COMPARATIVE EVALUATION OF FUNCTIONAL PROPERTIES AND CONSUMERS' ACCEPTABILITY OF DIFFERENTLY RECONSTITUTED CHICKEN EGG POWDER

BY

AHMAD Yusuf

DEPARTMENT OF ANMAL SCIENCE,
FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY,
ZARIA

MARCH, 2021

COMPARATIVE EVALUATION OF FUNCTIONAL PROPERTIES AND CONSUMERS' ACCEPTABILITY OF DIFFERENTLY RECONSTITUTED CHICKEN EGG POWDER

BY

AHMAD Yusuf
B. AGRICULTURE ABU ZARIA (2015)
P16AGAN8049

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIAIN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA

MARCH, 2021

DECLARATION

I hereby declared that the work in this dissertation entitled**"Evaluation of Reconstituted Egg Powder for Consumer Acceptability and Functional Properties"** was carried out by me at the Department of Animal Science and National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria under the supervision of Prof.S. Duru and Prof. M. Jibir. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any tertiary institution.

AHMAD, Yusuf		
Student	**Signature**	**Date**

CERTIFICATION

This dissertation entitled **"EVALUATION OF RECONSTITUTED EGG POWDER FOR CONSUMER ACCEPTABILITY AND FUNCTIONAL PROPERTIES"** by **AHMAD, Yusuf**, meets the regulation governing the award of the degree of Master of Science (Animal Science) of the Ahmadu Bello University, Zaria. It is approved for its literary presentation and contribution to scientific knowledge.

_____ _____

Prof. M. Jibir **Date**
Chairman, Supervisory Committee,

_____ _____

Prof. S. Duru **Date**
Member, Supervisory Committee,

_____ _____

Prof. M. Kabir **Date**
Head, Department of Animal Science,

_____ _____

Prof. Sani A. Abdullahi **Date**
Dean, School of Postgraduate Studies
Ahmadu Bello University, Zaria.

DEDICATION

This project work is dedicated to the Almighty Allah and my dearly parents, Malam Ahmad Ibrahim and Maryam Sani, for their parental care and support.

ACKNOWLEDGEMENTS

My thanks and appreciations go to the Almighty Allah, who in His infinite mercies saw me through the course of this project work and stay in the University. All glory, honour, power and adoration belong to Him, for He is worthy of my praise. My appreciation goes to my fatherly Supervisors; Prof S. Duru and Prof. M. Jibir for their support. It is impossible to quantitfy their efforts towards this work from the beginning to the end. May the Almighty continue to bless them abundantly. My immense gratitude goes to all staff members of the Faculty of Agriculture and the Department of Animal Science, the Head of the Department Prof. M. Kabir. Special appreciation goes to Prof. S. B. Abdu and Prof. Olugbemi and to the teaching and non-teaching staff of the Department whom through their personality imparted incomparable virtues in my life. You are the best. And to all the lecturers from, Dr. M.R. Hassan, Prof. J.J. Omage, Dr. (Mrs) Adedibu, Prof. D. Zahraddeen, Dr Alli-Balogun, Prof. P.A. Onimisi, Dr. Musa Abubakar, Dr. Abdulrasheed, Malam L.A.Jinadu, Mal. Ibrahim Taofik, Malam Salisu Salisu Garba and Malam Ma'aruf B. S. of the Department of Animal Science and Prof. S.M. Otaru, Prof. P.P. Barje, Prof.Sekoni, Prof.Abeke of NAPRI and all the other lecturers that I could not mention. I am forever indebtedto you. Alsoto all my family members, friends and coursemateslike Abubakar Muhammad, OyewoTeslim, Moses Eunice, Danladi Yussuf, Aliyu Zuwaira Isah, Abubakar Sadiq Abdullahi, Badmus Abas Olayemi, Talabi Adeola, Bello Muizzat, Millah, Duke, Kayode, Hamman and all 2016 classmates. I appreciate you all.
Fpnally to all my colleagues at NAERLS, NAPRI, IAR and DAC thank you all for the support.

ABSTRACT

Dehydrating and packaging of eggs are successful ways of solving the problems of egg glut and addition of values to the eggs as well as improving future values of eggs. Hence, in this study, a comparative evaluation of egg powder comprising of fresh albumen, yolk and whole egg and powdered or reconstituted albumen, yolk and whole eggs was determined for the purpose of measuring consumers' acceptability and functional properties of reconstituted eggs. A dehydrator (PRESTO Dehydro digital electric food dehydrator 06301) was used in drying the eggs; the fresh liquid eggs yielded 5g, 10g and 15g of powdered albumen, yolk and whole eggs respectively. A survey of 120 respondents was conducted at ABU quarters to determine the consumers' awareness or acceptability on powdered egg and their attitudes towards quality attributes of egg products. Consumers showed more preference for fresh eggs to powdered eggs while some never used powdered eggs. Only 5.8% have known about powdered egg and 15.1 % were aware of powdered egg and 67.5% of the consumers did not care if the product is of fresh or powdered when buying. Hence there is a market potential for powdered egg as 66.7% were willing to buy powdered eggs. There were no significant differences ($P>0.05$) between the fresh and powdered eggs for *E. coli, Staphyloccusspp, Bacillus spp, Lactose bacillus* and *Clostridium spp* as all were found to be negative. There was a two sensorial sessions employed for the evaluation of the reconstituted eggs employed. Two sensorial sessions were employed, the first session comprised of 30 sensory panellists who evaluated the egg products using an affective test for preference ranking and the second session comprised of 16 sensory panelists that evaluated the products for the quality attributes and acceptability of omelattes using descriptive test. Omelattes made from fresh albumen and whole eggs were ranked first with more preference to omelattes made from reconstituted albumen and whole eggs, while omelatte made from reconstituted yolk was ranked first and most preferred to omelatte made from fresh yolk. The reconstitution of whole egg was done using ratio of 1:2/3 for whole egg, 1:4/5 for albumen and 1:1/2 for yolk. There was significant difference ($P<0.05$) for acceptability of omelatte prepared from fresh and reconstituted albumen. There was no significant difference ($P>0.05$) for acceptability of omelatte prepared from fresh and reconstituted whole eggs as well as yolk. It could be recommended that, more awareness on processing and utilization of powdered egg should be done through extension services to producers and consumers.

TABLE OF CONTENTS

COVER PAGE ……i
TITLE PAGE ……ii
DECLARATION ……iii
CERTIFICATION ……iv
DEDICATION ……v
ACKNOWLEDGEMENTS ……vi
ABSTRACT ……vii
TABLE OF CONTENTS ……viii
LIST OF TABLES ……xii
LIST OF FIGURES ……xiii
CHAPTER ONE ……1
1.0 INTRODUCTION ……1
1.1 Background to the Study ……1
1.2 Statement of the Problem ……2
1.3 Justification ……3
1.4 Aim and Objectives of the Study ……3
Aim of the study ……3
The specific objectives were to: ……3
1.5 Hypotheses ……3
CHAPTER TWO ……4
2.0 LITERATURE REVIEW ……4
2.1 Egg ……4
2.2 Structure and Composition of Egg ……4
2.2.1 Shell ……4
2.2.2 Cuticle ……5
2.2.3 Shell Membranes ……5
2.2.4 Albumen ……5
2.2.5 Chalaziferous Layer with Chalazae ……6
2.2.6 Yolk ……6
2.3.0 Composition of egg from chicken, duck, quail and turkey ……6

