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EFFECT OF CARBOXYL METHYL CELLULOSE (CMC) ADDITION ON PHYSICOCHEMICAL QUALITY OF SALTED EGG WHITE POWDER

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Abstract
Duck eggs which are processed into salted eggs by the salting method have various advantages, but it cannot be stored for a long time. Producing powdered salted egg whites is one way to improve qualities and extend shelf life. The salted egg white powder lacks the desired consistency, making it necessary to add CMC to enhance its structure. Carboxyl Methyl Cellulose (CMC) is a stabilizer that can be used because it has good hydrophilic properties. The application of Salted Egg White Powder (SEWP) stabilized with CMC has the potential for diversification of functional foods. The objective of this research was to use CMC to produce stable, high-quality SEWP that could be used in functional food compositions. Four treatments and six replications were employed in a completely randomized experiment as part of the research methodology. Salted egg white and CMC in the following treatments—2%, 4%, 6%, and control—are the research material. The addition of CMC to SEWP had a very significant (P<0.01) effect on moisture, protein, fat, salt content, solubility, L, a*, b* and also had a significant effect (P<0.05) on the pH value. Based on the research results, 6% CMC added to SEWP can improve the physicochemical characteristics.
Keywords: salted egg powder, duck egg, carboxyl methyl cellulose, egg product

PENGARUH PENAMBAHAN KARBOKSILMETIL SELULOSA (CMC) TERHADAP KUALITAS FISIKOKIMIA BUBUK PUTIH TELUR ASIN

Abstrak
Pengolahan telur itik menjadi telur asin dengan metode penggaraman memiliki berbagai keuntungan, namun tidak dapat disimpan dalam waktu lama. Salah satu upaya yang dapat dilakukan untuk meningkatkan daya simpan, memperbaiki karakteristik, dan meningkatkan kandungan gizi telur asin adalah dengan membuat putih telur asin berbentuk bubuk. Bubuk telur asin dapat dibuat dengan cara pengeringan menggunakan oven, sehingga diperlukan bahan penstabil untuk mengurangi kerusakan akibat pemanasan. Karboksil Metil Selulosa (CMC) merupakan bahan penstabil yang dapat digunakan karena memiliki sifat hidrofilik yang baik. Tujuan penelitian ini adalah untuk meningkatkan mutu fisikokimia dan kandungan gizi tepung putih telur asin (SEWP) sehingga dapat digunakan sebagai salah satu bentuk diversifikasi pangan fungsional. Metode penelitian yang digunakan adalah eksperimen laboratorium dengan rancangan acak lengkap dengan 4 perlakuan dan 5 kali ulangan. Materi yang digunakan adalah putih telur asin dan CMC sesuai dengan perlakuan 2%, 4%, 6%, dan kontrol. Penambahan CMC pada tepung putih telur asin berpengaruh nyata (P<0,01) terhadap mutu fisikokimia dan juga berpengaruh nyata (P<0,05) terhadap nilai pH. Berdasarkan hasil penelitian, penambahan CMC 6% pada tepung putih telur dapat meningkatkan sifat fisikokimia.
Kata kunci: tepung telur asin, telur bebek, karboksil metil selulosa, produk telur

INTRODUCTION

Duck eggs are a source of protein that is widely favored by people in Indonesia. The Central Statistics Agency (BPS) revealed that Indonesia produced a total of 358 thousand tons of duck eggs in 2023 (Badan Pusat Statistik, 2023). Generally, duck eggs are consumed by the public after being processed into a food product that is ready for consumption such as salted eggs, cakes, flour eggs, and others. Duck eggs that have gone through the salting method, can increase added value, selling value, and extend the shelf life of the product. Salted duck eggs are one of the processing products that are often found in the community. Salted duck eggs have a distinctive taste, can be consumed by various groups, are easy to find on the market, and have better nutritional content than duck eggs without processing. Salted duck eggs have nutritional content in the form of potassium, phosphorus, calcium, vitamin A, iron, beta carotene, riboflavin, and macro components such as fat, protein, and carbohydrates that are good for the body (Sativa, 2022). Besides the advantages, salted eggs have the disadvantage of being easily damaged and have a short shelf life (growth of microorganisms) if not handled and distributed properly (Ayu & Novi, 2022).

