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Egg value addition, egg powder: A sustainable alternative

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Abstract

Resolving egg glut, a seasonal problem to poultry farmers in Nigeria is the focus. 1,350 freshly laid eggs were purchased from Teaching and Research farm poultry unit, Osun State University, and were divided into 5 treatments (270 eggs each), with three replicates. T1, freshly laid eggs; T2, eggs produced into powdered egg; T3, eggs stored in refrigeration, T4, eggs stored on the shelf; T5, eggs immersed in soya oil and stored on the shelf, to determine cholesterol status, shelf life, palatability status, proximate and mineral composition in a completely randomized design. Results of shelf life when stored (T3 - T5), observed that yolk, albumen, and chalazae remain intact in first to third weeks. From third to fifth weeks, deterioration begins to set in, and broken shells were observed in T3, broken membranes of albumen and yolk, leading to watering eggs, and disappearance of chalazae. T2 had highest ($P<0.05$) nutrients composition except for moisture content. Cholesterol status of T2 (931.43mg/100g) was ($P<0.05$) higher than T1 (240.83mg/100g). Cumulatively eggs stored for fifth weeks, revealed that T2 had highest nutrients while T4 had lowest significant nutrients. Nutrients and cholesterol content decreased as week's increases and palatability score of garnished fresh eggs (7.89) had highest ($P<0.05$) values followed by garnished powder eggs (6.53), fresh eggs (6.11), and plain powder egg (5.78) respectively. Powder egg is a good substitute for fresh eggs and should be introduced to all poultry farmers in Nigeria, to combat yearly egg glut, in Nigeria.

Nomenclature and units

%	Percentage
g	Grams
Mg/100g	milligrams per 100grams
g/100g	grams per 100 grams
mg/kg	Miligrams per Kilogram
Kg	Kilogram
₦	Naira
W	Watts
V	Volume

1.0 Introduction

In the poultry egg glut is a serious problem for poultry farmers all over Nigeria, (Ajakaiye *et al*., 1999). Egg glut is a resultant of poor storage facilities in Nigeria, (Adene 2004). It happened when there is over supply of egg seasonally. And this is because egg farmers in Nigeria lack adequate facilities to preserve their eggs. Many eggs get spoilt before they are sold, leading to a loss to the farmers. Eggs are a very good source of inexpensive, high-quality protein; they are rich sources of vitamins B_6, B_2, B_{12}, and minerals such as zinc, iron, and copper. They are also good sources of fat-soluble vitamins A, D, E, and K, but lack only vitamin C. Eggs contain twelve of the thirteen vitamins that is required by man. Yolk and albumen contribute about 40% and 60% of the total protein of the egg respectively, (Kumaravel, 2012). Eggs are regarded as a complete source of protein as they contain all nine essential amino acids, the ones we cannot synthesize in our bodies and must be obtained from our diet (Rannou, *et al.,* 2013). With its numerous benefits, eggs can only be preserved for a few weeks before spoilage sets in. (Johnson, 2018) reported that, the shelf life of eggs ranges from a few hours to weeks, months, and years, depending on the way in which they are stored. Therefore, it is necessary to prolong the shelf life of eggs right from the production site to avert egg glut or low demand, affecting poultry farmers.

Value addition is the extra value or efforts added over the original ways of producing products to improve on it quality and sustainable developed the products, to meet up with the country needs and improving income. Many products have experience value addition in time past, egg have also had it shares in the production of hard-cooked peeled eggs, coloured Hard-cooked egg, cook-in-bag scrambled eggs, filled omelets, French eggs etc. An egg glut is a seasonal occurrence that occurs when the demand for eggs is less than its supply, (Ajakaiye *et al*., 1999). Few of the yearly glut periods in Nigeria are predictable while others may be due to unforeseen circumstances, like the recent covid'19 lockdown, etc. Meanwhile, the primary cause of the yearly egg glut in Nigeria could probably be a result of the attitude of poultry farmers toward the marketing of their products. One outstanding fact is that the majority of the poultry farmers in Nigeria are just purely producers, meaning they depend mostly on middlemen as they have surrendered all the marketing responsibilities to them otherwise known as the distributors (Kumaravel, 2012). Eventually, these middlemen usually aggravate their problems, whenever there is a slight drop in demand for table eggs. (Johnson, 2018). And to combat the problem of glut, improved techniques in preservation could be employed. The fresh eggs could be converted into egg powdered which could store for up to ten years, often used in baked foods just like normal eggs, or reconstituted and made into fluffy scrambled eggs or crushed eggs in most eateries (Rannou, *et al.,* 2013). Egg powder is comparatively easier to transport and there is no question of any breakage during the transit. Egg powders are also easy to store (no need for refrigeration, all you need is a dry place, and a conducive package. This study will therefore determine the shelf life of fresh eggs, their production into egg powder, its nutrients composition, and acceptability study, as an alternative to the egg glut in Nigeria.