2.3.1 Nutritional/Chemical Composition of Egg 7
2.3.2 Whole Egg 7
2.3.3 Albumen 9
2.4.0 Consumption of Egg 10
2.5.0 Powdered Egg and its utilisation 10
2.5.0 Microbial attack on egg 11
2.6.0 Consumers' Perception on Powdered Egg 12
CHAPTER THREE 14
3.0 MATERIALS AND METHODS 14
3.1 Location of the Study 14
3.2.0 Experimental Materials 14
3.3.0 Experiments of the Study 14
3.3.1 EXPERIMENT ONE: Egg drying, its reconstitution and frying 14
3.4.1 EXPERIMENT TWO: Functional Properties of fresh and reconstituted chicken egg constituent, proximate composition and microbial analysis 16
3.4.2 Functional Properties of fresh and reconstituted chicken egg constituent, ... 16
3.4.3 Emulsifying activity (EA) 16
3.4.4 Foaming stability 16
3.5.0 Proximate composition 17
3.5.1 Determination of Moisture content 17
3.5.2 Determination of Ash content 17
3.5.3 Determination of Fibre 18
3.5.4 Determination of Lipids (Fat) 18
3.5.5 Determination of Crude Protein 18
3.5.6 Determination of Carbohydrate (CHO) (Pearson 1976) 19
3.6.0Microbial-count Analysis 20
3.6.1 Total bacteria, Coliform and Non-coliform 20
3.6.2 Fungal culture 20
3.6.3 Selective isolation of Salmonella spp 21
3.4.1 EXPERIMENT THREE: Sensory Evaluation 21
3.4.2 EXPERIMENT FOUR: The household consumer survey 22

3.5.0 Data Collection 22
3.7.0 Data Analyses 22
CHAPTER FOUR 24
4.0 RESULTS 24
4.1.0 Results 24
4.1.1 Consumers' Perceptions on the Quality Attributes of Egg Products (fresh and powdered yolk, albumen and whole eggs) 24
4.1.2 Attitudes of the Consumers towards Powdered (reconstituted) Egg by Ranking 27
4.1.3 Consumers' Awareness and Attitude on Powdered Egg 29
4.1.4 Products Yield 31
4.1.5 Proximate Compositions of Egg Products (fresh and powdered yolk, albumen and whole eggs) 33
4.1.6 Functional Properties of Fresh and Reconstituted eggs 35
4.1.7 Microbial load of Fresh and Powder Eggs 37
4.1.8 Reconstitution of powdered eggs 40
4.1.9 Sensory evaluation of omelattes preference made from components of the egg produced 42
4.10 Sensory Evaluation of Omelattes Prepared from Fresh and Reconstituted Powdered Eggs 44
CHAPTER FIVE 46
5.0.0 DISCUSSION 46
5.1.0 Discussion 46
5.2.0 Quality attributes, Awareness and Attitudes of the Consumers towards Powdered Egg 46
5.3.0 Products Yield, Proximate Compositions of Egg Products (fresh and powdered yolk, albumen and whole eggs) 47
5.4.0 Functional Properties of Fresh and Reconstituted eggs 48
5.6.0 Microbial load of Fresh and Powder Eggs 49
5.7.0 Sensory evaluation of omelattes preference made from Fresh and Reconstituted Powdered Eggs 49
CHAPTER SIX 50
6.0.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS 50
6.1.0 Summary 50

6.2.0 Conclusion 50
6.2.0 Recommendations 51
REFERENCES 52
APPENDIX I: Consumers' Research Questionnaire 60

LIST OF TABLES

Table 2.1: The nutritional composition of fresh chicken egg 8

Table 4.1: Consumers' Perception on the Quality Attributes of Egg Products 26

Table 4.2: Attitudes of the Consumers towards Powdered Egg by Ranking 28

Table 4.3: Consumers' Awareness and Attitudes on Powdered Egg 30

Table 4.4 Yield of processed albumen, yolk and whole egg powders (g, ml/g) per 65g egg32

Table 4.5:Proximate compositions of fresh and reconstituted powdered eggs 35

Table 4.6:Functional Properties of Fresh and Reconstituted eggs 36

Table 4.7: Microbial load of Fresh and Powder Eggs 38

Table 4.8: Reconstitution of powdered egg (g, ml) 41

Table 4.9:Sensory evaluation on omelette preference made from components of egg 43

Table 4.10: Sensory Evaluation of Omelattes Prepared fromFresh and Reconstituted Powdered Eggs 45

LIST OF FIGURES

Figure 1: Egg yolk, albumen separator 15

Figure 2: Total aerobic plate counts 39

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Eggis an affordable nutrient-rich food commodity thatcontains highly digestible proteins, lipids, minerals, andvitamins.The high content of highly bio-available protein in eggs is of great benefit tohuman nutrition(Fisinin*et al.*,2008). The quality of protein in eggs is used as thestandard for measuring the quality of other food proteins. Eggs are used in polymer, paint, ink and paper making(Audic*et al*.,2005).

Specific protein components of the hen's egg are associated with diverse biological properties, which include antimicrobial activity,immune modulatory, anticancer, and antihypertensive activities, and antigenic or immunologic characteristics (Li – Chan *et al*.,1995; Mine and Kovacs-Nolan, 2006).Eggs are also utilized for their functional properties mostly by the food and confectionaryindustries as well asnon-food industries,because of eggs foaming ability, gel texture, emulsifying or binding activity(Desrosier, 1977; Bueschelberger, 2004). The functional properties of emulsification, thickening, foaming and moisturizing help in contributing desirable texturing and physical characteristics in the industrial production of many food products in which they are being incorporated.

Examples of egg productsinclude hard-cooked chopped eggs, precooked scrambled eggs or omelettes, quiches, precooked egg patties, scrambled egg mixes, and crepes, whole egg without shell (melange), liquid egg product, egg yolk, egg albumen, frozen egg product, dried egg product, concentrated (condensed) egg product, blended egg product, conventional(natural) egg product, modified egg product, fermented egg product, thermo-stabilized egg product,

pasteurised egg product, acidified egg product, heat-treated egg albumen, salted or sugared product and commodity lot (Froning, 2008; Jay, 2000)

Eggs do not stay long at ambient temperature, as it is vulnerable to microbial spoilage. Processing protects it against spoilage and increases its value and shelf life.Shell eggs are however, difficult to transport because of their bulkiness, fragility, and highly perishable nature (Frazier and Westerhoff, 1988; Jay, 2000). Egg in powder form, provides a near complete solution to these problems. Interior characteristics such as yolk index, Haugh Unit, and chemical composition are important in the egg- product industry as the demand for liquid egg, frozen egg, egg powder and yolk oil increases (Jay, 2000).

Egg has a lot of uses. A special technology has been developed by Yamamoto *et al*. (1997) for the commercial-scale production of antigen-specific yolk immunoglobulins (IgY) from eggs for food, feed, cosmetics, diagnostics and affinity chromatography applications. Oral administration IgY has been effective in preventing disease like dental caries, rotaviraldiarrhea, etc.

1.2 Statement of the Problem

Egg glutis one of the major problems of egg farmers, especially during the hot dry season, henceeggperishes. Also, fresh shell egg requires voluminous storing space in the farm; high cost of handling like transporting it to market is higher, it easily spoils and it is labour intensive for food industries (Jay, 2000). Conventional methods of egg preservation like dipping in water glass and spraying of oil are not good enough to solve egg glut and handling of eggs. Thus, processing of eggsinto dried productsand preserve eggs for future use during period of scarcity. For many years, eggs were marketed primarily as shell eggs, but in recent years, egg consumption in the form of egg products has increased (Brennan, 2005). Drying is a successful

way of preserving eggs, and the egg drying industry has developed over the years. However, there is lack of consumer awareness on powdered egg and its utilization.