Damage that occurs due to improper packaging and storage processes can be overcome by further processing into flour-shaped products to minimize moisture content by drying. Drying techniques on eggs usually use spray drying, freeze drying, and pan drying. The heating process that occurs in the processing of powdered salted eggs carried out by pan drying or oven technology will result in denaturation, oxidation, and degradation of proteins and lipids because it uses thermal induction (Wang et al., 2021). Powdered salted eggs are easier to store in the long term and distribute through long-distance transportation due to their economical form (Wang et al., 2020). Drying of salted eggs in the albumin part is easier when compared to the yellow part which has a moist texture due to high fat content. Salted egg white powder has a high salt concentration, foaming ability, and low viscosity (Su et al., 2021). Salted egg white has lower stability after drying (Sanusi et al., 2020).

The shortcomings of powdery salted egg whites can be overcome by the addition of stabilizers so as not to lose their functional properties. The stabilizer that can be added is CMC (Carboxyl Methyl Cellulose). CMC is a solvent with hydrophilic polymer properties. This hydrocolloid is often used as a stabilizer and increases colloidal viscosity. The addition of CMC can improve product characteristics, and make particle size more uniform, and more soluble (Keller, 1986). The combination of CMC and soluble salt can break down proteins into simpler structures to shorten the drying process of salted egg white flour (Tang et al., 2019). The hydrophilic nature of CMC makes it easier for compounds in salted egg white powder to interrelate so that the results of the flour obtained are more dried evenly. Polysaccharide bonds in CMC will more easily break down hydrogen and protein to minimize the occurrence of nutritional damage due to Maillard reactions that occur during drying (Jiang et al., 2023). Previous studies found that using egg white and carboxymethyl cellulose (CMC) as foaming agents and foam stabilizers improved the characteristics of tomato powder. High temperatures reduced the quality of the resultant powder (Hossain et al., 2021).

Previous research on salted egg white powder is the use of garlic extract as an antioxidant, antioxidants do not impact SEWP's physical structure, but they are necessary to prevent protein and lipid oxidation, increasing shelf life and maintaining sensory quality. (Evanuarini & Susilo, 2022), incorporation of salted duck egg powder with maltodextrin and tricalcium phosphate as an anti-caking agent functions as a carrier, helping to solubilize powder and avoid agglomeration, but does not directly preserve protein or manage moisture content (Mahmudah et al., 2023), and development of salted egg powder with black and white pepper (Suretno et al., 2021). The usage of CMC in this study is expected to improve viscosity, protein stability, and water content management, making it a suitable material for preventing protein denaturation during drying and storage.

The purpose of this study was to determine the effect of the addition of CMC as a stabilizer in the manufacture of salted egg white powder. The high moisture content of salted egg whites can be handled by the addition of CMC so that the drying process is faster and minimizes macro-nutrient loss during heating.

MATERIALS AND METHODS

The material of this study is salted eggs made by using the traditional dry salting method and obtained from a salted egg business in Malang, East Java. The salted eggs used are 10-14 days old after salting, free from strange odors, the structure of the egg white is still firm, the uniformity of the egg size is moderate, the color of the egg white is clear white slightly cloudy, the texture of the egg white is thick, and free from fungi and pathogenic bacteria. CMC powder was obtained from a chemical store in Malang City, East Java. The method used is a laboratory experiment using a complete randomized design given 4 treatments (without CMC addition as a control, 2%, 4%, 6% addition of CMC from total salted egg white) and repeated 6 times.

The procedure for making salted egg white powder starts from cleaning the salted eggs that have been made, by cleaning the paste attached to the egg shell using running water. Furthermore, raw salted eggs are broken and separated between the yellow and white parts. Salted egg white is weighed 100 g in a measuring cup, then pasteurized at 52°C for 15 seconds. The pasteurized salted egg white is then cooled to room temperature. Pasteurization of egg white at 52°C for 15 seconds is an optimum process that balances product quality and food safety. The process achieves the reduction of microbial risk without compromising the functional qualities of salted egg white, resulting in a powder with acceptable foaming ability, solubility, and stability. After that, CMC will be added to salted egg whites according to the treatment without the addition of CMC (control) and the addition of CMC by 2%, 4%, and 6% of the amount of egg whites used. CMC mixing in the study still used manual mixing, but more carefully so that the CMC could still be distributed and no clumping occurred. Salted egg whites with the addition of CMC are then oven-dried for approximately two hours at 60°C. The drying temperature of 60°C for two hours was chosen because it is sufficient to reduce the moisture content to a level suitable for storage without significantly reducing nutritional quality. The temperature of 60°C prevents excessive protein denaturation, preserves the solubility and usefulness of salted egg white powder, and inhibits Maillard reactions, which can alter color and flavor. Furthermore, the two-hour period allows efficient water evaporation, bringing the water content to the appropriate limit for product stability, preventing microbial development, and extending shelf life without losing vital nutritional components like protein and minerals.