2.0 Materials and Methods

2.1 Experimental site

This study was conducted at the poultry unit (Layers birds' section) of the Teaching and Research Farm, of Osun State University, College of Agriculture, Ejigbo Campus. The farm is located on latitude 7 ^{0} 54 N and longitude 4 ^{0} 18 E and 4 ^{0} S4 E. (Wikipedia.org\wiki\Ejigbo, 2011). Ejigbo is located in the middle portion of 35 km to the North East of Iwo, 30km from Ogbomosho in the north and about 24 km east also, the laboratory analysis was conducted at Meat Science Laboratory, Department of Animal Science, College of Agriculture, Ejigbo Campus, Osun State University, Osogbo.

2.2 Shelf-life determination

Forty - five (45) trays day old fresh eggs were bought from the Teaching and Research Farm, and 1350 pieces of eggs were divided into five treatments (270 eggs for each) with three replicates (90 eggs per replicate) as listed below;

T1 = Fresh eggs
T2 = Powdered egg
T3 = Eggs stored in the refrigerator
T4 = Eggs stored on the shelf
T5 = Eggs immersed in soya oil and stored on the shelf

Each treatment, especially T3 - T5 were evaluated for the time of spoilage and stored for five weeks, to determine their shelf life. At the end of each week, the proximate, cholesterol, and mineral analyses were carried out in the laboratory. T3 was placed in the refrigerator for five weeks, T4 eggs were placed on the shelf in the laboratory for five weeks and T5, and eggs were coated with soya oil and placed on the shelf in the laboratory for five weeks

2.3 Proximate and Mineral composition

Proximate analysis was carried out on fresh, powered, refrigerated, shelf, and oil-coated eggs. Crude protein, ash, moisture, minerals, and ether extracted and phosphorous, selenium, and iodine were evaluated according to AOAC (18th Edition, 2005).

2.4 Cholesterol status

Cholesterol status was determined according to the method of (Howell *et al.*, 1997), in mg/ 100 g.

2.5 Palatability study.

A total number of twenty trained panelists, ages ranging from 45-60 was selected based on their past performance on blind-coded samples.

Sample A: Fresh egg with seasoning was served, with ingredients; 597 g of fresh eggs, 180 g of soya oil, 80 g of tomatoes, 60 g of onion, 40 g of pepper, 6g of salt, and Maggi (monosodium glutamate) 6 g.
Sample B: Fresh eggs without seasoning, 586 g of fresh eggs, 180 g of soya oil, and salt 6 g.
Sample C: Powdered egg with seasoning, with ingredients 73 g of powdered egg, 190 g of water, 80 g of tomatoes, 180 g of soya oil, 60 g of onion, 40 g of pepper, 6 g of salt, sand 6 g of Maggi,
Sample D: Powdered egg without seasoning, 73 g of powdered egg, 190 g of water, 180 g of soya oil, and 6 g of salt.

Trays of fresh eggs
↓
Broken into a bowl
↓
Blended (Blender Machine)
↓
Dehydrated (Food Dehydrator)
↓
Ground (LG Grinder Machine)
↓
Packaging.

Fig 1: Processing of powder egg production

Fakolade and Atarase, (2022)

2.6 Dehydration
Eggs were broken into a bowl with the use of an egg separator, blended (Excella mixer, grinder with 3 S.S. JARS, of 1000Watts, 230V by MAHAVIR IMPEX Mumbai, India VTCL and poured into the DeLonghi, food dehydrator, made in Italy (250W, 220V - 240V). After the process, it was then ground with the same grinder machine.

2.7 Experimental Design and Statistical Analysis
The experimental design used was a Completely Randomized Design. All data obtained were subjected to a one-way analysis of variance in order to observe statistical significance. Significant differences were separated using Duncan multiple range tests using the same statistical package (Duncan, 1995).