1.3 Justification

There is shortage of information and awareness about the consumers' acceptability and utilization of powdered egg to enhance processors to go in to it.. However, food and non-food industrial applications of eggs require the use of specific egg component (albumen or yolk) because of specific functional properties they impart on food and non-food products (Bueschelberger, 2004; Mine and Kovacs-Nolan, 2006). Therefore, there is need for separating egg into its components for different food and non-food applications.

1.4 Aim and Objectives of the Study

Aim of the study

The aim of the study was to determine consumer perception onpowdered eggand compare qualities fresh and reconstituted eggs.

The specific objectives were to:

1. Compare reconstituted and fresh eggs for functional properties and proximate compositions
2. Examine quality attributes of the eggs
3. Determine the consumer attitude/awareness/perception/acceptabilitys on powdered egg

1.5 Hypotheses

- ✓ Null Hypothesis (H_0) = there is nosignificant difference in the functional properties and proximate compositions of reconstituted yolk, albumen and whole egg
- ✓ Null Hypothesis (H_0) =there is nosignificant difference inthe consumer acceptability of omelette produced from fresh egg and reconstituted egg powder

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Egg

The egg is an animal product produced by poultry mainly chicken, guinea fowl, duck, goose, turkey, pigeon, quail and some other birds. There are many types of poultry eggs consumable as protein and amino acid supplements playing roles in the human diet and nutrition (Fisinin *et al.,* 2008). A statistical data by (FAO, 2010) reported that, the total World's, African and Nigerian productions of eggs is about 66,373.6, 2,991.9 and 640metric tons respectively.

2.2 Structure and Composition of Egg

The egg is basically composed of a yolk at the centre with about 9.5%, surrounded by an albumen with about 63%, both enclosed within the shellwith about 27.5%(Li-Chan et al., 1995;Hincke*et al.,* 2012; USDA, 2000). Other components of egg are: the cuticle, the shell membranes, the chalazaeferous layer together with chalazae, the vitelline membrane. The formationand development of the yolk occurs in the left ovary of hensfollowing ovulation, egg formation continues in theleft oviduct where the albumen and later the shell are deposited. The total respective solids of the albumen and yolk are 11% - 12% and 50% - 52% (Zaheer, 2015). Proteins are present primarily in egg yolk and egg white, while lipids are almost exclusively in the yolk and minerals are found as the primary component of the eggshell.

2.2.1 Shell

The shell is composed of a foamy or thin film layer of cuticle, with about 90-94% calcium carbonate crystals and two shell membranes (Li-Chan et al., 1995;Hincke *et al.,* 2012).
It has high content of glycine, glutamic acid, lysine, cysteine and tyrosin.The porous structure is semi-permeable limiting air and water passage. Variability in egg shell colour is due to the

genetic make-up of a hen. Shells are more commonly white or brown, but may be blue or green. Shell colour influences regional consumer demand but does not influence egg quality or taste (Bell, 2000).

2.2.2 Cuticle

The cuticle is the most outer coating layer of egg about 10 μm thick covering the pore canals, which helps to prevent moisture loss, microbial or foreign material invasion (Board & Hall, 1973; Whittow, 2000). Inner and outer egg shell membranes separating the shell and albumen are transparent protein membranes that provide an efficient defence against bacterial invasion as well as a foundation base for shell formation (Sparks, 1994; Hincke *et al*., 2012). The air cells form, between the outer and inner membranes at the blunt end of the egg as the egg contents cools and contracts after oviposition. The air cells grow larger with age after lay (Zaheer, 2015).

2.2.3 Shell Membranes

This is composed of the inner and the outer membranes residing between the albumen and the inner surface of the shell. The inner membrane (the *egg membrane)*, has three layers of fibres that are parallel to the shell and at right angles to each other. On the other hand, the outer membrane (the *shell membrane)*, has six layers of fibre oriented alternately in different directions (Li-Chan et al., 1995; Hincke *et al.,* 2012)

2.2.4 Albumen

Albumen or egg white is composed of four distinct layers: an outer thin white next to the shell membrane, a viscous or outer thick white layer, an inner thin white, and a chalaziferous or inner thick layer.The contents of each layer are about 23.3%, 57.3%, 16.8%, and 2.7%, respectively (Li-Chan et al., 1995;Hincke *et al.,* 2012; USDA, 2000)). The egg white or albumen is

comprised of about 90 % water and 10% protein (Li-Chan et al., 1995;Hincke *et al.,* 2012; USDA, 2000)).

2.2.5 Chalaziferous Layer with Chalazae

The chalaziferous layer is a fibrous layer covering egg yolk, which is twisted at both sides of the yolk membranes long axis of the egg, forming the chalazae cord. The chalazae cord stretches into the thick albumen layer at both sides to suspend the yolk in the center of the egg (Okubo *et al*., 1997).The chalazae, are opaque ropes of albumen connecting and holding the yolk in the center of the egg and attach the casing of the yolk to the membrane lining the shell (Zaheer 2015).

2.2.6 Yolk

The yolk is made up of a germ cell (germinal disc), which is the site of cell division for a fertile egg. The vitelline membrane, a transparent barrier enclosing the yolk, preventing leakage of yolk contents into the albumen. The colour of the yolk is due to the carotenoides (carotene and xanthophylls) which are natural pigments conferring the various yellow colours (light yellow, intense yellow, pale yellow, dark brilliant orange etc.) depending upon the diet of the layer. However the colour of the yolk has no connection with the nutritive value of an egg. The yolk is adhesively firm that can easily be scooped or separated after lay immediately. However, there is transfer of water from albumen to the yolk during storage which weakens the adhesive force and makes the yolk loosen its vigor. (Kiosseoglou 1989;Thapon and Bourgeois 1994; Li-Chan *et al*., 1995; Zaheer 2015).

2.3.0 Composition of egg from chicken, duck, quail and turkey

The compositions of eggs from different poultry species share some characteristics in common, while others differ (Huang and Lin 2011; Tserveni-Goussi and Fortomaris 2011).They possess

some differences in their energy contents that are mostly explained proportionately by the change in relation to yolkwith albumen. The energy (kcal/100g) for chicken, quail, duck, goose, and turkey eggs is 143, 158, 185, 185, 171, respectively. The relative protein content is stably around 13%. Lipid content varies from 9.5% (chicken) to more than 13% (duck, goose). Duck and goose have relatively higher fat content and higher percentage of yolk than chicken egg (Huang and Lin 2011).

2.3.1Nutritional/Chemical Composition of Egg

2.3.2 Whole Egg

Egg is an excellent source of high-quality nutrients such as proteins, lipids, minerals, trace elements and vitamins (Song and Kerver, 2000;Herron and Fernandez, 2004). Egg is approximately composed of 75% water, 12% proteins 12% lipids, ~1% carbohydrates and minerals (Li-Chan et al., 1995). Most of the egg's proteins are present in the egg white with about 50% and 44% in the yolk, while eggshell contains the rest of the proteins. Lipid is majorly in the egg yolk with very little in the albumen (0.03%, w/w) content (Li-Chan *et al*., 1995; Mine, 2002; Hincke *et al*., 2012). It is reported that, the nutritional profile of egg in egg yolk can be modified through diet, leading to "designer eggs" such as"omega-3 eggs" and"vitamin-enriched eggs" with additional health attributes (Mine, 2002; Hincke *et al*., 2012). Designer eggs continue to grow to meet the demands of health-conscious consumers through value addition.

Egg is an important food ingredient that contains most essential nutrients required for proper body functioning with available high quality proteins, which are used as the reference standard scale for measuring proteins of other food items (Tshikosi 2009). Also egg is an important source of vitamins A, B, D, E and K, fat and minerals like iron, zinc, iodne (BunchasakandKachana 2009; Fisinin*et al.*,2008;Iannotti, Lutter, Bunn, and Stewart, 2014).

