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Physicochemical Properties of Egg Yolk Powder from Eggs of Different Types of Bird

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***Abstract* — The goal of this study was to determine whether the physicochemical properties of egg yolk powders produced from eggs from different types of bird (Fighting chicken, Kampung chicken, Serama chicken, Leghorn chicken, Guineafowl, and Turkey) differ from each other and from those of commercial egg yolk powder. The powders were analysed to determine yield; proximate composition; colour, solubility; water holding capacity (WHC); and emulsion activity and stability. Egg yolk powders were prepared by separating the egg yolk manually followed by blast freezing and freeze drying. The weight of the egg ranged from 22.16 g for Serama to 66.25 g for Turkey. The lowest yield of egg yolk liquid was found in Leghorn egg (27.63) and highest in Serama egg (44.31). Egg yolk powder yield was also lowest for Leghorn eggs (12.85%) , followed by Turkey (15.85%), Guineafowl (16.22%), Kampung (16.48%), Fighting (16.62%), and the highest for Serama (18.92%). All parameters studied except WHC differed significantly ($p < 0.05$) among at least some of the different egg yolk powders. Egg yolk powder from Serama chicken had the highest protein content (40.77%), lowest fat content (51.96%), highest solubility (20.20 ^{o}Brix), and lowest WHC (79.78 %). Egg yolk powder from Fighting chicken had the highest emulsion activity (54.13%) and that from Leghorn chicken had the highest emulsion stability (48.41%). Egg yolk powder from Guineafowl had the highest yellowness intensity (72.21), whereas the value was lowest (35.84) for commercial egg yolk powder. In conclusion, physicochemical properties of egg yolk powder depend on the source of the eggs.**

***Keywords* — egg yolk powder; local chicken breeds; layer chicken; physicochemical properties; proximate composition.**

I. Introduction

In the last three decades, chicken egg production increased 152% worldwide and that in Asia increased 388%, which shows that eggs are a common food source consumed by many [1] [,2]. Eggs are a main ingredient in many food products because of their high nutritional value, good functional properties, and unique sensory qualities [3]. The emulsifying properties of liquid egg yolk are of particular interest to food scientists. Egg yolks are used to make mayonnaise and salad dressing and are an important ingredient in other foods such as bakery products, custards, and pasta [4].

Dried egg powder (egg white and egg yolk) is widely used in food preparation because it is microbiologically safe and easy to transport compared to unshelled or liquid eggs. Dried egg powder also is also comparably easier to store, handle, measure, and obtain uniformity [5]. In addition, processing fresh eggs into powder form can extend the shelf life of the product to up to a year when refrigerated. Dried egg yolk offers uniformity relative to that of fresh eggs, as the composition of egg yolk may change over time because the porous shell allows exchange of carbon dioxide and moisture. Egg yolk powder can be reconstituted easily by mixing the powder with water, and the reconstituted product has the same nutritional value and functional properties as fresh egg yolks.

Commercial egg yolk powder normally is produced using the spray drying method. However, the high temperature required for spray drying may lead to protein denaturation, which negatively impacts the functional and physicochemical properties of the product [6]. Therefore, in this study the freeze drying method was used, as it is believed to have a minimal effect on egg yolk properties [7]. Lili et al. [8] reported that freeze dried egg white powder had higher emulsifying capacity and stability compared to spray dried egg white powder.

Common chicken breeds used to produce eggs include hybrids such as Golden Comet, Lohmann, Delkab, and Hisex. Pure breeds such as Rhode Island Red, Leghorn, Sussex, and Plymouth Rock are also known to be good egg laying chickens. Although eggs from different types of bird are sold for different prices because the public believes that the nutritional value varies among breeds, to date no reliable evidence supports the premise that eggs from different types of bird have different physicochemical characteristics. To address this issue, the objective of this study was to compare the physicochemical properties of egg yolk powders made from eggs from different types of bird (Local Fighting, Local Kampung, Local Serama, Leghorn, Guineafowl, and Turkey) as well as commercial egg yolk powder found in the market.