Physicochemical testing on salted egg white flour consists of moisture content, protein content, fat content, salt content, solubility, pH, and L a*b* color. Analysis of moisture content using the thermogravimetric method (AOAC, 2005), protein content using the Kjeldhal method, fat content using the Soxhlet method (AOAC, 2005), salt content using the Mohr argentometric method (AOAC, 2005), solubility using the gravimetric method (Iskandar et al., 2021), pH using a pH meter (AOAC, 2005), and L a*b* color with a color reader (AOAC, 2005).

The collected data were then processed using Microsoft Excel 2010, the mean and standard deviation were taken and then analyzed using analysis of variance (ANOVA), if there were significant differences ($p<0.05$), it would be followed by the Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Moisture Content

Moisture content is a measurement parameter of the moisture content contained in food which affects the durability of a product. If the food product contains a high moisture content, it has a shorter shelf life since it promotes the growth of pathogens. The analysis of variance data demonstrate that the addition of CMC with varied percentages has a very significant influence ($P < 0.01$) on the moisture content of SEWP. The average moisture content of SEWP is shown in Table 1. The average moisture content of SEWP after adding CMC ranged from 4.86% to 6.2%. The control treatment had the highest moisture content (6.2%), whereas the treatment with 6% CMC had the lowest at 4.86%. The standard moisture content of SEWP set by the National Standardization Agency in SNI 01-4323-1996 is a maximum of 8%. The percentage of moisture content in SEWP with the addition of CMC following SNI standards is a maximum of 8%. The percentage of moisture content decreases as CMC increases. CMC functions at the molecular level by binding water with hydrogen bonds, increasing viscosity to limit water movement, and interacting with egg white proteins to improve drying. It significantly reduces moisture content in SEWP, enhances product stability, and increases shelf life by limiting moisture reabsorption after drying. CMC has hydrophilic properties so if CMC is added to a food ingredient it can absorb and bind moisture (Nurminah et al., 2019).

Moisture content can affect the shelf life of the product where if the food has a low moisture content value, the product has a longer shelf life because it can suppress the growth of microorganisms (Alp & Bulantekin, 2021). The addition of CMC as much as 0.5% in flour chicken egg whites has a low moisture content value compared to the control treatment. The percentage of the control treatment was 9.03% while the addition of CMC was 7.94% (Hayuningtyas et al., 2022). The addition of maltodextrin in the manufacture of powder-salted eggs is also able to reduce moisture content. The moisture content value of the salted egg powder control treatment is 1.94% while the percentage of moisture content with the addition of maltodextrin as much as 2% is 1.60% (Mahmudah et al., 2023).

Protein Content

Protein is one of the indicators of good food quality if there is no significant damage during the heating process. Protein can play a role in improving the stability of food products because it binds to water and fat. Protein from SEWP with the addition of CMC ranges from 88.63 - 90.71%. The highest percentage level lies in the addition of 6% salted egg white flour which is 90.71% and the lowest percentage in the control treatment which is 88.63%. SNI 4323: 1996 states that the standard of egg white powder protein content is at least 75%, and the protein content contained in salted egg white flour with the addition of CMC is higher than the minimum value of SNI criteria for egg white flour. The average protein content of SEWP is shown in Table 1.CMC is used in the preparation of flour by providing dough with viscosity such as gluten protein. The protein in CMC functions as a thickener to slow down the crystallization of sugar in SEWP (Abdelnaby et al., 2021).

