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Quality of IPB-D1 Chicken Egg Yolk Powder Using Various Drying Methods

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ABSTRACT

IPB D-1 chickens had good egg productivity. Chicken eggs are often used as functional ingredients in the form of powder because they have many advantages for the food industry. This research aims to produce egg yolk powder with good physicochemical, microbiological, and fatty acid qualities derived from IPB-D1 chicken eggs using various drying methods namely spray drying, oven drying, and vacuum drying. This study also aims to examine the functional properties of IPB-D1 chicken egg yolk powder by application to mayonnaise. It is compared with mayonnaise made from fresh egg yolks and commercial egg yolk powder. The experimental design used in this research was a randomized block design (RBD) based on the manufacturing period. The result showed that different drying methods for egg yolk powder can affect the emulsion activity, total plate count (TPC), a_w, pH, water, ash, and fat content. The drying method did not affect the protein content and emulsion stability. Egg yolk powder with oven drying gave the best results for quality.

Key words: Drying method; egg yolk powder; IPB-D1 chicken egg

INTRODUCTION

Chicken eggs are a significant animal protein source that has found extensive application in the food industry due to their exceptional nutritional, functional, and sensory attributes (Rannou *et al*. 2015). There are various types of chickens which of course produce eggs of different quality (Ramadhani *et al.* 2018). IPB-D1 chicken is one of the local chicken varieties that has been approved as a new superior local chicken family by the Indonesian Ministry of Agriculture based on Decree No.693/KPTS/PK.230/M/9/2019.

Habiburahman *et al*. (2020) stated that IPB D-1 chickens had good egg productivity. Chicken eggs are often used as a functional ingredient in the form of powder because it has many advantages including reduced transportation and storage (Costa *et al*. 2015). In addition, egg yolk powder also has almost all the same main compound components as egg yolk (Gu *et al.*2021). One of the egg yolk powder production methods is drying technology, and there are various types of methods, such as spray drying, oven drying, and vacuum drying.

However, heat treatment during drying can change the components and functional properties of the eggs so that the quality of the resulting egg yolk powder is not good (Alaboudi *et al.* 2013). Thus, several alternative drying methods with low temperatures are expected to minimize this matter. The development of egg yolk drying methods can provide a more efficient and economical way of producing good egg yolk powder and applying good processed products as well. Currently, egg yolk powder (EYP) is mainly used by the food industry to produce various products such as pasta (Pérez-Reyes 2021), pastries (Miranda *et al.* 2015), bakery (Tsivirko 2021) and salad dressings such as mayonnaise. This study aims to produce egg yolk powder which has good physicochemical, microbiological and fatty acid qualities derived from IPB-D1 chicken eggs using various drying methods, namely: spray drying, vacuum drying and oven drying.

The information generated from this research can contribute to scientific knowledge about egg drying and its application in the food industry. The findings and data obtained can be a reference and reference for researchers and practitioners in the future who are interested in this field. Apart from that, this research also database knowledge about the new IPB-D1 chicken race. Information regarding the drying of egg yolks from IPB-D1 chickens will be an important part of knowledge about the characteristics and product potential of this chicken variety. This can provide a more in-depth understanding of the quality of IPB-D1 chicken eggs and how this potential can be utilized further in the food industry.

MATERIALS AND METHODS

This research was conducted from January to March 2023 at the Livestock Products Laboratory and IPTP Integrated Laboratory, Faculty of Animal Husbandry, IPB University to produce EYP by the oven drying method. Meanwhile, EYP by the spray drying and vacuum drying methods was produced at the Laboratory of Pilot Plants, Faculty of Agricultural Technology, IPB University. The materials utilized in this study consisted of IPB-D1 chicken eggs and chemicals designated for analysis.

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Egg Yolk Powder-Making Procedure

The IPB-D1 chicken egg yolks one to five days old from the selected and cleaned were cracked and separated from the egg whites using an egg separator. Before being dried, homogenization then pasteurization was conducted through a water bath at a temperature of 60 ºC for 5 minutes (Bai *et al*. 2020). The drying process employed three methods: spray drying (M1), oven drying (M2), and vacuum drying (M3). Spray drying involved an inlet temperature of 130 ºC and an outlet temperature of 73 ºC, an airflow rate of 30 L/min under pressure, and an atomizer nozzle with a diameter of 0.7 mm. (Abreu *et al*. 2014). Vacuum drying was performed at 50 ºC under a vacuum pressure of 0.01 MPa (Bai *et al.* 2020), and oven drying lasted for 24 hours at 60 ºC (Imawan *et al*. 2023).