II. Materials and Methods

A. Materials

Eggs laid by different types of bird (Fighting, Kampung, Serama, Leghorn, Guineafowl, and Turkey) were purchased from local farmers in the eastern part of Malaysia. Eggs were processed using the freeze drying method to produce egg yolk powder. Commercial egg yolk powder, which was used as the control, was purchased from SIM Company (Penang, Malaysia).

B. Egg Yolk Powder Preparation

Whole eggs were washed, and eggs were weighed to obtain an average weight per egg. For each egg, the yolk was separated from the white manually. Each egg yolk then was weighed. The liquid egg yolk of each sample was homogenized by stirring prior to further processing. Liquid egg yolk was poured into a plastic container (thickness of sample not more than 1.0 ± 0.5 cm) and blast frozen for 3 h at –40 ^{o}C. A LyoAlfa laboratory freeze dryer (Terrassa, Spain) then was used to freeze dry the samples for 2–3 d at –40 ^{o}C. The resulting freeze dried products were homogenized using a blender until a powder form was obtained, and the powdered sample was weighed. The egg yolk powder was packed into a labelled sealed plastic container and stored in the refrigerator at 4 ^{o}C [9].

C. Yield

The percentage yield of the product from the raw material during egg yolk powder processing was determined using the weight of the fresh egg, egg yolk liquid, and egg yolk powder:

D. Proximate Analysis

Proximate analysis to determine moisture, protein, fat, ash, and carbohydrate content of the egg yolk powder was conducted following Association. of Official Analytical Chemists (AOAC) guidelines [10].

E. Colour

Colour intensity of the egg yolk powder was determined using a Konica Minolta CM-350d spectrophotometer (Osaka, Japan). Before analysis, the apparatus was calibrated using a zero calibration box and a white calibration plate. To take measurements, a sample of egg yolk powder was placed in a CM-A128 Petri dish, which was lightly shaken in the horizontal plane to shuffle the contents for a more accurate result. Each measurement was repeated three times. The colour characteristics analyzed were L* (lightness), a* (redness), and b* (yellowness) [3].

F. Solubility

Solubility of the egg yolk powder was determined by dissolving 1 g of egg yolk powder in 5 mL of 5% (w/w) sodium chloride solution [11]. After 20 min, the Brix value of the solution was read using a refract meter. The ^{b}rix value was calculated as follows:

$$Briix = Brix_{Degg} - BrixNaCl \tag{1}$$

where $Brix_{Degg}$ corresponds to the refractive index of the egg powder in 5% (w/w) NaCl solution and $Brix_{NaCl}$ corresponds to the refraction index of 5% NaCl solution.

G. Water Holding Capacity (WHC)

WHC was determined using 0.25 g of egg yolk powder dissolved in 10 mL of distilled water. The mixture was shaken for 30 s, and the dispersion was stored at 4 °C overnight. The next day the solution was centrifuged using a Kubota Tabletop Centrifuge Model 4000 (Osaka, Japan) at

Tabletop Centrifuge Model 400 (Osaka, Japan) at 2800 x g for 30 min [12]. The supernatant was filtered using filter paper. WHC was calculated as follows:

$$\mathrm{WHC}(\%) = \frac{\text{supernatant volume(ml)}}{\text{Intial volume(ml)}} \mathrm{x}100 \tag{2}$$

H. Emulsion Activity and Stability

Emulsifying activity (EA) and stability (ES) were determined using the method described by Wang and Kinsella [13]. About 0.7 g of egg yolk powder was added to 10 mL of water, and the mixture was vortexed for 1 min. Next, 10 mL of peanut oil were added prior to vortexing for another minute. The emulsion was centrifuged using a Kubota (Tokyo, Japan) Tabletop Centrifuge Model 4000 at 3200 x g for 5 min. EA was calculated using the following formula:

$$\mathrm{EA}(\%) = \frac{\text{Height of emulsified layaer}}{\text{Height of total content on the tube}} \mathrm{x}100 \tag{3}$$