Table 2.1: The nutritional composition of fresh chicken egg

Nutrient	Nutrient content per 100 g	per medium egg (58 g)[a]	Cut-off for source'claim (15%RDA)	RDA
Energy (kcal)	151	78	-	-
Protein (g)	12.5	6.5		
Carbohydrate (g)	Trace	Trace	-	-
Fat (g)	11.2	5.8	-	-
Cholesterol (mg)	391	225	-	-
Retinol equiv. (mg)	190	98	120	800
Vitamin D (mg)	1.6	0.9	0.75	5
Riboflavin (mg)	0.47	0.24	0.21	1.4
Folate (mg)	50	26	30	200
Vitamin B_{12} (mg)	2.5	1.3	0.38	2.5
Choline (mg)	160	83.2	82.5	550
Biotin (mg)	20	10	7.5	50
Phosphorus (mg)	200	104	105	700
Iron (mg)	1.9	0.99	2.1	14
Zinc (mg)	1.3	0.68	1.5	10
Iodine (mg)	53	28	22.5	150
Selenium (mg)	11	5.7	8.25	55

Notes: Values italics meet the minimum requirement to be labelled as 'a source' according to EU regulations (European Parliament and Council, 2006; European Commission, 2008), except for protein which can be labelled 'high' because more than 20% of the energy value is protein (European Parliament and Council, 2006); RDA, recommended daily allowance; refers to edible portion of an average 56 g egg
Source: compiled by Ruxton*et al.* (2010)

2.3.3 Albumen

Albumen is considered an ideal protein by which all others are measured, because it contains all essential amino acids abundantly, digestible and complete in correct proportion forhumannutrition (Meister, 2002). The major constituents of albumen are water (92%) andprotein(~10%), and then followed by carbohydrates (0.4–0.9%) that exist in free form, usually as glucose, or forming complexes with proteins such as glycoproteins that contain mannose

and galactose units, lipid (0.03%) and ash (0.5–0.6%). Albumen can also be considered as a protein system that contains ovomucinfiber in an aqueous solution of globular proteins (Li-Chan *et al.,* 1995). Ovoalbumin, a phosphoglycoprotein with a molecular weight of 45 KDa and an isoelectric point (pI) of 4.5, is the most abundant protein in albumen (54–58%) (Li-Chan *et al*., 1995). Ovotransferrin, accounting for about 12% of albumen proteins, is a glycoprotein with a molecular weight of 75 KDa and a pI of 6. Ovoglobulins consist of two proteins, G2 and G3, with molecular weights between 30 and 45 KDa and a pI of 4.0; these proteins are known for their excellent foaming and beating properties. Ovoinhibitor possesses a molecular weight of 49 KDa and a pI of 1.5; it is capable of inhibiting trypsin and chymotrypsin as well as fungal and bacterial proteases (Li Chan *et al*., 1995). Other components, including avidin, cystatin, ovoinhibitor, ovostatin, ovoglycoprotein, ovoflavoprotein, and G2 and G3 globulin, are found in the egg white and contain minor levels of carbohydrates, minerals, and lipids (Li-Chan et al., 1995; Mine, 2002).

2.3.3 Yolk

The lipid matrix within the egg yolk is believed to enhance the bioavailability of nutrients, such as lutein and zeaxanthin (Herron and Fernandez, 2004).

IgY technology, including the production and use of polyclonal IgYantibody(Ab), is a highly innovative and an expanding branch of biotechnology. Indeed, an extraordinary amount of Ab can be produced from only onehen—approximately 17–35 g of total IgY/chicken/year—of which 1–10% canbe expected to be antigen-specific. In addition, IgY Abs has no cross reactivity withrheumatoid factors (Larsson *et al*., 1991).

2.4.0 Consumption of Egg

Eggs are one of the most commonly recognized, accepted food by the consumers as well as available and affordable source of nutrients required for wellbeing worldwide and wholesome food with a balance of essential nutrients particularly protein for growth and development (Ojo 2003; Aboki *et al*., 2013). Besides their nutritionalvalue, eggs are consumed for their health promoting properties such as for prevention of disease and therapeuticpotential. Also, eggs are consumed for enjoyment particularly because of its sensory taste. Globally, there has been an increase in the consumption of egg in many countries between the periods 1990-1992 and 2003-2005. It is observed from the result that, the increase was at a rate ranging from 2% in Beninand Nigeria to 346% in Myanmar. (Martinez-Michel *et al*., 2011)

2.5.0 Powdered Egg and its utilisation

The per capita egg consumptionin most countries varied between 2 to 4 eggs weekly. Over the past 20 years, an increase in the consumption of egg was observed to be slow in most of the industrialized westernized countries (International Egg Commission, 2011).

Powdered egg is an egg in the form of powder state which is dehydrated or dried and then ground into fine particle size (Lechevalier*et al.* 2011).It is used as an emulsifyer in emulsion formulations, increasing their stability, properties and economy. It is an excellent source of high quality protein, about 44% found in the yolk and 56% in the egg white (Deman, 1999). It is

alsoused widely in processed foods due to its microbiological safety and reduced volume (Caboni*et al*., 2005). It can be use instead of fresh liquid egg with or without reconstitution depending on the intended use.Powdered eggs provide a convenient alternative to fresh eggs which makes iteasier to be storedup to about a year or under proper storage conditions with reduced risk of contamination due to processing thus contributing to its microbiological safety and reduced volume (Caboni*et al* 2005). It is a good solution to egg glut and better way of handling eggs (Frazier and Westerhoff, 1988; Jay, 2000). There is an industrial increase in the use of powdered eggs. Food industries use dried egg products as ingredients instead of liquid eggs (Rao and Labuza 2012). According to Rannou*et al.* (2012) egg powder is used in products like bakery foods, bakery mixes, mayonnaise and salad dressing, confections, ice cream and pasta. Food drying is not just a new phenomenon; rather it has been practised successfully in drying of fruits and vegetables (Sagar and Suresh Kumar 2010). The current technological procedures of egg powder production is to wash, break, filter and pasteurize the egg liquid produced, dry them whole or into their various components of egg yolk and egg white.

Several methods of dehydrating or drying eggs have been developed. It has been stated by Sperber and Doyle (2009) that, the most commonly use methods of dehydrating or drying eggs are: spray drying method, freeze drying method, sun drying and pan drying method. Other methods like sun/solar drying, microwave drying, drum drying, spouted bed drying, fluidise foam mat freeze drying method and the use of dehydrator method (Mujumdar 1995; Vega-Mercado *et al*. 2001; Mnyandu 2014)

2.5.0 Microbial attack on egg

The content of shell eggs is generally sterile, yet vertical contamination may occur. The microbial contamination can lead to sanitary or spoilage problems. The sanitary problem mainly

concerns Salmonella Enteritidis, one of the most important agents involved in outbreaks in relation to shell eggs and egg products (Techer *et al* 2013).The microflora of the eggshell is dominated by Gram-positive bacteria such as Staphylococcus, Streptococcus, Bacillus, Aerococcus and Micrococcus, other minor contaminants are Gram-negative bacteria, such as Salmonella, Escherichia and. Alcaligenes sp. (De Reu *et al*., 2009; De Reu *et al*., 2008; Moats, 1980). Depending on the study, the level of mesophilic aerobic microbiota on the surface of the eggshells ranges from 103.8 to 106.3 cfu/egg, with an average level around 104.5 cfu/egg (Moats 1980; Jones *et al*. 2004; De Reu *et al*., 2005; Musgrove *et al.* 2005).

