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Functional Properties of Salted Duck Egg Powder with Maltodextrin and Tricalcium Phosphate Incorporation as Anticaking Agents

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A B S T R A C T

The protein content in egg contributes effectively to the fulfilment of nutrients in daily life at an affordable price and acceptable organoleptic properties. This study aimed to investigate the effect of anti-caking agent addition (maltodextrin and tricalcium phosphate) on the quality and functional properties of salted duck egg powder. Addition of 2% maltodextrin increased the moisture content in salted duck egg powders as much 36% compared to the control. 2% TCP incorporation decreased the moisture content up to 54%, could not maintain the emulsion stability, but it increased the emulsion activity. There were no significant differences ($p < 0.05$) on the parameter of foaming capacity and foaming stability. Anticaking agent maltodextrin and TCP did not affect the water holding capacity of all four salted duck eggs powder. However, maltodextrin addition slightly increased the oil holding capacity. Due to the functional properties of emulsification, foaming, water and oil binding, salted duck egg powders are potentially utilized for the complementary of a large number of food products with its characteristics of longer shelf life and specific flavor.

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Introduction

Eggs have perishable properties, which means they are easily spoiled and have a short shelf life (Evanuarini and Susilo, 2022). Eggs become basic food ingredient with high demand and consumption throughout the world (Fisinin et al., 2008). Eggs refer to a food product produced from poultry that is used as both an ingredient and a main dish for baked foods. Eggs come with hard shell and laid from female species of fowl, birds, reptiles, amphibians, and fish. The main type of egg consumed by humans is from the type of poultry.

The protein content in eggs contributes effectively to the fulfilment of nutrients in daily life at an affordable price and acceptable organoleptic properties. Among the poultry eggs, chicken egg and duck egg are commonly found. Blitar is a regency in Indonesia where business of egg products is developing. One of the product massively consumed is salted egg. Salted egg generally made using duck eggs (Rukmiasih et al., 2015). Salted eggs, and the yolks specifically, are impressively versatile. It has buttery, full-bodied, and rich flavor since duck eggs contain higher lipid concentration than chicken eggs (Ismoyowati *et al.*, 2019).

The principle of making salted eggs is the process of salting with NaCl which then diffuses into the egg through the pores of the shell/shell (Wulandari et al., 2014). Salted duck egg contains protein and fat, respectively, 13.6% and 13.3%. The protein content is higher than raw duck eggs (11.8%), and the fat content is lower than raw duck eggs (14.2%) (Indonesian Food Composition Table, 2019). The purpose of making salted eggs is not only as one effort to preserve, but also to improve the taste of eggs. Furthermore, salted egg has the potential to be developed into salted egg powder. Salted egg powder has more widely application with specific falvor and longer shelf life. It is also appropriate to be applied as a mixture, flavoring, or additive in various food products.

Food powder has main problem called ‘caking’ that affects quality and functionality, due to water absorption during storage. The addition of anticaking agent is needed to keep the powder stability in its form without extreme coagulation. The mechanisms of the anticaking agent’s function were explained by competing to bind the moisture it with the host powder (Jose, 2013); creating barriers on the surface of hygroscopic particles or physical barriers between particles (Nurhadi et al., 2018); smoothing surfaces to eliminate inter-particle friction (Jaya et al., 2006); and also inhibiting crystal growth (Lipasek et al., 2012). Some of the anticaking agents had known to be used in food powder were maltodextrin (Nortuy et al., 2018), tricalcium phosphate (TCP), silicon dioxide, calcium stearate (Barbosa-Cánovas et al., 2005).

Sunyoto et al. (2017) explained that the administration of 2% tricalcium phosphate gave the results of an instant sweet potato puree product with a water content of 11.74%; clumping rate 1.10% (no clumping); and 2.82 mL/g rehydration power. On the other hand, Ekpong et al., (2016), revealed that a product of tamarind powder dispersibility was significantly improved by using maltodextrin (0-15%) and also improved the overall acceptance score. This study aimed to investigate the effect of anti-caking agent addition (maltodetrin and tricalcium phosphate) on the quality and functional properties of salted duck egg powder. Processing salted egg into egg powder being an effort of local food exploration to increase the value of final product.