ES was determined similarly, except that the emulsion in the centrifuge tube was initially heated in a water bath at 80 ^{o}C for 30 min and subsequently cooled to 15 ^{o}C before centrifugation. ES was calculated as follows:

$$\mathrm{ES}(\%) = \frac{\text{Height of emulsified layaer}}{\text{Height of total content on the tube}} \mathrm{x}100 \tag{4}$$

I. Statistical Analysis

The results were subjected to one-way analysis of variance using IBM SPSS Statistics 20. Duncan's multiple range test was employed to determine the significant level at $p < 0.05$.

III. Results and Discussion

A. Yield

Table 1 shows the yield during the steps of the breakdown process from fresh whole egg to egg yolk liquid to egg yolk powder. Eggs from different types of bird differ in size and therefore yield different proportions of egg shell, egg white, and egg yolk.

TABLE I
WEIGHT AND YIELD OF WHOLE EGG, EGG YOLK LIQUID, AND EGG YOLK POWDER FROM DIFFERENT TYPES OF BIRD

Sample		**Whole egg**	**Egg Yolk Liquid**	**Egg Yolk Powder**
Fighting	Weight (g)	45.26	15.32	7.52
	Yield (%)	100.00	33.85	16.62
Kampung	Weight (g)	41.08	14.11	6.77
	Yield (%)	100.00	34.35	16.48
Serama	Weight (g)	22.16	9.82	4.20
	Yield (%)	100.00	44.31	18.95
Leghorn	Weight (g)	60.99	16.85	7.84
	Yield (%)	100.00	27.63	12.85
Turkey	Weight (g)	66.25	21.70	10.50
	Yield (%)	100.00	32.75	15.85
Guineafowl	Weight (g)	40.82	13.85	6.62
	Yield (%)	100.00	33.93	16.22

According to the Malaysian Department of Veterinary Services [14], an average egg from a layer chicken weighs 65 g. The Domestic Animal Diversity Information System [15] reported the average weight of a Kampung chicken egg to be 42 g. For five of the birds tested in this study, the average egg weight ranged from 40.82 g for Guineafowl to 66.25 g for Turkey. Eggs from Serama chickens were much lighter (22.16 g), as this is a small sized bantam chicken. The Serama Special Club [16] reported that egg weights generally range from 15 to 35 g for this type of chicken.

Egg yolk liquid yield was similar for Fighting and Kampung chickens, Guineafowl, and Turkey, whereas values for Leghorn and Serama eggs were lowest (27.63%) and highest (44.31%), respectively (Table 1). Sujata [17] reported that egg yolk liquid normally constitutes ~32% of the whole egg. The data show that larger eggs have a smaller proportion of yolk and smaller eggs have a larger proportion of yolk. As egg size increases, the relative amount of yolk decreases but the total absolute amount increases. Furthermore, about 88% of differences in proportions of parts of the egg are influenced by egg size rather than hen age [18].

Egg yolk powder yield was also lowest for Leghorn eggs, followed by Turkey, Guineafowl, Kampung, Fighting, and Serama (Table 1). Thus, egg yolk powder yield generally agreed with the amount of egg yolk liquid obtained. Most industries produce egg yolk powder from supplied egg yolk liquid and thus cannot calculate yield from the original whole egg. Aditya [19] previously reported that the yield of egg yolk powder from egg yolk liquid was 43.48%. In the current study, the egg yolk powder yield from egg yolk liquid was 46.51% for Leghorn eggs and 42.77% for Serama eggs. Thus, the yield of egg yolk powder from egg yolk liquid was comparable with the previous report (19).