The predominant microorganisms surviving pasteurization are Gram-positive bacteria, such as Streptococci, Enterococci and Bacillus spores (Protais *et al.*, 2006). Nevertheless, the spoilage of egg products is most commonly due to post-pasteurization contaminations by Gram-negative bacteria, such as Pseudomonas or Enterobacteriaceae. Visual spoilage of egg white is difficult to evaluate. Liquefaction may occur throughout storage times, mainly due to protein denaturation accompanying microbial growth (Correa *et al*., 2008). On the other hand, the bacterial spoilage of liquid whole egg and egg yolk often involves visible modifications such as coagulation and/or colour changes. The other spoilage characteristics concern the consistency/viscosity and flavour. Whole egg and egg yolk are particularly rich in proteins and lipids including phospholipids.

2.6.0 Consumers' Perception on Powdered Egg

The attitudes of consumers towards egg are affected by many factors particularly the intrinsic and extrinsic quality attributes. The products quality attributes such as egg colour, packaging, price, form/state, taste etc are animportant factors to consumers' demand and purchasing power (Fearne and Lavelle, 1996; Goddard et al., 2007).They also demonstrated that brand name and nutritional information on package might have influence on the consumers' taste perception and

consequently their consumption of eggs. It is reported from the results of a work which revealed that the consumers believe that nutritional value of white regular eggs is very low, even though white regular eggs may have the same nutritional value as brown regular, free-run and free-rage eggs (Egg Farmers of Canada, 2008; Goddard *et al*., 2007). According to Mnyandu (2014) consumers expressed their willingness to powdered egg. Mnyandu (2014) indicated that acceptability of scramble egg made from fresh egg had higher score than that made from powdered egg.

Sensory attributes and psychological aspects of an individual play a major role in determining food acceptance to meet their sensory requirement in their perceptions of appearance, texture, taste and aroma (Prescott 2007 and Heldam 2004).

CHAPTERTHREE

3.0MATERIALS AND METHODS

3.1Location of the Study

The study was conducted at the Food Technology and Home Economics Department of the National Agricultural Extension and Research Liaison Services of Ahmadu Bello University (ABU) Zaria, which is islocated on longitudelatitude 11^0 and 12^0, withinan altitude of640m above sea level. The area falls within the Northern Guinea Savanna agro-ecological zone of Nigeria, having an average rainfall of 1100mm with temperature varying from 26^0Cto 35^0Cdepending on the season. While the relative humidity during the Harmmatan period and wet season are 21% and 72% respectively (Institute for Agricultural Research, 2018).

The survey was conducted within ABU Staff Quarters of Samaru and Kongo Campuses of ABU while the functional properties determination was conducted at the Biochemistry Laboratoryof the Department of Animal Science ABU Zaria.

3.2.0Experimental Materials

The following materials were used: Dehydrator, 6 crates of ShikaBrowneggs, blender, knives, spoons, scooping/separating equipment, buckets, trays, plates, bowls, clean satchet water, serviette, crackers biscuits and hand gloves.

3.3.0 Experiments of the Study

3.3.1EXPERIMENT ONE: Egg drying, its reconstitution and frying

A total of 180 fresh, cleaned and good quality eggs of Shika brown hens was sourced from the poultry farm of National Agricultural Extension and Research Liaison Services (NAERLS), ABU, Zaria Livestock Department demonstration farm.

The eggs were washed, dried, broken and separated into albumen and yolk using a simply local yolk separator. The eggs were whipped up using blender for a homogenised product. Then the egg slurry of albumen, yolk and whole eggs were poured into sheets attached to dehydrator(PRESTO Dehydro digital electric food dehydrator 06301) and set at 62.8°C and allowed to dry for about 16 hours, 19 hours and 24 hoursfor the egg white (albumen), whole egg and yolk respectively, then all ground into powder. The resulting powders were reconstituted into liquid albumen, liquid yolk and liquid whole egg with distilled water. The proportions of water for reconstitution added was determined from the modal moisture content of each component obtained from the broken eggs according to Ross (2008). The ratios of whole egg powder, albumen powder and yolk powder to water used were 1:2, 1:4, and 1:1.5 respectively. All the reconstituted eggs were allowed to settle for about 5 minutes. Thereafter fresh eggs were broken and separated into albumen and yolk, then beaten thoroughly using fork. Both fresh and reconstituted egg powder were fried unspiced by heating 6 table spoons of vegetable oil each on frying pans. The fried egg components were then cut into 2x3cm each. Samples of unspiced omelattes were prepared two each from fresh and reconstituted eggs.

Figure 1: Egg yolk, albumen separator

3.4.1 EXPERIMENT TWO: Functional Properties of fresh and reconstituted chicken egg constituent, proximate composition and microbial analysis

3.4.2 Functional Properties of fresh and reconstituted chicken egg constituent,

Functional properties ofthe reconstituted and fresh eggs were comparatively determined at the Biochemical Laboratory of the Department of Animal Science, Faculty of Agriculture, ABU Zaria. The functional properties including emulsifying activity, foaming ability and foaming capacity were determined. Fresh and reconstituted eggs were subjected to the following tests.

Three samples each of the fresh and reconstituted products Albumen, Yolk and whole eggs were tested for proximate composition, emulsifying activity (EA), and Foam stability.

Proximate composition was determined using the AOAC, (2000) methods.

3.4.3 Emulsifying activity (EA)

This was determined similar to the method described by (Yasumatsu *et al*., 1972)

Emulsifying activity

The emulsion 100ml each of fresh and reconstituted eggs was be poured into a graduated measuring cylinder and shook. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage.

$$\text{EA} = \frac{(\text{Height of the emulsified layer}) \text{ mm}}{(\text{Height of the total amount of content in the tube}) \text{ mm}} \text{ x } 100$$

3.4.4 Foaming stability

This followed the method of Coffman *et al*. (1997), where 100ml of both fresh and reconstituted eggs was poured into a graduated measuring cylinder and then whipped. The total volume after 15min was noted. Percent volume increase/decrease was calculated.

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

$$\mathbf{Foamingcapacity} = \frac{\mathbf{(Volumeafterstanding - volumebeforestanding)ml}}{\mathbf{(Volumebeforestanding)ml}}\mathbf{x100}$$

3.5.0 Proximate composition

3.5.1 Determination of Moisture content

The eggs were analysed for their proximate compositions according to AOAC (2000) procedure. Aluminum or plastic dishes were washed and dried to a constant weight in an oven at 100^0C. They were later removed and cooled in a dessicator and weighed (W1). 2grams of the grounded (powder) sample was placed in the weighed moisture dish (W2). The dish containing the sample was kept in an oven for about 3hours, the sample were removed and cooled in the dessicator and weighed W3.

The % of moisture was calculated as: $\frac{\text{W2-W3} \times 100}{\text{W2-W1}}$

3.5.2 Determination of Ash content

Crucibles were cleansed and dried in the oven, after drying; they were cooled in the dessicator and weighed (W1). 2grams of the grounded (powder) sample was placed in the crucibles and weighed (W2). They were transferred into the Muffle Furnace for about 550^o C, then removed and cooled in the dessicator and weighed (W3).

The % of Ash was calculated as: $\frac{\text{W3-W1} \times 100}{\text{W2-W1}}$

3.5.3 Determination of Fibre

2grams of the sample was placed in a beaker containing 1.2ml of H_2SO_4 per 100ml of solution and boiled for about 30minutes, the residue was filtered and wash with hot water, the residue was transferred to a beaker containing 1.2gram of NaOH per 100ml of solution and boiled for about 30minutes, the residue was washed with hot water and dried in an oven and weighed (C2), the weighed sample was incinerated in a Furnace for about $55O^OC$, remove and allow to cool, and weigh (C3).