Materials and Methods

Sample Preparation

Salted duck egg samples were obtained from Doko, Blitar, East Java Province, Indonesia. The eggs have 14 days aged of salting. Uncracked eggs were selected, washed, and drained. Egg samples were homogenized using Phillip HR2222 homogenizer and dried in temperature 80°C for 8 hours with Food Dehydrator MKS-FDH10. The treatment for samples were control (K) with no addition of anticaking agent, addition of 2% maltodextrin (M), addition of tricalcium phosphate 2% (T), and addition of maltodextrin combined with tricalcium phosphate 2% (MT). All of dried samples were milled to get powdered form, sieved to 60 mesh, weighed for determination of yield value and then stored in alumunium foil packaging prior to analysis.

Determination of Moisture Content

Moisture content of the salted egg powder was determined by using oven drying method. Triplicate samples of salted egg powder (5 g each) were weighed, placed in porcelain crucible, and then dried in oven (Memmert UF110) at 105°C for 24 h. The samples were removed from oven, cooled in a desiccator, and weighed. The drying and weighing processes were repeated until constant weight was obtained (Tze et al., 2012).

Determination of Functional Properties

The functional properties of salted duck egg powder was analysed according to the method of Sanusi et al. (2020) with modification. For the emulsifying activity (EA), 1 g sample, 10 mL distilled water and 10 mL palm oil was prepared in calibrated centrifuge tube. The mixture then centrifuged at 2000 g for 5 min. The height ratio of the mixture calculated as emulsion activity in percentage.

$$\text{EA \%}=\frac{\text{Height of emulsified layer}}{\text{Height of total concentration in the cylinder}}\times 100$$

The sample in centrifuged tube then heated at 80°C for 30 min in a water-bath, cooled for 15 mins under running tap water and centrifuged again at 200 g for 15 min. The emulsion stability expressed the ratio of the height of emulsified layer to the total height of the mixture in percentage value.

Foaming Capacities (FC) and Foaming Stabilities (FS) measurement was adapted from Sanusi et al. (2020) with slight modification. 1 g powdered salted duck egg sample was added to 50 mL distilled water in a graduated cylinder at room temperature. The suspension was mixed and shaken for 5 min to foam. The volume foam at 30 seconds after whipping expressed as foam capacity using the formula:

$$\text{FC \%}=\frac{\text{Vol after whipping - Vol before whipping}}{\text{Vol before whipping}}\times 100$$

The volume of foam was recorded 15 min after whipping to determine foam stability (FS) as per percent of initial foam volume.

$$\text{FS \%}=\frac{\text{Foam vol after 15 min}}{\text{Height of total concentration in the cylinder}}\times 100$$

The water holding capacity (WHC) and oil holding capacity (OHC) of the samples determined by using the methods suggested by Heywood et al. (2002) and Nguyen et al. (2015). 2.5 g salted duck egg powder was weighed in pre-weighed 30 mL centrifuge tubes. For each sample 10 mL of distilled water were added and well mixed with the sample. Samples stood at room temperature for 30 min. The mixture was centrifuged at 1200 g 30 min (Joan lab MC-7S). The supernatant was carefully decanted and the new mass of the sample was recorded. WHC (g water /g powder) was calculated as:

$$\text{WHC}=\frac{\text{Total water mass}}{\text{Dry matter mass}}\times 100$$

Oil absorption capacity was also determined by 1 g of sample mixed with 10 mL palm oil and allowed to stand at ambient temperature for 30 min, the centrifuged for 30 min at 200 g. Oil absorption was examined as percent oil bound per gram powdered egg.

$$\text{OHC}=\frac{\text{M oiled - Md}}{\text{M d}}\times 100$$

With md and moiled are the mass of dry material and the mass of sample including held oil, respectively.

