in the L (Lightness) color value in baked egg custard is because suji leaves have a high green chlorophyll color pigment. The addition of increasing suji leaf juice resulted in the green pigment contained in baked egg custard increasing (Rahardjo, 2015). This is supported by the opinion of Khilmi et al. (2020) that suji leaf juice has a green color due to the chlorophyll pigment content in suji leaves. As time goes by, suji leaves are popularly used as a coloring agent in food or drinks. Hidayana et al. (2022) the higher the brightness, the greater the color value L (Lightness) with the brightness level of dark colors having a value of 0 and bright colors having a value of 100.

The decrease in the color value a* (redness) in baked egg custard is thought to be due to the green pigment content contained in suji leaf juice. The more suji leaf juice added, the more greenish value will be added to the baked egg custard. According to Indrasti et al. (2018), the juice from suji leaves produces a deep green color due to the high chlorophyll content in suji leaves. This is supported by the opinion of Dewi et al. (2018) that suji leaf juice has a more dominant chlorophyll content when compared to other compounds such as flavonoids, saponins, tannins, and alkaloids.

The decrease in the yellowish color b* in baked egg custard was caused by the addition of suji leaf juice which has a green color. As the addition of suji leaf juice increases to baked egg custard, the b* (yellowness) color decreases. The color b* decreased because of the color of the baked egg custard mixed with the color of the suji leaf juice. The yellow color in baked egg custard is produced because of the main ingredient, egg yolk. Egg yolks produce a yellow color that comes from feed containing carotenoid pigments (Kartina et al., 2022). The more suji leaf juice added will affect the b* (yellowness) color of baked egg custard. According to Sari & Nasution (2021), suji leaves are a natural dye plant that produces the green pigment chlorophyll. This is supported by the opinion of Fitri (2022) that chlorophyll is found in green plants, especially in suji leaves, chlorophyll in leaves can play a role in photosynthesis in plants.

The chemical quality of baked egg custard was significantly affected ($p<0.01$) by the addition of suji leaf juice in varying percentages. Data on chemical quality profile of Baked Egg Custard with Suji Leaf are shown in Table 3.

Table 3. Chemical Quality of Baked Egg Custard with Suji Leaf Juice Addition

Parameter	P0	P1	P2	P3
Protein content (%)	7.10 ± 0.14^{a}	7.25 ± 0.12^{ab}	7.52 ± 0.13^{bc}	7.75 ± 0.13^{c}
Fat content (%)	8.20±0.23^{d}	7.60±0.33^{c}	6.70±0.20^{b}	6.30±0.20^{a}
Moisture content (%)	41.15 ± 2.16^{a}	41.33 ± 2.22^{b}	43.42 ± 2.22^{c}	44.52 ± 9.32^{d}
Carbohydrate (%)	42.60 ± 0.37^{a}	41.64 ± 0.34^{b}	40.38 ± 0.12^{c}	39.63 ± 0.14^{d}
Crude fiber (%)	0.27 ± 0.03^{a}	0.32 ± 0.03^{b}	0.36 ± 0.03^{c}	0.42 ± 0.03^{d}

Note: $^{a, b, c, d}$ Different superscripts in the same row indicate very significant differences ($p<0.01$)

Protein content

Baked egg custard contains protein from eggs and milk. Protein plays an important role in the formation of custard texture during baking. The addition of suji leaves with chlorophyll compounds, flavonoids, and vegetable proteins. Suji leaf juice, which is rich in chlorophyll, can interact with proteins produced by milk and eggs. The interaction can affect protein denaturation during baking. The compounds contained in suji leaves will affect the formation of protein gel, resulting in a soft texture in the custard. In addition, the addition of suji leaf juice to baked egg custard can accelerate or slow down protein denaturation. So that the level of softness and ability to hold water. Research conducted by Arisandi (2012) used the addition of 50 ml of suji leaf water to produce 7.71% protein. Zulfa & Andriani (2017) stated that the formation of complex compounds against extracellular proteins will produce antibacterials as a flavonoid mechanism.

