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EFFECT OF OVEN DRYING METHOD ON THE YIELD AND FUNCTIONAL PROPERTIES OF EGG POWDERS MADE USING EGGS FROM THREE POULTRY SPECIES.

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ABSTRACT

This study aimed to evaluate the effects of oven drying method on the functional properties of whole eggs powders obtained from chickens, quails, and turkey eggs, respectively. A total of 1000g 1000g of liquid egg for each of the three poultry species was dried at 60 °C and the product yield (%) was determined. Foaming capacity, foam stability, emulsion activity, swelling capacity, bulk density, water absorption and oil absorption were all recorded using the standard procedure. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05.}$ Dried egg was higher for quail egg powder (26.9), followed by turkey egg powder (24.4), with the lowest yield in chicken egg powder (21.9). The results showed that chicken egg powder had the highest emulsion activity (73.4±0.2) compared to quail egg (73.4±0.1) and turkey egg powder (69.2±0.2). Quail egg powder gave the highest foaming stability (62.5±0.3) and foaming capacity (79.3±0.3) compared to turkey egg powder (60.5±0.2) and (77.3±0.3) and lastly chicken egg powder (57.2±0.3) and (76.3±0.2) powders. The highest water retention was recorded in quail egg powder (3.1±0.3%), followed by chicken egg powder (2.9±0.2) and turkey egg powder (2.7±0.5) powders. The quail egg was the preferred choice regarding the processing yield and functional ability.

Keywords: Drying Method, Egg Powder, Turkey, Quail, Yield

INTRODUCTION

Eggs are a traditional food rich in essential nutrients, offering benefits beyond basic nutrition, which suggests they should be promoted as functional foods (Herron *et al*, 2004). With their moderate calorie content (approximately 150 kcal per 100g), high-quality protein, versatility in cooking, and affordability (Carrillo *et al*, 2012), eggs are accessible to most people. Furthermore, eggs are rich in fat-soluble compounds, making them a valuable dietary addition for individuals of all ages and life stages, especially those at risk of nutrient deficiencies, such as the elderly, pregnant women, and children (Natoli *et al*, 2007). Additionally, eggs can be enjoyed worldwide without any restrictions related to religious beliefs (Abeyrathne *et al*, 2013).

Egg products are also rich in nutrients that support memory and eye health. The zeaxanthin and lutein found in egg yolks are thought to protect against age-related eye conditions, such as macular degeneration and cataracts. Additionally, choline in egg yolks is believed to aid in infants' brain development and enhance memory throughout life (Morgan and Armstrong, 1992). Both egg whites and yolks contain proteins with unique characteristics that can be marketed for various uses (Stadelman and Cotterill, 1995).

Current methods to manufacture egg powder involve washing, breaking, filtering, and pasteurising the egg liquid before drying it entirely or separating it into egg yolk and egg white components. Various technology, including spray drying, tray drying and freeze drying are employed for processing and preservation. These different drying methods show significant difference on the final product's qualities (Potter and Hotchkiss, 2006). Spray drying, a ubiquitous technique in food processing, and entails spraying a liquid feed material into a hot gas stream, where temperatures typically range from 100°C to 300°C, to produce powdered products. (Schuck *et al*., 2009).

Eggs are primarily valued for their essential functional properties, such as emulsification, gelling, taste, and colour. In baking, whole eggs are commonly used for their ability to increase in volume during both the baking process and beating. Egg albumen is particularly known for its excellent foaming properties in food (Chen *et al*. 2009). These properties stem from the ability of eggs to rapidly absorb at the air-liquid interface and form a cohesive film through molecular interactions (Mine, 1995). The increase in volume when beating is due to the viscosity of the egg, while the rise in volume during baking is attributed to the coagulation of egg proteins (Stadelman *et al* 1977). Although the elastic properties of proteins are lost during cooking, their firming qualities still enable eggs to perform other functions, such as binding ingredients together. This helps prevent meatloaf from crumbling and allows casseroles to maintain their form. Coatings, such as those on veal cutlets, adhere more effectively when the meat is dipped in egg before being rolled in breadcrumbs. In quiche and crème caramel, egg proteins form a mesh-like structure that holds cream and milk in a soft gel (Stadelman *et al* 1995). On the other hand, in recipes like crème anglaise or stirred custards, eggs thicken more efficiently at lower temperatures than corn or flour.

Several factors influence the formation and durability of egg white foam, including the age of the hen, egg storage conditions, whipping speed, temperature, pasteurisation, pH levels, dry matter content, the presence of yolk or lipids, additives, and various enzymes (Hata *et al*., 1997; Hammershoj *et al*., 2001). Studies have revealed that certain processing steps can compromise the functional properties of egg albumin, highlighting the need for strategies to mitigate these effects and optimize drying times.