Analysis Procedure

The observed responses of IPB-D1 chicken EYP which was dried with three different dryers were physicochemical properties (water content, ash content, a_w, pH, protein content, and fat content), functional properties (activity and emulsion stability), microbiology (total plate count and *Salmonella* sp.) and fatty acids. Tests for water content, ash content, pH, protein content, and fat content were carried out using the method determined by AOAC (2005), and water activity was obtained using an a_w meter. Emulsion activity (Wang and Kinsella 1976) was tested by centrifuging the emulsion at 3000 rpm for 5 minutes, then the emulsion activity was calculated based on the percentage of emulsion mixture height ratio. Emulsion stability (le Denmat *et al.* 2000) was tested by left to age the emulsion for 24 h at an ambient temperature of 22 °C, it was then centrifuged with a slight modification at 3000 rpm for 30 minutes. The volume of the upper emulsion and the underlying aqueous phase was measured and calculated the emulsion stability index.

Microbiological analysis of total plate count and *Salmonella* sp. is based on the method by Pelzar and Chan (2007) and Waluyo (2008). A sample of 20 g was reconstituted and then a 10^{-1} dilution was made using buffer peptone water (BPW) and homogenized with a vortex. Furthermore, fertilization was carried out in accordance with the microbiological analysis carried out. 1 mL of suspension was poured into a petri dish, then mixed with 20 mL of plate count agar (PCA) for the TPC test and xylose lysine desoxycholate agar (XLDA) for the Salmonella sp. After that, the petri dish was incubated in an inverted position, at 37 ºC for 24 hours for Salmonella sp. bacteria and 48 hours for the TPC test.

Fatty acids testing refers to the method by Ariyanti *et al.* (2021), the sample was added 0.5 N NaOH, then heated in a water bath at 800 °C for 20 minutes and cooled to room temperature. After that, BF3 was added and the solution was reheated in a water bath at the same temperature and duration. It was cooled, saturated NaCl and n-HEXAN was added, shaken, and then settled. The upper phase (n-HEXAN layer) was taken and the solution was ready to be injected into the GC device.

Experimental Design and Data Analysis

This study utilized a randomized block design (RBD) based on the manufacturing period, and there were three groups during the manufacturing period. Preparation of EYP was carried out for 3 repetitions. Physicochemical, functional, and microbiological properties data were analyzed using analysis of variance (ANOVA) to determine the effect of treatment on the observed variables. If the treatment has a significant or very significant effect, then it is continued with multiple division tests using the Tukey test (Steel and Torrie 1997). The fatty acid data were analyzed using descriptive analysis.

Best Method Determination

The analysis results obtained will be used to determine the best drying method. The determination of IPB-D1 chicken EYP with different drying methods will be carried out by scoring the variables analyzed (Pamungkas 2007). Scoring of physicochemical properties (such as water content, fat content, protein content, pH, and a_w), functional properties (such as emulsion stability), microbiological properties (such as total plate count and bacteria *Salmonella* sp.), and fatty acid levels based on existing standards. If the results obtained are within the standard range and are not significantly different between methods, then they are given the same score, 1. If the results obtained are not within the standard range and are significantly different between methods, then the score is based on the ranking of the best results.

RESULTS AND DISCUSSION

IPB-D1 Chicken Egg Yolk Powder Physicochemical Quality

The results of testing the physicochemical, functional, microbiological, and fatty acid quality of IPB-D1 chicken EYP using the drying methods spray drying, oven drying, and vacuum drying are presented in Table 1. The results of the physicochemical analysis showed that the drying method had a significant effect (P < 0,05) on the water content, ash, a_w, pH, and fat content of IPB-D1 chicken EYP.

Significant differences in those variables between methods can be caused by temperature and drying time.

Table 1. Quality of IPB-D1 chicken egg yolk powder with various drying methods and recapitulation of scoring values

Variables	Drying Method Treatment						Standard
	Spray Drying		Oven Drying		Vacuum Drying		
Physicochemical properties							
Water content (%)	3,38±0,12^b	(3)	2,52±0,19^c	(3)	4,44±0,24^a	(1)	2,55-4,52*
Ash content (%)	4,57±0,43^{ab}	(1)	5,25±0,30^a	(2)	4,26±0,49^b	(1)	4,36-6,42*
a_w	0,49±0,01^b	(2)	0,41±0,01^c	(3)	0,56±0,03^a	(1)	-
pH	6,11±0,01^b	(1)	6,03±0,01^b	(2)	6,25±0,05^a	(1)	≥6**
Fat content (%)	36,98±1,00^b	(2)	50,79±1,07^a	(2)	51,46±1,82^a	(2)	53,3-57,2*
Protein content (%)	30,96±0,58	(1)	32,29±0,91	(1)	32,12±2,13	(1)	33,1-36,1*
Functional properties							
Emulsion Activity	62,80±1,96^a	(2)	54,98±2,78^b	(1)	52,24±1,18^b	(1)	-
Emulsion Stability	75,97±4,51	(1)	67,64±8,13	(1)	66,10±5,76	(1)	-
Microbiological properties							
Total plate count (Log CFU g^{-1})	5,25±0,02^a	(1)	3,41±0,04^b	(2)	3,50±0,06^b	(2)	< 3,39 ***
Salmonella sp.	Negative	(1)	Negative	(1)	Negative	(1)	Negative***
Total Scoring		15		**18***		12	