The addition of CMC to chicken egg white powder increased the protein content ranging from the control treatment by 39.26% and the highest treatment with the addition of 0.5% CMC by 47.62%. The treatment factor, which only employed a relatively low temperature during processing (a maximum of 60°C), had an impact on the sample's highest protein concentration. CMC can create a gel structure that increases the viscosity of egg white before drying, this can limit protein mobility. In addition, the hydrophilic group of CMC can form hydrogen bonds with egg white proteins so that the protein remains hydrated longer to avoid over-drying conditions. The temperature employed is not too high, thus few proteins or amino acids in egg powder are denatured (Hayuningtyas et al., 2022). The addition of *Lactobacillus bulgaricus* to egg white powder raised protein content by 78.26% compared to the control treatment and 82.23% for the highest treatment with 6% Lactobacillus bulgaricus. The increased protein content in egg white flour is due to proteins being reduced into smaller components. The drying procedure for egg white flour will somewhat alter the protein structure due to oven heating at 60°C. Drying at 60°C does not cause coagulation and denaturation of egg proteins, because egg whites gel when the temperature reaches 62°C (Azizah et al., 2022). Higher protein in SEWP tends to make it more mixable and foamable. Nevertheless, its functionality is heavily reliant on the maintenance of protein structure after processing. When the protein becomes too damaged or interacts too greatly with salt, its functional properties decrease despite having high protein. Thus, proper processing is necessary to maintain the functionality of protein in SEWP.

Fat Content

The addition of CMC with different percentages has a very significant effect ($P < 0.01$) on the fat content of SEWP. The fat content of CMC addition SEWP ranged from 0.45% - 0.65%. The average fat content of SEWP is shown in Table 1. The highest percentage lies in SEWP without treatment which is 0.65% and the lowest percentage in P3 which is 0.45. SNI 4323: 1996 states that the standard fat content of egg white powder is a maximum of 1%, the fat content contained in SEWP with the addition of CMC is already lower than the maximum value of SNI criteria for egg white powder. The addition of CMC to chicken egg white powder reduced the fat content of the control treatment by 0.77% and the maximum treatment with 0.5% CMC by 0.25%. The treatment factor, which only employed a relatively low temperature during processing (a maximum of 60°C), had an impact on the sample's highest protein concentration. CMC has no direct contact with lipids upon drying since it is more hydrophilic and utilized to stabilize water, not fat. Fat loss in SEWP will be more due to slight thermal degradation and lipid oxidation, although at 60°C this activity is still very minimal compared to drying at elevated temperatures. Therefore, if the ultimate goal is to maintain the fat content, packaging in low oxygen and using natural antioxidants can help minimize the breakdown of fat in the end product. The temperature employed is not too high, thus few proteins or amino acids in egg powder are denatured (Hayuningtyas et al., 2022). The addition of black pepper to SEWP reduced fat content ranging from the control treatment by 9.08% and the highest treatment with the addition of 20% black pepper by 8.46% during 10 days of observation (Suretno et al., 2021).

Salt Content

Adding CMC at varying percentages significantly affects the salt content of SEWP ($P < 0.01$). CMC concentrations range from 0.19% to 0.25%. The control treatment has the highest proportion (0.25%), whereas P3 has the lowest (0.19%). The average salt content of SEWP is shown in Table 1. The addition of salt has the potential to modulate the level of changes in SEWP quality. The decrease in salt content after the addition of CMC is in line with the increasing ability of CMC to dissolve microsubstances. CMC will cause an optimal decrease in the addition of 6% due to polymerization between NaCl and hydroxyl groups (Tang et al., 2019). Egg white powder added with 3% STPP causes a significant decrease in particle size so that parameters such as salt content also decrease (Li et al., 2021). Reducing the salt content in SEWP can increase the flexibility of its application in various foods, but it can also reduce the sensory characteristics of traditional salted egg white such as a strong salty taste. Reformulating SEWP using flavor balancing agents can be a solution if the desired sensory is to maintain.

Solubility Test

Solubility is calculated based on the weight percentage of the remaining material that is unable to dissolve through filter paper. The solubility of SEWP with the addition of CMC ranges from 95.86%-97.04%. The highest percentage of solubility is located in P3 which is 97.04% and the lowest percentage is located in the control treatment which is 95.86%. The solubility index standard for egg powder is above 80%, while for egg white powder it is 96% (Wulandari & Arief, 2022). SEWP has met the standard amount with an increase in the amount of CMC added. The solubility index in SEWP is closely related to protein. The added CMC belongs to the hydroxyl group which can bind protein and water faster.

Hydroxyl groups can bind to molecular-sized hydrogen molecules and consist of a simple structure to increase the solubility of SEWP (Setiyawan et al., 2021). The drying method using high-temperature heating also increases the solubility of the powder. This is because high temperatures during the drying process can reduce water content so that salted egg whites have high hygroscopic ability and increase the ability to dissolve in water (Huda, 2020). The addition of CMC to egg white powder has a percentage of 95.65%, while egg powder with no addition or control has a percentage of 94.75% (Setiyawan et al., 2021).