The % of Fibre was calculated as: $\frac{C2-C3}{W} \times 100$

3.5.4 Determination of Lipids (Fat)

250ml clean boiling flask was dried in oven, it was then transfered into a dessicator and allowed for cooling. The empty filter paper was weighed and labeled W1. 2 grams of sample was weighed into labeled thimbles (filter paper). W2 and then filled the boiling flask with petroleum spirit or N-hexane. The soxhlet apparatus was assembled and allowed refluxing for 8hours then emoved and transfered to an oven to dry. It was then transfered from the oven into a dessicator and allowed cooling then weighed W3.

The % of Fat was calculated as: $\frac{W2-W3}{W2-W1} \times 100$

3.5.5 Determination of Crude Protein

Digestion:

0.5- 2gram of sample was weighed out into a kjeldahl flask. A catalyst (copper) and 15ml conc. Sulfuric Acid (H_2SO_4). Were added in the fume cupboard, heated till solution assumed a green colour. Any black particles showing at the mouth and neck of the flask was Cooled and washed

down with distilled water. After cooling, the digest was transferd with several washings into 100ml with distilled water.

Distillation:

Steam was use through the Markham distillation apparatus for about 15minutes.

Under the condenser, a 100ml conical flask containing 10ml of Boric indicator was placed. 10ml of the digest was Pipetted into the body of the apparatus via the small funnel aperture; washed down with distilled water followed by 10ml of 40% NaOH solution. It was Steamed through for about 5-7 minutes and collected ammonium sulphate. (about 30-40ml). The receiving flask was removed and washed down the tip of the condenser into the flask.

Titration:

The solution in the receiving flask was titrated using N/100 (0.01N) hydrochloric acid and the Nitrogen content was calculated and hence the Protein content of the sample.

The % of protein was calculated as: Final reading –Initial reading-blank (0.2) x standard number of Nitrogen (1.4) divide by initial weight (0.5) x standard number of protein (6.25)

3.5.6 Determination of Carbohydrate (CHO) (Pearson 1976)

By difference, in this method carbohydrate content is obtained by calculations having estimated all other fractions by proximate analysis i.e.

=100- (% of moisture + %Ash + %Protein + %Fat)

Functional properties for reconstituted and fresh eggs were comparatively determined using comparison in the Biochemical Laboratory of the Department of Animal Science Faculty of

Agriculture ABU Zaria. Functional properties such as emulsifying activity, foaming ability and foaming capacity were determined.

3.6.0 Microbial-count Analysis

Preparation of media: Plate count Agar and McConkey agar media were used for total bacteria count, coliform count and non- coliform count. Sabauroud dextrose agar was utilized for the isolation of fungal organisms after incubation for 2-3 days at room temperature and triple sugar ions agar for the selective isolation and identification of *Salmonella* spp. All the media were prepared following the instruction of the manufacturer and sterilized by autoclaving at 121°C for about 20 minutes as described by Osei-Somuah*et al.* (2003).

Sterile opening and egg mixing for culture: Disinfection of the surface of all the eggs was done using 70% ethanol for culturing the contents of the eggs. For a sample of all the eggs, a sterile spatula was used to create an opening in the egg and the content was poured into a sterile measuring glass beaker then thoroughly mixed.

3.6.1 Total bacteria, Coliform and Non-coliform

The total bacteria, coliform and non-coliform counts were determined using the spread plate method as reported by Bartram *et al.* (1996). The plates showing colonies were selected, the counted and then the results were presented in CFU/ml for fresh eggs and CFU/g for powdered egg.

3.6.2 Fungal culture

Lacto-phenol cotton blue staining technique was used for the identification of fungi by cellular morphology and colony. Tests such as citrate utilization, methyl red and urease were carried out biochemically (Holt, 1994).

3.6.3 Selective isolation of Salmonella spp

A sterile incubating wire loop was used repeatedly for all the samples to pick a colony from non-coliform growth on the McConkey medium and sub-culture and sub-culture it on the triple sugar Ions agar in a slant tube. The incubated medium was then incubated for about 24 hours at 37°C.

3.4.1EXPERIMENT THREE: Sensory Evaluation

This involved reconstitution of powdered eggs into liquid forms in the ratio of 1:2 table spoon portions of egg powder and water respectively according to Ross (2008). Also plain omelattes were prepared using a frying pan and vegetable oil thereafter sensory evaluationcarried out.

Two sensory evaluation sessions in the manner of Kemp *et al.* (2009) was carried out to compare the two samples of omelattes. The panelists consisted of men and women of about 20-40 years. They were made to sit on a back to back position or far apart there by not facing each other to avoid interaction. The score sheets were provided to them to test and describe or rate their perceived acceptability or preference of the samples. The first session was a 'Quantitative Descriptive Analysis (QDA)'using a five-point hedonic scale to compare the two samples for the quality descriptors obtained in the experiment one of the study. This employed a non-smoker trained panel of 16 judges. The 16 panelists have undergone rigorous training sessions on the sensory evaluation procedures prior to the sensory evaluations. The second session was done using a ranking scale for the comparison of consumer preference on omelattes made from fresh and reconstituted powdered egg using atrained consumer panel of 30 judges. In all sensory evaluation sessions, samples were blind coded using three digit codes obtained from the table of random numbers of excel and presented in a balanced randomised order of presentation in order to avoid bias. Before and after tasting of any sample, all the panellists were provided with

crackers biscuits to chew and sachet water for rinsing mouth pallets so as to avoid bias and sample tasting effect. Serviette and tooth picks were also provided to the panelists.

3.4.2 EXPERIMENT FOUR: The household consumer survey

This was done using a simple random sampling and 120 households were selected using a card system technique. The respondents were household heads or none household heads. The households were divided in a manner of cluster sampling into low density with 20, medium density with 40 and high density with 60 respondents respectively. And this was done using a proportionate sample size. A house to house one on one contact with all the respondents was done. In all 120 respondents were choosing for this study. The questionnaire used for the survey is at appendix 1. Samples of powdered egg products were taken to the consumers for interviewing them.

3.5.0 Data Collection

For the purpose of survey; primary data was collected for this study through the use of questionnaire and interview schedule.

3.7.0 Data Analyses

Descriptive statistics using frequency distribution, percentage, mean, coefficient of variation and standard deviation for the survey was used. Analysis of Variance using General Linear Model Procedure for the parametric data.

Experimental Design

Three egg components constituents of (albumen, yolk and whole) were allocated to two product treatments (reconstituted and fresh) 2x3 factorial arrangement in a completely randomized design.

$Y_{ijk} = \mu + F_i + C_{j+} (FXC)_{ij} + e_{ijk}$

Where:

Y_{ij}= Response parameter

μ= population mean

F_i = the jth form of egg (Fresh or Reconstituted)

C_j= thejth egg constituent (whole, Yolk and Albumen)

CHAPTER FOUR

4.0 RESULTS

4.1.0 Results

4.1.1 Consumers' Perceptions on the Quality Attributes of Egg Products (fresh and powdered yolk, albumen and whole eggs)

Table 4.1 presents the consumers' perceptions on the quality attributes of egg products. The price has the highest value showing that it is an important quality in egg consumption with the frequency of 60%, followed by very important with the value of 26.7%. Both somewhat important and not important have the lower values of 6.7% each. Price is therefore a good quality indicator towards consumer demand for a product.

Convenience of packaging as a quality for egg products has its highest value as very important with the value 60%, followed by important with 30%. Those that responded not important have 6.7% and for somewhat important with 3.3%. Food safety is another quality attribute to egg products. The respondents rated food safety to be important with the highest value of 60.8% as an important indicator for consumers' attitude to egg products demand, followed by very important with 44.2%. Very few respondents considered food safety to be not important with the value of 4.2% and fewer considered food safety to be somewhat important with 0.8%.

Colour as a quality attribute to egg products which was responded to be very important by most of the respondents 45% followed by stating the colour to be important by 42.5%. Few respondents perceived colour to be none important quality attribute to egg products with 6.8% and fewer as somewhat important with 5.8%.