Remarks : (...) The numbers in parentheses indicate the score in order of scoring;
*The best drying method of IPB-D1 chicken egg yolk powder
Different superscripts in the same column/row show a significant (p<0.05) difference

Results of water content and a_w according to the statement by Samantha *et al.* (2015) and Utama *et al.* (2022), the increase in drying temperature causes a decrease in the water content and water activity of the product obtained, and the water content of a product is affected by the heating time. The water content of EYP using spray drying, oven drying, and vacuum drying methods is in the range of 2.52-4.44%. Based on the USDA National Nutrient Database for Standard Reference (2017), the water content of M1 and M3 aligns with the standard range of 2.55%-4.52%. However, the M2 results in lower water content than the standard. It is worth noting that water content is linked to the shelf life of a product, as a lower water content can prevent quality deterioration or damage (Syafrida *et al.* 2018).

The highest ash content is owned by egg yolk powder with oven drying method. This can be caused by the drying time. Yulita and Rahmawati (2015) stated that the longer the drying process, the ash content will increase along with the decrease in water content. The lower the water content of egg yolk powder, the higher the percentage of minerals, so the ash content also increases. Referring to the USDA National Nutrient Database for Standard Reference (2017), the ash content of M1 and M2 egg yolk powder adhered to the standard range of 4.36-6.42%. However, the ash content of egg yolk powder obtained through vacuum drying exhibited a lower value compared to the standard, specifically 4.26%. The pH is significantly different because the heat treatment method of spray drying can affect the pH properties of egg yolk (Strixner *et al.* 2013). pH value of egg yolk powder by drying method spray drying, oven drying, and vacuum drying is in the range of 6.03-6.25 and complies with the United Nations Economic Commission for Europe egg yolk powder standard, namely a minimum pH of 6.

EYP produced through the spray drying method (M1) exhibited the lowest fat content, and this treatment showed a significant difference (P < 0,05) compared to M2 and M3 treatments. The real difference between the fat content of EYP by spray drying and the other treatment is shown in Figure 1.

Remarks: (M1) IPB-D1 chicken egg yolk powder using spray drying, (M2) IPB-D1 chicken egg yolk powder using oven drying, (c) IPB-D1 chicken egg yolk powder using vacuum drying.

Figure 1. IPB-D1 chicken egg yolk powder using spray drying (M1), oven drying (M2), and vacuum drying (M3) methods

The temperature utilized during spray drying is responsible for this outcome. Javed *et al.* (2018) stated that the higher temperature conditions in the method of spray drying caused the loss of some fat compounds. This was also explained by Zardetto *et al.* (2014) in their research, that the levels of fat and cholesterol in egg yolks decreased as a result of the heating process. The fat content of EYP M1, M2 and M3 drying methods is in the range of 36.98-51.46%. In addition, the crude fat content of egg yolk flour from the four treatments was lower when compared to the USDA minimum standard (2017), namely 53.3%. The lower overall crude fat content of the treatment could be due to the drying process in making EYP which reduces the fat content.

The results of the analysis of various crude protein levels showed that the drying method had no significant effect (P > 0,05) on the protein content of IPB-D1 chicken EYP. The protein content of EYP M1, M2 and M3 drying methods is in the range of 30.96-32.29. The protein content of the

EYP produced does not reach the UNECE minimum standard (2010), which is 33%. Lower content than standard can be caused by protein aggregation due to heat treatment. Anton (2013) stated that egg yolk protein aggregation causes a protein to be more difficult to extract by analytical methods.

IPB-D1 Chicken Egg Yolk Powder Emultion Quality

The three treatments of the drying method had a significant effect (P < 0,05) on the emulsion activity but did not significantly affect the stability of the IPB-D1 chicken EYP emulsion. The particle size of EYP by drying method spray drying is smaller than by oven drying and vacuum drying. Referring to Ariantie *et al.* (2021) state that egg yolk powder, which has a smaller particle size, can easily cover the oil-water interface to form an emulsion. The difference in emulsion stability which was not significant between drying methods could be affected by the protein content of EYP which was also not significant. Referring to Li *et al*. (2020) research stated that the stability of the emulsion increased significantly with an increase in protein concentration.