B. Proximate Analysis

Table 2 shows the moisture, protein, fat, ash, and carbohydrate content of freeze-dried egg yolk powder made from eggs from different bird breeds as well as values for commercial egg yolk powder.

TABLE II
RESULTS OF PROXIMATE ANALYSIS OF DIFFERENT EGG YOLK POWDERS

Sample	**Moisture (%)**	**Protein (%)**	**Fat (%)**	**Ash (%)**	**Carbohydrate (%)**
Fighting	$2.67^{e} \pm 0.05$	$39.60^{e} \pm 0.01$	$51.77^{a} \pm 0.63$	$0.032^{ab} \pm 0.002$	$5.92^{cd} \pm 0.61$
Kampung	$2.43^{d} \pm 0.04$	$40.05^{f} \pm 0.19$	$52.19^{ab} \pm 0.71$	$0.032^{ab} \pm 0.001$	$5.31^{bc} \pm 0.91$
Serama	$1.90^{c} \pm 0.09$	$40.77^{g} \pm 0.08$	$51.96^{a} \pm 0.50$	$0.034^{b} \pm 0.001$	$5.33^{bc} \pm 0.62$
Leghorn	$2.91^{f} \pm 0.01$	$39.17^{d} \pm 0.07$	$53.31^{bc} \pm 0.61$	$0.033^{ab} \pm 0.002$	$4.58^{b} \pm 0.56$
Turkey	$1.28^{a} \pm 0.09$	$37.31^{a} \pm 0.07$	$54.36^{cd} \pm 0.43$	$0.031^{a} \pm 0.001$	$7.02^{d} \pm 0.39$
Guineafowl	$1.54^{b} \pm 0.14$	$37.65^{b} \pm 0.11$	$54.89^{d} \pm 0.69$	$0.034^{b} \pm 0.001$	$5.90^{cd} \pm 0.79$
Commercial	$2.97^{f} \pm 0.06$	$38.80^{c} \pm 0.09$	$57.39^{e} \pm 0.88$	$0.033^{b} \pm 0.001$	$0.86^{a} \pm 0.89$

Data are expressed as mean ± standard deviation (n = 3). Different letters in the same column indicate significant differences ($p < 0.05$).

The moisture content of egg yolk powders from different types of bird and commercial powder differed significantly from each other ($p < 0.05$), except commercial powder and Leghorn powder ($p > 0.05$), which had the highest values. Egg yolk powder from Turkey eggs had the lowest percentage of moisture (1.28%). In all cases, the freeze-dried egg yolk powders contained less moisture than commercial egg yolk powder. Commercial egg yolk powder generally is produced using the spray drying method, which is a fully automated continuous process that is fast, safe (free from bacteria), and cost-effective [19]. In contrast, freeze drying requires processing in batches, which is more costly. Obara et al. [9] reported that freeze-dried egg yolk powder contained 1.67% moisture, whereas spray dried egg yolk powder contained 2.78% moisture. This trend of high moisture content in spray-dried powder, and low moisture content in freeze-dried powder agrees with the results of the current study. According to the Malaysia Food Act & Regulation [20], dried egg yolk should not contain more than 5% moisture, and all egg yolk powders in this study met this criterion.

The protein content of all of the egg yolk powders tested differed significantly from each other ($p < 0.05$) (Table 2). Protein content was lowest for Turkey egg yolk powder (37.80%) and highest for Serama egg yolk powder (41.56%). Smith [21] reported that Turkey eggs have higher cholesterol and fat compared to chicken eggs, which results in lower protein content. The protein content of commercial egg yolk powder was in the middle of the range of the other powders. The protein content values in this study all exceeded the values reported by Obara et al. [9], which were 32.50% for freeze-dried egg yolk powder and 33.66% for spray-dried egg yolk powder. All egg yolk powders in this study surpassed the standard for pasteurized spray dried hen egg yolk powder, (i.e., the minimum percentage of protein of 30.0% [17] or 33.0% [22]).