SEWP's high solubility improves user ease, shelf stability, and flexibility in a variety of food applications. SEWP improves the flavor and texture of instant soups and ready-to-eat meals, while it also provides a handy supply of functional protein in protein drinks. With the increasing popularity of healthy quick foods and functional proteins, SEWP has the potential to become a modern ingredient in the current food industry.

pH value

pH measurement is used to determine the acidity of a food ingredient. The pH level can determine the quality of durability or shelf life of food products, especially livestock products. The pH of SEWP with the addition of CMC ranges from 6.72-7.05. The highest pH value is located in P3 which is 7.05 and the lowest value is located in the control treatment which is 6.72. The pH standard of egg white powder set by the National Standardization Agency in SNI 01-4323-1996 ranges from 6.5 to 7.5. SEWP with the addition of CMC meets SNI and increases with the addition of CMC. CMC has polar properties that can bind solids such as water, sugar, salt, and several other components so that more substances are dissolved in it.

Table 1. Average of physicochemical quality results on SEWP with CMC addition

Treatments	Parameters (%)					
	Moisture	Protein	Fat	Salt	Solubility	pH value
P0	6.20 ± 0.15[a]	88.63 ± 0.30[a]	0.65 ± 0.06[b]	0.25 ± 0.01[d]	95.86 ± 0.27[a]	6.72 ± 0.16[a]
P1	5.99 ± 0.07[ab]	89.02 ± 0.33[ab]	0.52 ± 0.05[a]	0.23 ± 0.01[c]	96.33 ± 0.30[a]	6.79 ± 0.12[a]
P2	4.96 ± 0.04[b]	90.33 ± 0.40[b]	0.47 ± 0.05[a]	0.22 ± 0.00[b]	96.84 ± 0.31[b]	6.88 ± 0.09[a]
P3	4.86 ± 0.11[b]	90.71 ± 0.19[b]	0.45 ± 0.10[a]	0.19 ± 0.00[a]	97.04 ± 0.03[b]	7.05 ± 0.07[b]

Note: [a,b] Different superscripts in the same column indicate a highly significant effect ($P<0.01$).

The number of dissolved sugar components indicates that more carbon dioxide is produced during the drying process. Associated with decreasing moisture content, it will increase the potential for salted egg whites to lose CO_2. The loss of CO_2 results in the onset of bicarbonate and the balance of salted egg whites will decrease so that the pH increases (Mangalisu & Armayanti, 2020).

The pH value in SEWP is influenced by protein denaturation (Chang et al., 2019). The addition of CMC after pasteurization can improve the stability of salted egg whites because the protein damage that occurs can be minimized. The formation of salted egg white protein bonds is more solid with increasing levels of CMC added so that protein denaturation can be reduced (Sommer Stephan et al., 2019). The addition of dextran sulfate to egg white powder will prevent a significant protein denaturation process due to the formation of polysaccharide-protein bonds (Liu et al., 2022). The pH value of SEWP added by Carano at 0.5% is classified as neutral because it is above the value of 6.5 (Fuentes et al., 2020).

SEWP is often alkaline (pH 8.5-9.5), which inhibits the growth of certain bacteria and fungi, particularly those that thrive in neutral or acidic environments. When maintained at consistent pH settings, microbial development is prevented, allowing the product to remain stable for longer periods of time. When the pH is reduced, the product develops discolouration, off-odors, and decreased protein solubility, hastening the degradation of SEWP quality.

Color L a*b*

Color is an important indicator by consumers in buying a product. Consumers are more interested in attractive colors than pale colors. Color testing uses a color reader by utilizing the light absorbed in the sample with 3 indicators of L (brightness), a* (redness), and b* (yellowish). The average color La*b* of SEWP is shown in Table 2. The L color of SEWP with the addition of CMC ranged from 86.49 - 83.24 while the a* color of SEWP with the addition of CMC ranged from -0.12 to -1.41. The highest L value is located in the highest treatment (P3) which is 86.49 and the lowest is located in the control treatment which is 83.24 as well as the a* color value where the highest is located in P3 at -0.12 and the lowest is located in the control treatment which is -1.41. The L and a* colors increase as the percentage of CMC given increases, indicating that the color of SEWP is increasingly heading towards bright colors. CMC has an inconspicuous white color, odorless, and tasteless, and can dissolve in water (Rizkyyani et al., 2020). Dark colors in food products can occur due to the Maillard reaction which causes a brownish color in food. The increasing addition of CMC can minimize the occurrence of brownish reactions in a product because polysaccharide groups (pectin, gum arabic, and CMC) have a low percentage of experiencing Maillard reactions compared to monosaccharide and disaccharide groups so that the resulting color is brighter (Jiang et al., 2023). The color difference in SEWP with the addition of CMC is presented in Figure 1.