3.0 Results and Discussion
Table 1 shows the fresh and powdered egg's proximate, mineral, and cholesterol content.
T2 gave the highest significant values of nutrients of protein, ash, ether extract, phosphorous, iodine, and cholesterol, of three to four times increase than the fresh eggs, so these huge differences in nutrients could be a result of coagulation of nutrients due to dehydration method used to convert of process fresh eggs into powdered eggs without affecting its nutrients composition. The process used to produce powder works by circulating air at a very low temperature for an extended period of time. The dehydrator used, draw moisture out of the eggs slowly till dryness is formed. Powdered eggs can also be produced using only white or the yolk, to get, white powdered or yellow powdered eggs. The process involved is called dehydration synthesis, which is the clinical reaction in involving water-reactant molecule removal from a product. The process of the combination of two or more molecules with the elimination of water molecules is called dehydration synthesis. It is also the creation of larger molecules from smaller monomers where a water molecule is released; such products are called intermediate moisture food (IMF).

Okubanjo and Egbunike, (1999) observed that intermediate moisture food IMF or Intermediate Moisture Meat is food with very low moisture content, having 3-4 times the nutrients of its raw counterpart and are shelf stable under tropical climatic conditions, or without a refrigerator. All nutrients observed for powdered eggs are three to four times higher than fresh eggs' nutrients. This shows that a weight amount of teaspoon of the powdered egg will contain a higher percentage of nutrients than the same weight of fresh eggs. The powdered egg has been reported with a shelf life of five to ten years of storage in an airtight container, meaning they can be replaced with fresh eggs in all food egg ingredients with numerous advantages over fresh eggs, especially during lockdown which could be caused by pandemic or egg glut. Poultry farmers can further have food dehydrators in their enterprises, to process fresh eggs into powdered eggs with good packaging to reduce loss during low demand of eggs, lockdowns, and egg glut, (Soderbery, 2013).

Table 1: Proximate and mineral composition of fresh and powdered egg.

Parameters	T1	T2
Protein %	11.14±0.10^{b}	47.87±0.23^{a}
Ash %	1.03±0.04^{b}	3.31±0.05^{a}
Either Extract %	10.07±0.13^{b}	36.4±0.06^{a}
Moisture %	74.00±0.47^{a}	7.07±0.20^{b}
P; mg/kg	0.18±0.001^{b}	0.38±0.002^{a}
SE; mg/kg	0.45±0.01	0.49±0.01
I; mg/kg	13.3±0.02^{b}	57.29±0.01^{a}
Cholesterol; mg/100g	240.83±0.20^{b}	931.43±0.36^{a}

^{abc} means of the different alphabet along the same row are significantly different (P<0.05).T1– Fresh egg, T2 – Powdered egg.

Table 2. Shows the different methods of storage used in the study which are; fresh eggs kept in the refrigerator, eggs kept on the shelf in the laboratory, and eggs kept on the shelf after being immersed in soya oil. The results shown in Table 2 above; for protein content (PC), shows that there appears to be a serious reduction in the content of fresh eggs stored on the shelf in the laboratory (9.87 %). The PC of the egg stored using a refrigerator and that of coated oil were significantly the same, (10.77 % and 10.79 %). This shows that the reduction of PC occurs during storage of eggs on the shelf but with other means of preservation e.g refrigeration and dipping in oil, the reduction of PC was curtailed, (Ali, 2012).

Ash content – reduction in ash content was also observed during the different storage methods, especially when it was not refrigerated. Refrigerated and fresh eggs had the same significant values, showing that the best form of storage is to store eggs under

the refrigerator in a country with a stable electricity supply, but if there is erratic supply of power, then egg can be coated in oil or produced to powdered egg to extend its shelf life, (Csong, 1983). Either extract- the content of either extract also reduces at 5 weeks using different storage methods. It was observed that the refrigerated eggs were significantly higher while nutrients of eggs stored on the shelf had the lowest either extract values. T4, eggs coated with oil were able to retain it either extract because, the oil used to coat the eggs block the spores and so nutrients were not able to evaporate, instead there is an increase in either extract meaning that oil used for coating penetrates into the egg, through the pores. It was observed that a typical egg will have 17,000 tiny pores on its shell.