MATERIALS AND METHODS

The research was conducted in the University of Ibadan at the Department of Animal Science. The poultry eggs used namely, chicken, turkey and quail were collected from farms in Ibadan. Brown shell eggs were collected from *Nera*black and *Isa* brown chickens with an average egg weight of (62.56g), the quail (ash colour) bird eggs used were all black dotted white eggs while white coloured eggs with sparse brown dots were collected from both the white and black turkey birds. The average weight of the quail and turkey eggs were (9.49g) and (70.36g) respectively.

The research utilized three types of egg powders (chicken, turkey, and quail) with three replicates each, sourced from freshly laid eggs. Due to the size difference of the eggs, an accumulated weight of ±1000g of liquid egg was dried. A total of 17, 142, and 22 eggs were collected for turkey, quail, and chicken, respectively, to make up 1000g.

Producing powdered eggs involved cracking a whole egg into a plastic bowl, followed by homogenisation. The egg mixture was then dried in an oven at 60°C for 27 hours and left to cool. The oven's heat and air circulation help remove moisture from the egg liquids, resulting in a solid or semi-solid mass. The weight of the egg liquids was recorded before and after the drying process. The resulting egg powders were stored in various plastic films for subsequent analysis.

Functional Properties

The functional properties of the egg, including emulsifying and foaming stability, were assessed.

Emulsifying Activity

The emulsifying activity was assessed following the method outlined by Yasumatsu *et al*. (1972). The emulsion was prepared by combining 1 g of egg powder, 10 ml of distilled water, and 10 ml of soybean oil in a calibrated centrifuge tube. This mixture were centrifuged at Revolutions per minute (RPM)) for 5 minutes. The emulsifying activity was quantified as the percentage ratio of the emulsion layer's height to the total height of the mixture.

$$\text{Emulsifying Activity} = \frac{\text{Height of the emulsified layer}}{\text{Height of the total amount of content in the tube}} * 100$$

Foaming Stability

Foaming capacity and stability were measured using the method outlined by Coffman *et al*. (1997). Two grams of egg powder were whipped (3,000 RPM) with 100ml of distilled water for 5 minutes at the 9,000 RPM in a Tamashi equipment. The mixture was then transferred to a 250ml graduated measuring cylinder. The total volume was recorded after 15 minutes, and the per cent volume increase was calculated.

$$\text{Foaming capacity} = \frac{(Volume\ after\ whipping - volume\ before\ whipping)ml}{(Volume\ before\ whipping)ml} * 100$$

$$\text{Foaming stability} = \frac{(Volume\ after\ standing - volume\ before\ standing)ml}{(Volume\ before\ standing)ml} * 100$$

Swelling Capacity

1g of dried egg powder was placed in a 100 ml conical flask, followed by the addition of 15 ml of distilled water. The mixture was stirred at low speed (3,000 RPM) for 15 minutes, then transferred to a hot water bath and heated for 40 minutes at 80–85°C with continuous stirring. After heating, the mixture was transferred into a pre-weighed centrifuge tube, and 7.5 ml of distilled water was added. The tube was centrifuged at 2200rpm for 20 minutes, following the procedure described by Coffman *et al*. (1997). The supernatant was carefully decanted and cooled in a desiccator. The weight of the precipitate, along with the centrifuge tube, was then recorded.

$$Swelling\ capacity = \frac{Weight\ of\ the\ centrifuge\ containing\ sample\ before\ drying}{Weight\ of\ the\ centrifuge\ containing\ sample\ after\ drying}$$

Water and Oil Absorption Capacity

Water and oil absorption capacities were determined following the method of Sefa-Dedeh *et al*. (2004). 5g of egg powder was measured in a centrifuge tube, and 20 ml of distilled water was added. The mixture was stirred thoroughly and allowed to stand for 30 minutes before centrifugation at 3000 rpm for 15 minutes. After centrifugation, the supernatant was carefully decanted, and the tube's weight was measured using a digital balance to record the weight increase. The water and oil absorption capacities were calculated as a percentage of the initial sample weight. Each determination was performed in triplicate for accuracy.

$$WHC/OHC = \frac{Hydrated\ residue\ weight - Dry\ residue\ weight}{Dry\ residue\ weight}$$

Water and Oil Retention Capacity

Water and oil retention capacities were measured according to the method described by Sosulski *et al*. (1976). 1g of egg powder was mixed with 10 ml of refined soybean oil and centrifuged at 2 000 rpm for 10 minutes. The retention capacities were calculated as the percentage of water and oil retained per gram of the sample.

$$WRC/ORC = \frac{Residue\ hydrated\ weight\ after\ centrifugation - Residue\ dry\ weight}{Residue\ dry\ weight}$$

Bulk Density

Bulk density was determined using the method described by Narayana *et al*. (2001). Ten grams of each egg powder sample were weighed (W1) and placed into a 25 ml measuring cylinder. The sample was gently tapped to remove any air space between the particles, and the weight was re-recorded (W2). The study was conducted in triplicate.