The b* color of SEWP with the addition of CMC ranges from 6.38-8.32. The highest b* color value is located in the control treatment which is 8.32 and the lowest is located in the highest treatment (P3) which is 6.38. The color value of b* decreased as the percentage of CMC given increased. This is because egg whites do not have carotene compounds, or coloring pigments in egg yolks and also contain low glucose (Azizah et al., 2022).

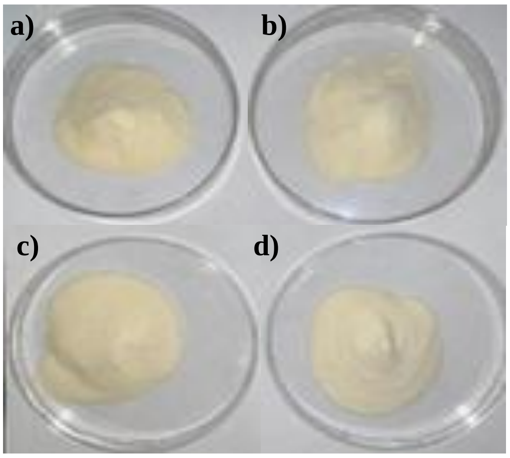

Figure 1. The color difference in salted egg white flour with the addition of CMC (a: control; b: 2% CMC; c: 4% CMC; d: 6% CMC)

Table 2. Average color results on SEWP with CMC addition

Treatments	Lightness (L) ± SD	Redness (a*) ± SD	Yellowness (b*) ± SD
P0	83.24 ± 1.03^{a}	-1.41 ± 0.17^{a}	8.32 ± 0.15^{a}
P1	85.68 ± 0.63^{b}	-0.84 ± 0.94^{a}	7.38 ± 0.13^{ab}
P2	85.01 ± 0.59^{b}	-0.27 ± 0.58^{a}	6.93 ± 0.13^{b}
P3	86.49 ± 0.08^{b}	-0.12 ± 0.10^{b}	6.38 ± 0.11^{b}

Note: ^{a,b} Different superscripts in the same column indicate a highly significant effect (P<0.01).

Glucose plays a role in the Maillard reaction which is an enzymatic reaction between glucose and protein that can cause browning (Tamanna & Mahmood, 2015). CMC is also a compound that minimizes the occurrence of Maillard reactions so that increasing the percentage of CMC addition to SEWP does not affect the yellow color of the product (Jiang et al., 2023).

The addition of food additives in the manufacture of egg powder can affect the color of the product. The addition of gum arabic as a stabilizer in fish egg powder can reduce the browning reaction in the powder but too long storage of egg powder will result in oxidation so that the brightness color (L*) which on the first day is 81.24 will decrease when storage for 1 week to 78.68 (Binsi et al., 2017). The addition of Lactobacillus bulgaricus in making egg white powder can increase the brightness color (L*). The highest color is located in the addition of Lactobacillus bulgaricus as much as 6% which is 86.24 while the lowest is located in the control treatment which is 77.28. Egg whites do not contain yellow coloring pigments, namely carotene found in egg yolks and egg whites contain little glucose so the browning reaction that occurs is very low (Azizah et al., 2022). The addition of garlic extract can increase the reddish color value (a*) in salted egg powder. The highest value is located at P3 of 6.33 and the lowest is located at P0 which is 5.01 (Evanuarini & Susilo, 2022). The addition of xanthan gum to SEWP can affect the yellowish color value (b*) where the control treatment has a value of 3.53 and the addition of 20% is 3.67 (Yao et al., 2023).

CONCLUSIONS

The results of research on the addition of CMC to the physicochemical quality of SEWP at a percentage of 6% had a significant effect. The addition of CMC to SEWP improved the characteristics and nutrition of SEWP. SEWP with the addition of CMC has lower moisture, salt, and fat content; increased protein content and solubility; and pale color (no browning); and has a stable pH. SEWP containing CMC can enrich diversification in the field of food technology.

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