Significant differences in fat content also were found among some of the egg yolk powders from different types of bird and commercial egg yolk powder ($p < 0.05$) (Table 2). Among the different bird breeds, fat content was lowest for Serama egg yolk powder (52.97%) and highest for Guineafowl egg yolk powder (55.74%). The value was highest for commercial powder (57.39%), and it was significantly higher than the values for all other powders tested. Froning [23] stated that the fat content of dried egg yolk is about 52.9%, which was surpassed by three of the breeds tested in the current study. The lower fat content in egg yolk powder from Fighting chicken eggs might be due to the vigorous movement of the chicken itself due to high activity level as a natural fighting chicken. According to UNECE [22], dried egg yolk must have a minimum fat content of 55.0%, whereas the USDA National Nutrient Database for Standard Reference [24] states that the fat content of dried egg yolk should be 59.13%. In the current study, only commercial egg yolk powder met the UNECE requirement [22], with a fat content of 57.39%.

Carbohydrate content ranged from 4.58% in Leghorn egg yolk powder to 7.02% in Turkey egg yolk powder (Table 2). Commercial egg yolk powder had the lowest carbohydrate content (0.83%). Significant differences in carbohydrate content were detected between some of the different egg yolk powders from different bird breeds ($p < 0.05$). According to the USDA National Nutrient Database for Standard Reference [24], carbohydrate content in dried egg yolk should be around 0.66%. In this study, only commercial egg yolk powder had a value near the standard; values for all other egg yolk powders produced during the study were comparatively higher. Commercial egg yolk powder contains a low percentage of carbohydrate because the egg yolk liquid is pre-treated with a desugarisation process to reduce its sugar content to prevent the Maillard reaction, and when the sugar level decreases the carbohydrate level also decreases [25].

C. Colour

Figure 1 shows the variation in color among the freeze-dried egg yolk powders from different bird breeds and commercial egg yolk powder. The color values obtained for the different egg yolk powders are shown in Table 3.

Fig. 1: Colour of egg yolk powders from eggs of different types of bird and commercial egg yolk powder

TABLE III
COLOUR ANALYSIS RESULTS FOR EGG YOLK POWDERS FROM EGGS OF DIFFERENT TYPES OF BIRD AND COMMERCIAL EGG YOLK POWDER

Sample	**L***	**a***	**b***
Fighting	$76.66^{a} \pm 0.03$	$14.05^{f} \pm 0.04$	$72.21^{f} \pm 0.07$
Kampung	$79.92^{e} \pm 0.03$	$9.24^{e} \pm 0.04$	$57.90^{f} \pm 0.05$
Serama	$79.57^{d} \pm 0.01$	$8.29^{d} \pm 0.03$	$53.16^{e} \pm 0.00$
Leghorn	$79.38^{c} \pm 0.09$	$5.60^{a} \pm 0.06$	$50.67^{d} \pm 0.12$
Turkey	$80.70^{f} \pm 0.05$	$5.65^{a} \pm 0.02$	$47.95^{c} \pm 0.02$
Guineafowl	$83.12^{g} \pm 0.02$	$6.99^{b} \pm 0.03$	$45.81^{b} \pm 0.01$
Commercial	$77.10^{b} \pm 0.01$	$8.00^{c} \pm 0.02$	$35.84^{a} \pm 0.02$

Data are expressed as mean ± standard deviation (n = 3).
Different letters in the same column indicate significant differences ($p < 0.05$).