Statistical analysis

All samples were run in triplicates. The data were expressed as mean ± standard of deviation. Data was analyzed for variation using one-way analysis of variance (ANOVA) and the means separated by Duncan's multiple-range test. Significance between related samples was analyzed at the level of 0.05 ($P<0.05$).

Results and Discussion

Moisture Content

The moisture content of salted duck egg powder samples ranged from 0.89 to 2.65% wb (Table 1). Compared to all four samples, TCP had lowest value of moisture content (0.89 ± 0.26). It is observed that TCP has relation with its ability to take up to 10 % of its own weight of moisture (humidity) from the environment (EU Commission Regulation, 2013). Later, TCP helps to avoid any lumps in a mix and keeping preparations free-flowable, which is considered to be a benefit to the consumer as well. On the other hand, salted duck egg powder with addition of 2% maltodextrin sample (M) had significantly higher value ($p<0.05$) among four samples. Maltodextrin as anticaking agent in this research is a popular drying aid. It has been reported to reduce stickiness and agglomeration problems during storage that commonly found in flour products (Silva, 2006). In line with Ramachandran et al. (2014) that investigated papaya powder with maltodextrins addition. The increase of moisture content was observed with the increase maltodextrin concentration. However, maltodextrin addition gave preferred sensory scores for appearance, color and overall liking in tamarind powder product (Jittanit et al., 2011).

All of the duck egg powder samples in this paper had lower moisture content (1–3% wb), compared to study of Ndife *et* al. (2010), that explained the moisture content of chicken whole egg had the value of 4.32%. Further study by Rao and Labuza (2012), revealed that hydrolysed egg white powder (HEW) and dried egg white powder (DEW) had higher range of moisture content valued at 8.6% and 6.0% respectively. Vargas-del-Rio et al. (2022) also investigated the moisture content of three samples of egg powders. The samples were made of 100% egg white, mixture of egg yolk:egg white 1:3, and mixture of whole egg that processed by spray drying. Those had values of 3.76%, 2.03%, and 2.22% respectively. Salting treatment in food significantly reduce the moisture content (Sipahutar et al., 2021).

The moisture content of powder product is a crucial factor in maintaining the physical quality of the product during storage (Razak et al., 2020). Caking has been a serious problem in all powdered food, feed, pharmaceutical, and related industries (Ruan et al., 2007). Caking occurs when water is absorbed by the powders either during processing or storage. When the food powder surfaces are mobilized by water, the texture become sticky. An inter-particle binding happens for the next, formation of clusters, and inter-particle fusion, which lead to caking. Caking may cause the decrease of solubility, but it may increase lipid oxidation and enzymatic activity, and reduce the sensory qualities. A study conducted by Nasir et al. (2003), explained that moisture had significant effect on crude protein, crude fat, mould growth and insect infestation. Protein and fat content were decreased with storage period and this trend was more in treatments of higher moisture content of wheat flour sample. The lower moisture content, the longer shelf life of a product. The dried foods were not easily exposed to the spoilage food and can increase the shelf life (Kortei et al., 2015).

Reduction in the degree of caking in mango powder with the addition of tricalcium phosphate and maltodextrin also has been reported by Jaya and Das, (2004). Maltodextrin causing a reduction in caking to some extent, meanwhile addition of TCP resulted further reduction in the degree of caking. Wheat flour given with 2% TCP was effective in forestalling adverse storage changes, preventing insect infestation, and did not have any adverse effect on sensory properties (Ruan et al., 2007).

Functional properties

The emulsion activity of salted duck egg samples were at the range of 57.04% to 66.34% (Table 1). Addition of anticaking agent (maltodextrin and TCP) gave significant difference ($P<0.05$) for emulsion activity. Emulsion activity is referred as maximum amount of oil that can be emulsified by a fixed amount of the protein in food, whereas emulsion stability is the rate of phase separation in water and oil during storage of the emulsion. Emulsion properties being important for delivery systems to encapsulate, protect and release functional ingredients into a food matrix (Padial-Domínguez et al., 2020).