Texture is perceived to be important with the highest value 65.8%, followed by very important with 23.3%. Somewhat important for texture is considered to have 7.5% and not important has

the least value. Aroma is considered to be very important as quality attribute to egg products with the highest value of 49.2%, followed by important with 41.7%, not important with 5.0% and least as somewhat important with 4.2%. Taste is considered to be important with 53.3%, followed by being very important with 35.8%, not important with 6.7% and least as somewhat important with 4.2%. Ease of preparation is considered to be very important with the highest value of 59.2%, followed by being important with 53.3%. 4.2%respondents' perceived ease of preparation to be not important and 1.7% considered it somewhat important.

Table 4.1: Consumers' Perception on the Quality Attributes of Egg Products

Parameter	NOT IMP	SOME WT IMP	IMPT	VERY IMPT
Price	6.7%	6.7%	60%	26.7%
C P	6.7%	3.3%	30%	60%
F S	4.2%	0.8%	50.8%	44.2%
Colour	6.78%	5.8%	42.5%	45%
Texture	3.3%	7.5%	65.8%	23.3%
Aroma	5.0%	4.2%	41.7%	49.2%
Taste	6.7%	5.8%	42.5%	35.8%
E P	4.2%	1.7%	35.0%	59.2

IMP, IMPT = important**, WT=**what**, CP=** convenience of packaging
FS= Food safety**, EP=**Ease of preparation

4.1.2 Attitudes of the Consumers towards Powdered (reconstituted) Egg by Ranking

Table 4.2 presents the attitudes of the consumers towards powdered egg by ranking between fresh and powdered (reconstituted) egg to be first or second preferred for some quality attributes of egg (taste, aroma, colour and texture) or even never use. For colour, fresh is ranked first with 85.8% and reconstituted 14.2%. Fresh is ranked second with 17.5% and reconstituted is ranked second with 24.4% and 58.3% never use. For texture, fresh is ranked first with 88.3% and reconstituted 11.7%. Fresh is ranked second with 10.8% and reconstituted is ranked second with 17.5% and 71.7% never use. For aroma, fresh is ranked first with 96.7% and reconstituted 0.8%. Fresh is ranked second with 3.3% and reconstituted is ranked second with 14.2% and 84.2% never use.For taste, fresh is ranked first with 99.2% and reconstituted 0.8%. Fresh is ranked secondwith 0.8% and reconstituted is ranked second with 9.2% then 90.2% never use.

Table 4.2: Attitudes of the Consumers towards Powdered Egg by Ranking

Parameter		First	Second	Never use
Colour	F	85.8%	14.2%	
	R	17.5%	24.4%	58.3%
Texture	F	88.3%	11.7%	
	R	10.8%	17.5%	71.7%
Aroma	F	96.7%	3.3%	
	R	1.7%	14.2%	84.2%
Taste	F	99.2%	0.8%	
	R	0.8%	9.2%	90.2%

F= Fresh egg, **R=** Reconstituted egg

4.1.3 Consumers' Awareness and Attitude on Powdered Egg

Table 4.3 presents consumers awareness and attitudes on powdered egg and their willingness to buy powdered egg. There was little knowledge on powdered egg as only 5.8% respondents were aware of powdered egg while 94.2% were not aware of powdered egg. For information on powdered egg, 15.1% have been informed and 84.9% have not been informed of powdered egg. This indicates that there is little awareness on powdered egg by consumers. When buying egg, 32.5% respondents cared whether the product is of fresh or powdered, while 67.5% did not care whether the product is of fresh or powdered. All they are after is just egg, it does not matter if it is fresh or powdered. For marketability of powdered egg, 78% are willing to buy powdered egg, while 21.7% are not willing to buy powdered egg. For food safety and consumers' satisfaction, only 33.3% are still willing to buy powdered egg if it is not certified by a quality and safety regulating agency, while 66.7% are not willing to buy unless if the powdered egg is certified.

Table 4.3: Consumers' Awareness on Powdered Egg

Parameter	Yes	No	Total
Knowledge on			
Powdered Egg	5.8%	94.2%	100
I PE	15.1%	84.9%	100
C F/P	32.5%	67.5%	100
WB PE	78.3%	21.7%	100
WB PE ENC	33.3%	66.7%	100

I PE= Information on powdered egg, **C F/P=** care if product is fresh or powdered, **WB PE**= willing to buy powdered egg, **WB PE ENC**= willing to buy powdered egg even if not certified

4.1.4 Products Yield

The yield of albumen, yolk and whole egg powders per egg of about 65g obtained from the use of dehydrator processing method amounted to 5g, 10g and 15g which translated to 2.30ml/g, 2.00ml/g, and 4.30ml/g respectively as shown in Table 4.4.

Table 4.4: Yield of processed albumen, yolk and whole egg powders (g, ml/g) per 65g egg

Yield	G	ml/g
Albumen	5.00	2.30
Yolk	10.00	2.00
Whole egg	15.00	4.30

4.1.5 Proximate Compositions of Egg Products (fresh and powdered yolk, albumen and whole eggs)

Table4.5 outlined the proximate compositions of both fresh and powdered eggs. There were differences($P<0.05$) between the fresh and the powdered egg yolks, egg whites and whole eggs in their proximate principles. There was increase as shown in table 4.5 in the crude protein of the yolk from 10.37% of the fresh yolk to 27.56% of the powdered yolk. There was also an increase in the ash content of the fresh yolk 1.73% compared to the powdered yolk 7.90%. The lipid content decreased from 64.40% in the fresh yolk to 49.53% in the powdered yolk.

There was also a difference between the fresh and the powdered egg whites in terms of their proximate principles. The crude protein of the fresh egg white, having 32.80% increased to 49.53%($P<0.05$). The lipid content of the egg white has increased from 1.85% to 2.40%. The increase in the lipid content of the egg white might not significantly differ. There was also an increase in the ash content from the fresh egg white of 1.00% to the powdered egg white of 9.25%.

More so, there was also a difference between the fresh and the powdered whole eggs in terms of their proximate principles($P<0.05$). The crude protein of the fresh whole egg 23.00% has increased to 35.68% of the dried whole egg. The lipid content of the whole egg has increased from 31.50% to 51.60%. There was also an increase in the ash content from the fresh whole egg of 4.35% to the powdered whole egg of 7.85%.

Table 4.5: Proximate compositions of fresh and reconstituted powdered eggs

Parameters	Crude protein	Lipid	Ash	Moisture
Fresh albumen	32.80[b]	1.85[b]	1.00[b]	54.34[a]
Reconstituted albumen	40.68[a]	2.40[a]	9.25[a]	3.65[b]
Fresh whole egg	23.00[b]	31.50[b]	4.35[b]	32.15[a]
Reconstituted whole egg	35.68[a]	51.60[a]	7.85[a]	2.75[b]
Fresh yolk	10.37[b]	64.40[a]	1.73[b]	21.53[a]
Reconstituted yolk	27.56[a]	49.53[b]	7.90[a]	2.40[b]

[abc]Means within rows having different superscripts differed significantly ($P<0.05$)

4.1.6 Functional Properties of Fresh and Reconstituted eggs

Table 4.6 presents the functional properties of fresh and reconstituted albumen, yolk and whole eggs. There were differences ($P<0.05$)between the fresh and reconstituted eggs for their functional properties. For emulsifying activity, fresh albumen has 35% while reconstituted albumen has 33%. For foaming capacity, fresh albumen has 43.5% while reconstituted albumen has 40%. For foaming stability, fresh albumen has 80.12% while reconstituted albumen has 78.40%. For emulsifying activity, fresh yolk has 55% while reconstituted yolk has 50%. For foaming capacity, fresh yolk has 32.10% while reconstituted yolk has 30.35%. The decrease will also be due to drying. For foaming stability, fresh yolk has 60.28% while reconstituted yolk has 57.33%, which the decrease might also be due to drying processes. For emulsifying activity, fresh whole egg has 41.3% while reconstituted whole egg has 38.5%. For foaming capacity, fresh whole egg has 35% while reconstituted whole egg has 33.2%. For foaming stability, fresh whole egg has 76.4% while reconstituted whole egg has 70.32%.