Egg yolk powder from Fighting chickens had the lowest L* value (76.66) and highest a* and b* values (14.05 and 72.21, respectively). It was darker and had a higher intensity of redness and yellowness compared to the egg yolk powders from the other bird breeds (Figure 1). These characteristics suggest that egg yolk powder from Fighting chickens contains a high amount of carotenoids such as lutein and zeaxanthin [3]. In contrast, commercial egg yolk powder had the lowest yellow intensity (35.84), the second lowest L* value (77.10), and a redness value in the middle of the range of the other powders. Rannou et al. [3] noted that processing at high temperature might reduce the lightness due to the Maillard reaction. This might explain the color pattern of the commercial egg yolk powder, which was produced using the spray drying method. Wenzel et al. [26] reported that the xanthophyll content in spray-dried egg yolk powder is lower than that of freeze-dried egg yolk powder. Thermal processing of carotenoid-rich food can reduce the carotenoid content (e.g., lutein and zeaxanthin) by as much as 50% because rapid drying leads to oxidation and degradation of carotene by free radicals.

The color of egg yolk powder does not affect nutritional value, as it is not an indication of protein, fat, or carbohydrate content. However, food color does influence our perception of food. Many people favor deep colored food and believe that it is more nutritious than lighter colored food [27].

D. Solubility and WHC

Solubility describes the rehydration of egg yolk powder into egg yolk liquid, and WHC is a measure of the ability of egg yolk powder to hold water. Table 4 shows the solubility and WHC of the different egg yolk powders tested.

TABLE IV
SOLUBILITY AND WHC OF EGG YOLK POWDERS FROM EGGS OF DIFFERENT BIRD BREEDS AND COMMERCIAL EGG YOLK POWDER

Sample	Solubility (°Brix)	Water Holding Capacity (%)
Fighting	$18.67^{c} \pm 0.15$	$81.76^{a} \pm 0.55$
Kampung	$18.33^{b} \pm 0.15$	$80.80^{a} \pm 0.59$
Serama	$20.20^{d} \pm 0.10$	$79.78^{a} \pm 2.54$
Leghorn	$18.50^{bc} \pm 0.10$	$80.00^{a} \pm 1.12$
Turkey	$18.30^{b} \pm 0.26$	$81.12^{a} \pm 1.13$
Guineafowl	$18.77^{c} \pm 0.25$	$81.25^{a} \pm 0.10$
Commercial	$9.07^{a} \pm 0.06$	$82.13^{a} \pm 0.95$

Data are expressed as mean ± standard deviation (n = 3). Different letters in the same column indicate significant differences ($p < 0.05$).

Solubility differed significantly among some of the egg yolk powders from different bird breeds and commercial egg yolk powder ($p < 0.05$) (Table 4). Egg yolk powder from Turkey and Serama eggs had the lowest and highest solubility, respectively (18.30 and 20.20 °Brix), among the different bird breeds. Wong and Kitts [11] reported that the interaction between protein and carbohydrates, lipids, and other food components affects the solubility of egg yolk powder. Also, a relationship between total solubility and protein solubility is likely: When total solubility is high, protein solubility is expected to be high as well. In this study, egg yolk powder from Serama chickens had the highest protein content and also the highest solubility. The solubility of egg yolk powder also is an indication of the efficiency of the powder's functional properties, and high protein content is considered to be a good quality of egg yolk powder [3].

The solubility of commercial egg yolk powder was very low (9.07 °Brix), likely because the high temperature used for spray drying reduced the powder's solubility via protein denaturation [3]. The formation of large insoluble particles can also cause the inability of egg yolk powder to solubilize. The low solubility of commercial powder is caused by the high concentration of free sulfhydryl groups created by the reduction of disulfide linkages that bind the sulfhydryl groups. The resulting unfolding of protein molecules increases the hydrophobicity of egg yolk powder and lowers its solubility in water. The secularisation step used when processing commercial egg yolk powder also affects solubility. The glucose oxidase-catalase enzyme system is applied to decrease the content of glucose in the powder [19,25]. This process is used to avoid the Maillard reaction, which will produce undesirable color and flavor.