Moisture – the moisture content follows the same trend as in either extract, it shows that eggs are not to be stored open on the shelf in our kitchen but refrigerated or coated with oil where electricity is a problem. Where the two can't be provided and the eggs to be stored are too many likes in a commercial farm, it is then advisable to process them into the powdered egg.

Minerals (Phosphate P, Selenium SE, Iodine I) and cholesterol content, were drastically reduced in the (P, SE, I) for egg stored on the shelf to egg stored coated with soya oil and refrigerated egg. The same trend was also observed for cholesterol content in this direction T1>T2>T3>T4 along the trend for all the nutrients except for either extract content, (Okubanjo and Egbunike, (1999). Also, Haugh (1937) observed that with an increase in length of storage, egg proximate and mineral composition declined as a result of an increase in weight losses, which could be due to loss of carbon dioxide, ammonia, nitrogen, hydrogen sulfide gas and water from the egg.

Table 2: Nutrient composition of eggs stored using different means; refrigerator, on the shelf, and soya oil coated, for five weeks.

Parameters	T1	T2	T3	T4	SEM
Protein %	11.14^{a}	10.77^{b}	9.87^{c}	10.79^{b}	0.05
Ash %	1.03^{a}	1.05^{a}	1.00^{b}	1.01^{b}	0.02
EE %	10.07^{a}	9.74^{b}	8.78^{c}	9.65^{b}	0.03
Moisture %	73.98^{a}	71.57^{b}	67.73^{c}	71.67^{b}	0.14
P; mg/kg	0.19^{a}	0.17^{b}	0.14^{c}	0.16^{b}	0.01
SE; mg/kg	0.45^{a}	0.27^{b}	0.23^{b}	0.16^{c}	0.01
I; mg/kg	13.50^{a}	12.50^{c}	12.94^{b}	12.60^{bc}	0.20
Chol; mg/100g	240.80^{a}	233.00^{b}	205.45^{d}	221.63^{c}	0.50

^{abcd} means of the different alphabet along the row are significantly different (P<0.05)

T1 – Fresh egg, T2 – Refrigerator, T3 – On the Shelf, T4 – Soya oil coated.

Fig 2 - 3, shows how the reduction in nutrients per week took place when comparing refrigerator, shelf, and soya-coated oil storage methods. From Fig 2 - 4, the protein content increases for all the methods used at the first week of storage. While either extract or cholesterol increases in soya oil-coated eggs throughout the time of storage period. Proving that oil coated penetrates through the spore of the shell to add up with the content, thereby increasing the either extract or the cholesterol at the first week of storage. But at the second week of storage to the fifth week of storage, the content gradually decreases as the week increases. (Panigraphs e*t al.,* (1989), noted that eggs are at a maximum when freshly laid and with storage time. Note that the nutrients in egg decrease with storage time as so it is advisable to buy fresh eggs from the farm because eggs bought from retailers may have spent weeks on their shelves, thereby reducing nutrients i.e low quality of such eggs. Oriji *et al.,* (1981), report that some factors like temperature, relative humidity, and flow of air or moisture are considered as the main factors in determining the technological condition of storing eggs.

Fig 2-4; Shows the differences in nutrient composition reduction of fresh eggs stored using different storage methods for five weeks.