IPB-D1 Chicken Egg Yolk Powder Microbiological Quality

The results of the total plate count analysis showed that the drying method had a significant effect (P < 0,05) on the total number of bacteria found in IPB-D1 chicken EYP. EYP by spray drying method has the highest TPC value even though in the drying process, this method uses the highest temperature compared to the treatment oven drying and vacuum drying. Referring to the research of Rodklongtan and Chitprasert (2017), this can occur due to a reduction in microbial viability of 4,2 log CFU/g which can occur when the temperature is applied *inlet* which is as high as 150 °C. The inlet temperature used in this research is referring to Abreau *et al.* (2014), 130 ºC and *outlet* 73 ºC. Bacteria *Salmonella* sp. was not detected in all treatments of IPB-D1 chicken EYP with drying methods spray drying, oven drying and vacuum drying.

These results are in accordance with SNI 01-6366-2000 which sets the maximum limit for microbial contamination *Salmonella* sp. in egg powder is negative CFU/g or no bacteria *Salmonella.* Bacterial contamination *Salmonella* sp. on eggs must be negative because *Salmonella* can infect the host egg and its derivative products. Bacterial growth of *Salmonella* on chicken eggs causes *Salmonella* can express *pef-fimbriae* of *St. Typhimurium* proved to be more dangerous than *Salmonella* from hosts other than eggs (Moreau *et al*. 2016).

IPB-D1 Chicken Egg Yolk Powder Fatty Acid Content

The results of the fatty acid analysis in Table 2 show that IPB-D1 chicken EYP contains higher unsaturated fatty acids than saturated fatty acids. The most abundant fatty acids in IPB-D1 chicken EYP were oleic acid, palmitic acid, and linoleic acid. This is in accordance with Xiao's statement *et al.* (2020), namely that the main fatty acids in egg yolk are oleic acid (40%), palmitic acid (30%), and linoleic acid (13%). The oleic acid content in IPB-D1 chicken EYP is in the range of 21,4-22,8%. Oleic acid (omega-9) and linoleic acid (omega-6) are unsaturated fatty acids that are superior in their benefits for the body, one of which is their role in preventing atherosclerosis (Mora and Selpas 2013). Oleic acid is the most common monounsaturated fatty acid (MUFA) and is a precursor to produce compound unsaturated fatty acids (PUFA).

Table 2. Fatty acid composition of IPB-D1 chicken egg yolk powder with various drying methods

Variables	Drying Method Treatment		
	Spray Drying	Oven Drying	Vacuum Drying
Saturated fat (%)	23,5	21,9	20,8
Lauric acid (C12:0) (%)	0,02	0,02	0,03
Myristic acid (C14:0) (%)	0,17	0,22	0,23
Palmitic acid (C16:0) (%)	13,3	13,3	12,6
Stearic acid (C18:0) (%)	5,19	4,79	4,5
Unsaturated fat (%)	33	33,8	31,4
Oleic acid (C18:1n9c) (%)	21,4	22,8	21,4
Linoleic acid (C18:2n6cc) (%)	7,76	7,77	6,99
Linolenic acid (C18:3) (%)	0,1	0,1	0,08

The palmitic acid content in IPB-D1 chicken EYP is 13,3%, 13,3%, and 12,6%. This percentage is lower when compared to the palmitic fatty acid content in chicken egg yolks obtained by Polat *et al.* (2013), namely 21,11%. The fatty acid content can decrease due to heat treatment during drying. Drying methods and conditions can affect the fatty acid composition of EYP such as temperature, time, and pressure. Javed *et al*. (2018) stated that inlet temperature, outlet temperature, and atomization speed in drying using a spray dryer are the main factors that influence the fatty acid content in EYP products.

Determination of the Best Formula for Making IPB-D1 Chicken Egg Yolk Powder with Various Drying Methods

The scoring was carried out on the observed variables including physicochemical properties, functional properties, and microbiology. The recapitulation of the results of the analysis and scoring of egg yolk powder with various drying methods can be seen in Table 1. Based on Table 1 it can be concluded that the best treatment in the process of making EYP is the treatment with the drying method *oven drying* which results in a higher total scoring value (18) than other drying methods.

CONCLUSION

The drying method using spray drying, oven drying and vacuum drying affected the water content, ash content, a_w, pH, fat content, emulsion activity, and total plate count (TPC) from IPB-D1 chicken egg yolk powder but did not affect the protein content and emulsion stability. The oven drying method produces the best quality egg yolk powder based on physicochemical, functional and microbiological properties.

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