WHC is important for processing and stability of products. Greater WHC of egg yolk powder is due to the partial denaturation and unfolding of the protein. Commercial egg yolk powder had the highest WHC (82.13%) among the powders tested (Table 4), likely because the high spray drying temperature used to produce commercial powder causes increased surface hydrophobicity [28]. Nevertheless, the WHC did not differ significantly among all of the powders tested (range 79.78–82.13%). Wong and Kitts [11] reported a much higher WHC (96.0%) for dried egg yolk, which could be due to a different method of egg yolk powder preparation. They also noted the inverse relationship between WHC and solubility. In the current study, egg yolk powder from Serama chickens had the lowest WHC and the highest solubility, whereas commercial egg yolk powder had the highest WCH and the lowest solubility.

E. Emulsion Activity and Stability

Table 5 shows the EA and ES of the different egg yolk powders.

TABLE V
EMULSION ACTIVITY AND STABILITY OF EGG YOLK POWDERS FROM EGGS OF DIFFERENT BIRD BREEDS AND COMMERCIAL EGG YOLK POWDER

Samples	Emulsion Activity (%)	Emulsion Stability (%)
Fighting	$54.13^{c} \pm 1.51$	$40.95^{ab} \pm 1.65$
Kampung	$49.21^{a} \pm 1.37$	$44.83^{c} \pm 2.63$
Serama	$51.59^{abc} \pm 1.37$	$40.95^{ab} \pm 1.65$
Leghorn	$50.79^{abc} \pm 1.37$	$48.41^{d} \pm 1.37$
Turkey	$50.00^{ab} \pm 2.38$	$44.29^{c} \pm 1.24$
Guineafowl	$53.25^{bc} \pm 1.51$	$43.57^{bc} \pm 1.24$
Commercial	$52.31^{abc} \pm 2.28$	$39.37^{a} \pm 1.10$

Data are expressed as mean ± standard deviation (n = 3). Different letters in the same column indicate significant differences ($p < 0.05$).

EA differed significantly among some of the egg yolk powders from different bird breeds and commercial egg yolk powder ($p < 0.05$) (Table 5). Emulsion activity of egg yolk powder from Kampung chickens was lowest (49.21%), and that of Fighting chickens was highest (54.31%). Thus, the latter has a greater ability to spread at the oil-water interface [3]. Egg yolk is widely used as an emulsifier in many foods. An emulsifier is a surface active agent that stabilizes fat droplets in water, and it functions only in the presence of protein [28].

ES also differed significantly among some of the egg yolk powders tested ($p < 0.05$) (Table 5). EA of egg yolk powder from Fighting chickens was lowest (40.95%), and that of

Leghorn chickens was highest (48.41%). Overall stability also was lowest for egg yolk powder from Fighting chickens (75.67%) and highest for powder from Leghorn chickens (95.31%). Ndife et al. [29] reported much higher values for emulsification activity (74.0%) and stability (72.40%) of oven dried egg yolk powder, whereas Wong and Kitts [11] reported average values of 50.0% and 45.0%, respectively. These differing results are due mainly to the different temperature treatments used to convert egg yolk liquid into egg yolk powder. ES is reported to have a dependent relationship with total solubility or protein solubility: When protein solubility is low, the majority of protein remains absorbed at the interface, resulting in high hydrophobicity and thus high ES [11]. In the current study, ES was lower for the commercial egg yolk powder compared to the powders from the six bird breeds, likely due to the processing techniques used to produce a commercial powder.

IV. CONCLUSION

Significant differences for all parameters studied, except WHC, were detected among all or some of the egg yolk powders tested. Among the powders from different bird breeds, that from Serama chickens had the highest protein content, lowest fat content, highest solubility, and lowest WHC. Egg yolk powder from fighting chickens had the highest protein and lowest fat content, excellent yellow color, high solubility, good WHC, and good emulsion activity. Commercial egg yolk powder had a low protein content, highest fat content, lowest carbohydrate content, lowest solubility, highest WHC, and lowest ES.

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