In salted duck egg powders, addition maltodextrin and TCP prior to drying effective in increasing the emulsion activity. Compared to the control (without anticaking agent), the emulsion activity inclined up around 4.45% to 16.30%. This might be due the role of maltodextrin as coating material to enhance the emulsion activity. Lecithin, proteins, gums, modified starches such as maltodextrin, and phospholipids could be used as emulsifying agent (Serdaroglu et al., 2015). Erbay and Koca (2015), evaluated maltodextrins addition for the production of cheese powder. It has effect on increasing the stability of fat emulsions during processing, which decreases the free fat content and improves the reconstitution properties of powders.

In egg product, protein act as the emulsifier due to its surface that containing a mixture of hydrophilic and hydrophobic amino acids along the polypeptide chains. Proteins have emulsification properties due to their amphipathic properties (having hydrophobic and hydrophilic groups), hence proteins are able to form a layer at the oil-water interface. Addition of maltodextrin and TCP did not interfere the protein properties for emulsion forming in salted duck egg powder.

Salted duck egg powder sample with TCP addition had the highest emulsion activity (66.34%). TCP probably has the properties as emulsifying agent with certain role. It might be increasing the viscosity of the medium, reducing coalescence by coating individual droplets as well as acting as weighting agents, or increasing the viscosity of the continuous phase thus retarding droplet movement (Maphosa and Jideani, 2017). Emulsion is important in food for dispersing one liquid in another immiscible liquid. In salted duck egg flour analysis, oil molecules are larger and move slower than water molecules, when oil molecules are dispersed throughout water, they create a thicker consistency throughout the entire mixture.

Table 1. Moisture content and functional properties of salted duck egg flour

Samples	Parameters				
	Moisture Content	Emulsion Activity	Emulsion Stability	Foaming Capacity	Foaming Stability
K	1.94 ± 0.66^{ab}	57.04 ± 4.50^{a}	17.33 ± 2.98^{a}	12.00 ± 6.93^{a}	9.33 ± 1.16^{a}
M	2.65 ± 0.21^{a}	59.58 ± 6.31^{ab}	17.89 ± 7.14^{a}	14.67 ± 5.03^{a}	10.67 ± 1.16^{a}
TCP	0.89 ± 0.26^{b}	66.34 ± 3.72^{b}	13.76 ± 6.94^{a}	10.67 ± 1.16^{a}	8.00 ± 2.00^{a}
MT	1.60 ± 0.35^{ab}	59.79 ± 2.00^{ab}	17.36 ± 3.23^{a}	12.67 ± 1.16^{a}	11.33 ± 2.31^{a}

Values were expressed as mean±SD (n = 3); means with the same superscript letters in the same column are not significantly different (P<0.05) with samples K= control (no addition of anticaking agent), M= Maltodextrin, TCP= Tricalcium phosphate, MT= Maltodextrin+Tricalcium phosphate.

Table 2. Water Holding Capacity (WHC) and Oil Holding Capacity (OHC) salted duck egg powder

Samples	Parameters	
	WHC	OHC
K	2.147 ± 0.22^{a}	1.560 ± 0.09^{ab}
M	2.247 ± 0.14^{a}	1.643 ± 0.11^{b}
TCP	2.167 ± 0.14^{a}	1.570 ± 0.20^{ab}
MT	2.363 ± 0.07^{a}	1.467 ± 0.34^{a}

Values were expressed as mean±SD (n = 3); means with the same superscript letters in the same column are not significantly different (P<0.05) with samples K= control (no addition of anticaking agent), M= Maltodextrin, TCP= Tricalcium phosphate, MT= Maltodextrin+Tricalcium phosphate.

All of control and treated samples showed no significant difference (P<0.05) in emulsion stability (Table 1). Emulsion in food is thermodynamically unstable system and rapidly separate into separate layers of oil and water (Ghosh and Roussseau, 2011) because of natural difference between the oil and aqueous phases density, and also the unfavorable contact between oil and water molecules (Maphosa et al.., 2017). The extent of emulsion stability is determined by various factors such as particle size, particle size distribution, density between the dispersed and continuous phases as well as the chemical integrity of the dispersed phase (Maphosa and Jideani, 2018). This showed that anticaking addition (maltodextrin and TCP) did not affect those aspects.