Bulk density (g/ml) was calculated using the formula:

$$Bulk\ density\ (g/ml) = \frac{W1 - W2}{Volume\ of\ sample\ before\ tapping}$$

W1 = Loss Density

W2 = Tapped Density

Colour Analysis

The colour of the powdered eggs was analysed with a colourimeter at the Food Science Laboratory at the University of Ibadan using different colour parameters (L*, a*, b*) (Francis, 1983).

1. L* (Lightness): Measures the lightness of the color, ranging from 0 (black) to 100 (white).
2. a* (Redness/Greenness): Measures the redness (positive values) or greenness (negative values) of the color.
3. b* (Yellowness/Blueness): Measures the yellowness (positive values) or blueness (negative values) of the color.

Statistical Analysis

Data was analysed using the general linear model of the SAS statistical package (SAS, 1999). Analysis of variance (ANOVA) includes the different forms of poultry egg species, the effect of oven drying and the effects on process yield.

RESULTS AND DISCUSSIONS

Product Yield

The yield percentage is shown in Figure 1, with an accumulation weight of ±1000 liquid egg. The highest value was recorded for quail (26.29%), followed by turkey (24.95%) and least in chicken (21.90%).

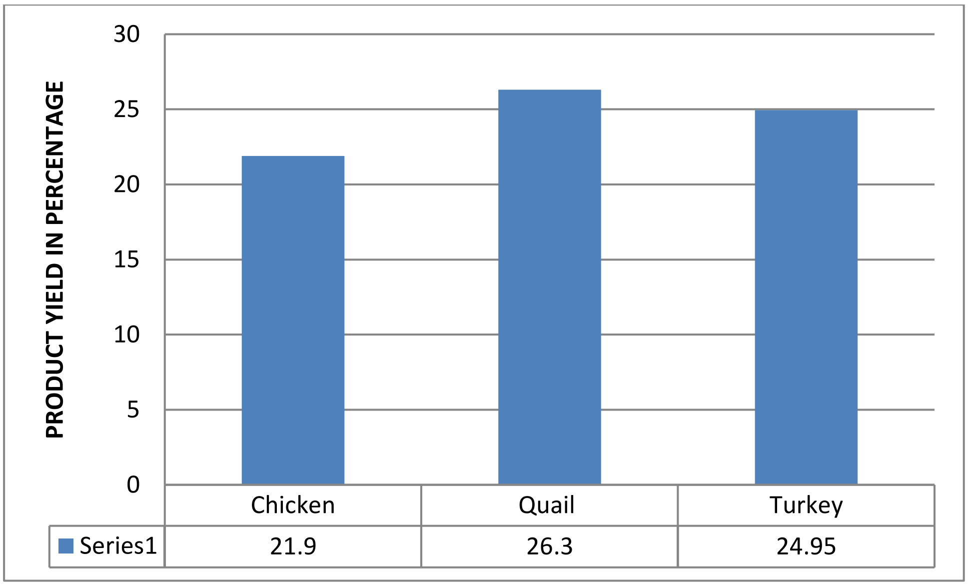

FIGURE 1: Yield per cent of 1000g of the liquid poultry egg after oven drying at 60ºC

The product yield served as an indicator of the water content in a whole egg, specifically focusing on the available water in 1000g of whole egg for this study. The drying process continued until the sample reached its final weight; at this point, the moisture content no longer decreased with additional drying time. The final moisture content was considered the equilibrium moisture content, as Ekechukwu (1999) and Ramaswamy *et al*. (2006) described. This moisture content was consistent with the findings of Mark *et al*. (2013) and similar to the results reported by Joel Ndife *et al*. (2010).

Functional Properties

The results presented in Table 1 indicate that the oven-drying method used influenced some of the functional properties of the dried egg components. The emulsification activity (EA) results showed significant differences (P<0.05), with chicken egg powder achieving the highest value at 74.3±0.1%, followed by quail at 73.4±0.1%, and turkey at 69.2±0.1%. This suggests that chicken egg powder may be a more effective emulsifier than the others.