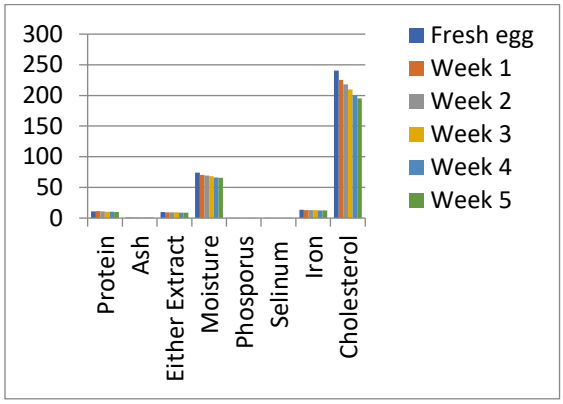

Fig2: Egg stored in the refrigerator

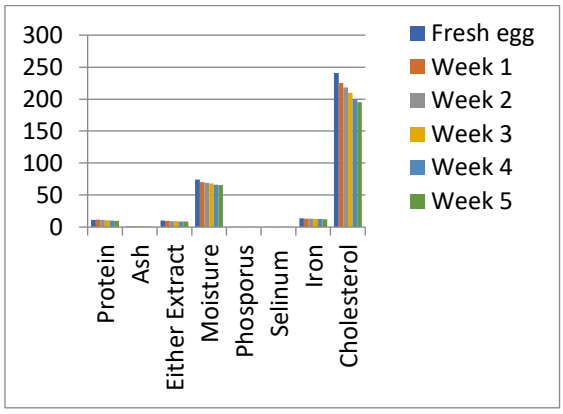

Fig 3: Eggs stored on the shelf at room temperature

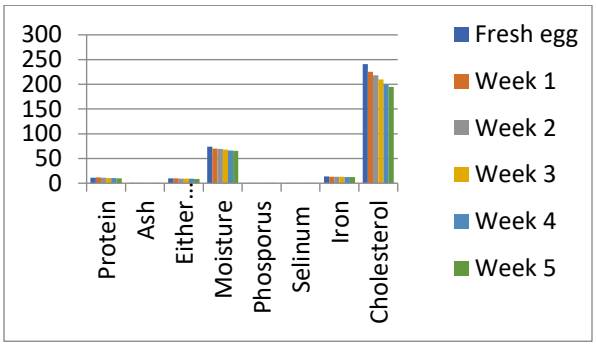

Fig 4: Eggs stored in Soya oil at room temperature.

Table 4 shows the palatability status of fresh and powdered eggs. The table answer question raised by consumers about the powdered egg; if it can be acceptable to consumers. Powdered eggs apart from making used of it in pastries industries, and baking, it can also be used as scrambled eggs and for omelets in homes, eateries or hotels. One pound of a whole powdered egg will make 40 fresh eggs e.g one tablespoon of powdered eggs plus 3 tablespoons of water equal the same nutrients as one fresh egg (American spices, 2012). The parameters on this table, show, the 9-hedonic scales, comprises of colour, flavour, tenderness, juiciness, texture, and acceptability. Sample A had the highest significant value for all the parameters measured, followed by sample C, this means that consumers prefer their fried garnished egg to an un garnished fried egg. The table also shows that when powdered eggs were garnished it was also preferred by the panelists after the garnished fresh fried eggs. For overall acceptability to be high, there will be higher scored value for flavour, tenderness, and juiciness since they affect consumer preference of acceptance, (Nagoda 1994, flavour; Safari *et al*., 2001, tenderness and Fakolade 2011, juiciness). Sample A had the highest palatability score (7.89) followed by sample C (6.33). Ingredient used influences the acceptability of the powdered egg, Solomon *et al*., (1994) stated that the ingredient used affects a better rating of a product's palatability status. Garnished fried powdered eggs could replace fried fresh eggs during glut, lockdown of low demand in the egg market, so producing powdered eggs in egg farms should be encouraged as it will increase their yearly income and reduce shortage from the egg glut, cracked and buried egg.

Table 4: Palatability status of fresh eggs and egg powder.

Parameters	A	B	C	D	SEM
Colour	6.56^{a}	4.00^{d}	5.56^{b}	4.78^{c}	0.42
Flavour	6.89^{a}	5.22^{c}	5.77^{b}	5.22^{c}	0.37
Tenderness	7.33^{a}	4.89^{d}	5.78^{b}	5.67^{c}	0.40
Juiciness	7.33^{a}	5.11^{c}	5.45^{b}	4.56^{d}	0.40
Texture	7.22^{a}	511^{c}	5.89^{b}	4.67^{d}	0.38
Acceptability	7.89^{a}	6.11^{c}	6.33^{b}	4.78^{d}	0.36

^{abcd} means of the different alphabet along the row are significantly different (P<0.05)

A; Garnished fresh egg, B; Plain fresh egg C; Garnished powder egg D; Plain powder egg

Conclusion

The work has just revealed that all Nigerian poultry farms need to be encouraged to produce powdered egg product, alongside their egg market to combat any foreseen situation that may affect the income of the farm

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Declaration of conflict of interest

This manuscript has not been previously reviewed by any other journal or publishing platform. Additionally, the authors do not have any affiliation with any organization that has a direct or indirect financial stake in the subject matter discussed in this manuscript, therefore no conflict of interest, and all efforts to the success of the manuscript were contributed by the authors.

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