A sort of food components showing capability as food emulsion stabilisers. When biopolymers such as proteins and polysaccharides or their complexes are applied as emulsion stabilisers, they exhibit different modes of action. Emulsion helps to confer foods with distinct functional attributes, such as desirable appearances, textures, mouthfeels, and flavor profiles. Emulsions also widely used as vehicle for the encapsulation and delivery of bioactive agents, such as vitamins and nutraceuticals. Some stabilizers generally applied to stabilize emulsion state by preventing break down which occurs due to creaming aggregation and coalescence.

Regarding the foaming capacity, all salted duck egg powder samples showed no significant difference (P<0.05) after addition of anticaking agent (maltodextrin and TCP). The values ranged from 10.67 – 14.67% (Table 1). Foaming capacity is corresponds to the ability of an ingredient to form and stabilise a foam, while the foam stability is the power foam, once formed, to persist. Both of them are important for various products such as ice cream, mousses, and marshmallow, with respect to shelf-life and appearance of the product. It must be maintained when subjected to process variations such as heating, mixing and cutting (Foegeding et al., 2006). In general, proteins that exhibit low foaming capacity show good stability and vice versa. At pH different from the isoelectric point of the protein, the foam ability is usually satisfactory, but the foam stability is low (Fennema et al., 2010).

The fat content within duck egg probably have a significant role for foaming behavior. Lipids are known to enhance the emulsification process in food but diminish the foaming potentials (Marques, 2000). The foaming properties are particularly important in the stability of ice cream and in bread production (Wilcox, 2006). Beside fat component, Panyam and Kilara (1996), reported about molecular properties of proteins that are relevant for foaming include solubility to enable rapid diffusion at the interface, to enhance interfacial interactions, segmental flexibility to facilitate unfolding at the interface and molecular rearrangement to prevent close approach of bubbles. Drying probably increase foaming ability of protein concentrates by increasing protein solubility.

For the water holding capacity (WHC) aspect, there was no significant difference (P<0.05) in all four samples. We can assume that addition of two types of anticaking agent had no effect to the WHC in salted duck egg samples. The values were 2.15 – 2.36% (Table 2). Water holding capacity is related to the protein content within food system. Some factors such as pH, ionic strength, and temperature affect the WHC of proteins. Water holding capacity (WHC) is the ability of food to hold its own or added water during the application of force, pressure, centrifugation, or heating (Gyawali and Ibrahim, 2016). Heating reduces WHC since denaturation of protein happens so it reduces the availability of polar amino groups for hydrogen bonding with water molecules. The values above were lower, if compared to the WHC in white egg powder (3.03%), but higher than the whole chicken egg powder (0.3%) investigated by Vargas-del-Río et al. (2022).

The oil holding capacity (OHC) of sample with addition of maltodextrin and tricalcium phosphate combination was significantly different from the sample with only had maltodextrion addition. Maltodextrin incorporation resulted the highest oil holding capacity of salted duck egg powder (Table 2). Maltodextrins provide good oxidative stability to oil encapsulation but exhibit poor emulsifying capacity, emulsion stability, and low oil retention (Gharsallaoui et al., 2007). The oil holding capacity is generally attributed to the physical entrapment of fat by the protein. Furthermore, oil holding capacity is also affected by hydrophobic amino acid properties to bind the oil component (Tharise et al., 2014).

Conclusion

Addition of maltodextrin and tricalcium phosphate (TCP) lowering the moisture content in salted duck egg powders. TCP is effective for increasing the emulsion activity, but could not maintain the emulsion stability. There were no significant differences ($p < 0.05$) on the parameter of foaming capacity and foaming stability in all duck egg powders. Anticaking agents maltodextrin and TCP did not affect the water holding capacity of four samples. However, maltodextrin slightly increases the oil holding capacity. Salted duck egg powder is usable for substitute in protein-rich baked goods due to the functional properties of emulsification, foaming, water and oil binding, with specific taste and aroma and also longer shelf life compared to fresh eggs.

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