Table 1: Functional Properties of Egg Powder

Functional properties	CE	QE	TE
Foaming Capacity (%)	$76.30±0.12^{c}$	$79.30±0.17^{a}$	$77.33±0.18^{b}$
Foaming Stability (%)	$57.23±0.15^{c}$	$62.40±0.17^{a}$	$60.47±0.09^{b}$
Swelling capacity (%)	$2.07±0.03^{b}$	$2.30±0.06^{a}$	$1.87±0.03^{c}$
Bulk density (g/ml)	5.43±0.19	5.13±0.09	5.20 ±0.12
Water Absorption (g)	$3.06±0.01^{b}$	$3.09±0.04^{ab}$	$3.24±0.08^{a}$
Oil Absorption (g)	2.35±0.43	1.96±0.02	1.97±0.04
Water Retention (g)	2.92±0.12	3.10±0.18	2.73±0.29
Oil Retention (g)	4.08±0.08	3.92±0.26	3.77±0.18
Emulsion Activity (%)	$74.34±0.14^{a}$	$73.41±0.07^{b}$	$69.24±0.12^{c}$
Colour (lightness)	$72.32±0.01^{a}$	$71.99±0.00^{b}$	$69.37±0.00^{c}$

$^{a,b,\,c}$ Means with different superscripts in the same row differ significantly ($p < 0.05$)
CE= Chicken egg powder
QE=Quail egg powder
TE= Turkey egg powder

The obtained values surpassed those reported by Joel Ndife *et al*. (2010) for oven drying at 44°C, but fell short of the results published by Kenawi *et al*. (2015). Emulsification activity (EA) assesses a surfactant's ability to form emulsions under specific conditions, with smaller oil droplets indicating higher activity. However, emulsions are inherently thermodynamically unstable and prone to separation into distinct oil and water phases over time, as noted by Pearce et al. (1978). Thus, EA reflects how slowly an emulsion separates. Additionally, the foaming activity and water absorption values were higher than those reported by Joel Ndife *et al.* (2010), while the oil absorption results were consistent with their findings.

The observed results reflect the influence of egg quality and differences in oven types. Emulsification properties are vital for stabilizing a suspension of one liquid in another, and the proteins and lipids, particularly lecithin, in egg yolks significantly contribute to these properties (Okezie and Bello, 1988; Bueschelberger, 2004). These characteristics make eggs especially useful in food products like mayonnaise and shortened cakes.

The foaming capacity (FC) and stability (FS) were highest in quail egg powder (79.3±0.2% and 62.4±0.2%, respectively), followed by turkey (77.3±0.2% and 60.5±0.1%), and lowest in chicken egg powder (76.3±0.1% and 57.2±0.2%). These values were higher than those reported by Kenawi et al. (2015) (P<0.05). The fat content in the eggs likely influenced these results, as lipids enhance emulsification but can reduce foaming potential (Marques, 2000). For example, the addition of 0.01–1.0% refined cottonseed oil decreased egg white foam volume and increased foam breakdown during prolonged beating, though foam stability was not significantly affected unless the oil content exceeded 0.5% (Dizmang and Sunderling, 1933). Previous studies also indicate that fats such as butterfat and cream have strong inhibitory effects on foam formation (Stadelman and Cotterill, 1994). Even small amounts of yolk can reduce foaming ability, as shown when one drop of yolk decreases egg white foam volume from 135 ml to 40 ml (John and Flor, 1931). Quail egg powder displayed relatively high foaming properties compared to turkey and chicken egg powder

The oil absorption (OA) and water activity (WA) values also differed across egg types. Chicken egg powder had the highest OA (2.35±0.43 g), followed by turkey (1.97±0.04 g) and quail egg powders (1.96±0.02 g), with no significant difference between the latter two ($P<0.05$). On the other hand, WA values showed significant differences ($P<0.05$), with turkey egg powder recording the highest value (3.24±0.08 g), followed by quail (3.09±0.04 g) and chicken egg powders (3.06±0.01 g). These results were lower than those found by Kenawi *et al*. (2015). Protein surface area and bulk density likely influenced oil retention, as most of the absorbed oil is physically trapped (Dench, 1982; Kinsella et al., 1985). Quail egg powder demonstrates superior emulsifying and foaming properties. Meanwhile, the high oil absorption capacity of chicken egg powder.

The results for bulk density were highest for chicken egg powder at 5.43±0.19, followed by turkey egg powder at 5.20±0.12 and quail egg powder at 5.13±0.09 ($P<0.05$). The value differences can be attributed to species variations and other factors such as handling.

CONCLUSION

This study demonstrated that whole egg powder can be produced using oven drying at 60°C without negatively impacting its functional properties.

Recommendation

Future research directions could include investigating the impact of storage duration on product shelf life. Additionally, examining the effects of varying oven temperatures and exploring the functional properties of other bird species could provide valuable insights, ultimately leading to enhanced product functionality.

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