Fat content

The main sources of fat found in baked egg custard are eggs and milk. The fat content plays an important role to form the soft texture and stability of the custard. Naturally added suji leaf juice does not contain large amounts of fat, so there is a decrease in fat content in

baked egg custard with the highest percentage with the addition. This happens because suji leaf juice can replace ingredients that contain fat. Chlorophyll contained in suji leaves has lipophilic properties, so it can interact with the fat in the custard. Antioxidants contained in suji leaves can slow down the oxidation of fat during baking, these interactions can maintain the quality of custard. During baking, the fat in the eggs and milk in the custard can undergo changes caused by heat. Suji leaf juice may play a role as a fat stabilizer in custard. Suji leaves contain active compounds in the form of flavonoids and saponins (Anggraini & Nabillah, 2018). Flavonoids are a type of antioxidant. Cikita et al. (2016) added that antioxidants are chemical compounds that can slow down the rate of fat oxidation reactions in food.

Moisture content

Baked egg custard has main ingredients that contain water, namely eggs, milk, and sugar used during the manufacture of the product. Moisture content serves to ensure the texture of baked egg custard remains soft. The composition of suji leaf juice is generally water, when added to food products, it certainly increases the moisture content. Flavonoids found in suji leaves can affect water binding by affecting viscosity. The addition of suji leaf juice increases the moisture content, causing higher evaporation during roasting. The water contained in suji leaf juice can distribute heat more evenly, thus affecting the formation of custard texture. This is by research by Lusiana et al. (2021) the more natural dyes added, the more moisture content of the product will increase. This is supported by the statement by Aryanti et al. (2016) that fresh suji leaves which have a wet basis moisture content of 73.25%, contain 3773.9 ppm chlorophyll consisting of 2524.6 ppm chlorophyll and 1250.3 ppm chlorophyll b. The increase in the average moisture content is proportional to the percentage of use of added suji leaf juice.

Carbohydrate

Carbohydrates found in baked egg custard come from sugar, milk, and cornstarch. The function of carbohydrates in custard is to sweeten, form texture, and play a role in the maillard reaction that occurs during the baking process. Chlorophyll and flavonoids in gambling leaf juice can inhibit the intensity of the maillard reaction, because these antioxidants prevent the oxidation of sugar. Heating the product can result in gelatinization of carbohydrates with the use of cornstarch, suji juice can change the consistency of the product. Suji juice can affect the distribution, interaction and functional properties of carbohydrates. This is by the statement of Yusmarini et al. (2021) that the carbohydrate content in suji leaves is not as large as dragon fruit or purple sweet potato. Yuniwati et al. (2012) stated that suji leaves contain chlorophyll which functions to absorb energy from sunlight which is used in the photosynthesis process to process biochemicals where plants synthesize carbohydrates which convert sugar into starch. Arfandi et al. (2013) also stated that suji leaves contain saponin which is a triterpenoid steroid/glucoside compound that is bound to carbohydrates.

Crude fiber

Baked egg custard is generally a low-fiber product, because the main ingredients do not contain fiber. The addition of suji leaf juice contributed to the increase in fiber content. The crude fiber of suji leaf juice does not dissolve in water but is dispersed in the custard mixture and affects its texture. Overall, the addition of suji leaf juice provides additional benefits in the form of increased nutritional value, especially fiber. Wardhana et al. (2019) stated that crude fiber consists of cellulose, hemicellulose, and lignin, as well as other minor compounds such as pectin. The increase in the average crude fiber content of baked egg custard with the addition of suji leaf juice was due to the fiber content in suji leaf juice. This is supported by the statement of Rambe et al. (2018) that in suji leaves there is a fiber content of 0.90%, ash of 0.19%, vitamin C of 19.36%, and total soluble solids of 5.49%.

Conclusion

Suji leaf juice can be used as a natural coloring in food. This study investigated how suji leaf juice, which is the natural colorant of baked egg custard, can contribute to the appearance of the product. Results showed that, when compared to the other treatments, the addition of 3% suji juice resulted in the best quality. With stable pH, soft texture, and good yield. The green color of naturally-derived chlorophyll provides visual appeal without altering the taste. The color parameter (Lab) showed that the addition of suji leaf juice resulted in a visually good and quality product. With a higher amount of moisture, the protein, fat, carbohydrate, and fiber content remained the same. This baked egg custard offers value-added product innovation and is interesting to develop because it has an ideal balance of nutrients, texture and appearance.

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The authors declare no conflict of interest.

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