Table 4.6: Functional Properties of Fresh and Reconstituted eggs (%)

Parameter	Emulsifying activity	Foaming capacity	Foaming stability
Fresh albumen	35.00[a]	43.50[a]	80.12[a]
Reconstituted albumen	33.00[b]	40.00[b]	78.40[b]
Fresh yolk	55.00[a]	32.10[a]	60.28[a]
Reconstituted yolk	50.00[b]	30.35[b]	57.33[b]
Fresh whole egg	41.30[a]	35.00[a]	76.40[a]
Reconstituted whole egg	38.50[b]	33.20[b]	70.32[b]

[abc]Means within rows having different superscripts differed significantly (P<0.05)

4.1.7 Microbial load of Fresh and Powder Eggs

Table 4.7 shows results for the microbial load of fresh and powdered eggs. There were significant differences(P<0.05)in the microbial load of fresh and powdered whole egg having lesser total aerobic plate count value (3.00). There were significant differences (P<0.05) in the albumen for the reconstituted powdered albumen having lesser total aerobic plate count value (7.00). There were significant differences (P<0.05) in the yolk for the reconstituted powdered having lesser total aerobic plate count value (5.00). There were no significant differences (P>0.05) between the fresh and powdered eggs for the salmonella except in fresh albumen. There were no significant differences (P>0.05) between the fresh and powdered eggs for *E. coli, Staphyloccusspp, Bacillus spp, Lactose bacillus* and *Clostridium spp*as all were found to be negative. Figure 2 shows that, fresh albumen has the highest microbial susceptibility having the least in powdered whole egg.

Table 4.7: Microbial load of Fresh and Powder Eggs

	whole		albumen		Yolk	
parameter	Fresh	Powdered	Fresh	Powdered	Fresh	Powdered
TAPC (CFU/ml/g)	7.00[b]	3.00[a]	12.00[b]	7.00[a]	10.00[b]	5.00[a]
Salmonella	-ve	-ve	+ve	-ve	-ve	-ve
E. coli						
Staphyloccusspp	-ve	-ve	-ve	-ve	-ve	-ve
Bacillus spp	-ve	-ve	-ve	-ve	-ve	-ve
Lactose bacillus	-ve	-ve	-ve	-ve	-ve	-ve
Clostridium spp	-ve	-ve	-ve	-ve	-ve	-ve

[abc]Means within rows having different superscripts differed significantly (P<0.05)TAPC= Total aerobic plate counts,

TCC= Total coliform counts, E. coli= Escherichia coli

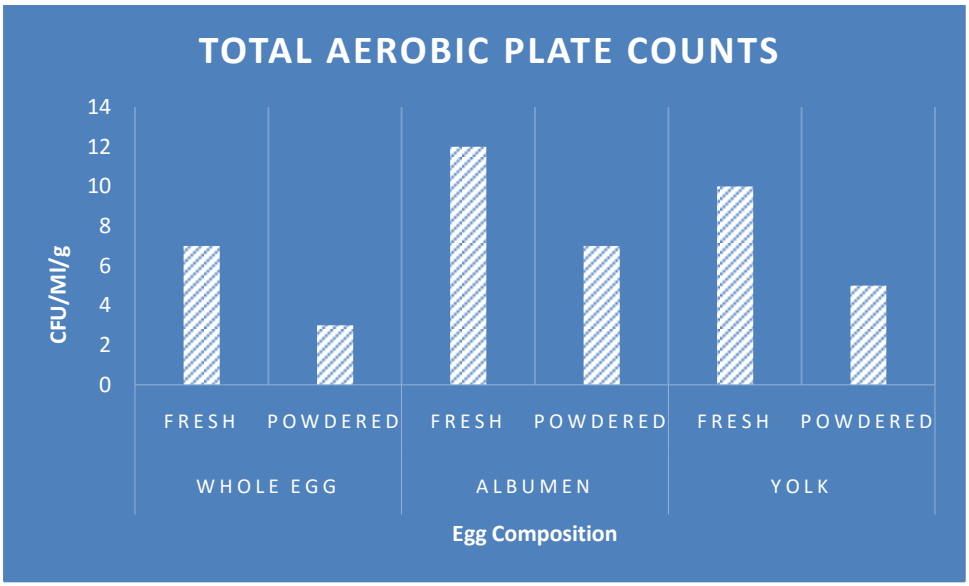

Figure 2. Total aerobic plate counts

4.1.8Reconstitution of powdered eggs

Table 4.8shows how to reconstitute powdered egg. Averagely, for a liquid whole egg of about 65g, the dried/powdered whole egg is about 15g. Therefore, to make the equivalence of one average liquid whole egg, add 50g of water to 15g of powdered whole egg. Averagely, for liquid albumen (egg white) of about 45g, the dried/powdered albumen (egg white) is about 5g. Therefore, to make an equivalence of average liquid albumen (egg white), add 40g of water to 5g of powdered albumen (egg white). Averagely, for a liquid egg yolk of about 20g, the dried/powdered egg yolk is about 10g. Therefore, to make the equivalence of one average liquid egg yolk, add 10g of water to 10g of powdered egg yolk. In a situation where by, you don't have whole egg but only albumen and yolk separately, just take 10g of powdered yolk and add it to 5g of powdered albumen in which you will have 15g of an average whole egg then add it to 40g of water to obtain a whole egg. The 15g could be multiplied by a number of your demand and then of course the reconstituting water.

To reconstitute using a table spoon, take one flat level tablespoon of whole egg powder and mix together with two to three tablespoons of water. The ratio of whole egg powder to water is 1:2/3 respectively. Stir it up and let it dissolve well for about five minutes and use as you would normal fresh liquid eggs. To mix powdered yolk with powdered albumen, take 2/3 of powdered yolk with 1/3 of powdered albumen to mix with 2-3 table spoons of water. To reconstitute albumen only, take 1 table spoon of powdered albumen and mix with 3-4 table spoons of water. The ratio of powdered albumen to water is about 1-3/4 respectively. For the reconstitution of yolk, take a table spoon of powdered yolk and mix with about 1-2 table spoons of water. The ratio of powdered yolk to water is about 1-1/2 respectively.

Table 4.8: Reconstitution of powdered egg (g)

Parameters	Fresh egg	Powdered egg	Water	Reconstituted egg
Whole egg (g)	65	15	50	65
Albumen (g)	45	5	40	45
Yolk (g)	20	10	10	20

4.1.9Sensory evaluation of omelattes preference made from components of the egg produced

Table 4.9 presents the sensory evaluation of yolk omelatte, albumen omelatte and whole egg omelatte made from both fresh and reconstituted eggs base on consumers' preference. There were significant differences between the fresh and reconstituted prepared omelattes($p<0.05$). For albumen, there was significant difference between the omelatte made from fresh albumen and reconstituted albumen powder as the omelatte made from fresh albumen is more preferred which differed significantly ($p<0.05$)with the higher value of 1.7000 and omelatte made from reconstituted albumen is second preferred with the value of 1.3000($p<0.05$). For yolk, omelatte made from reconstituted yolk is more preferred which differed significantlywith the higher value 1.7000 and omelatte made from fresh yolk is second preferred with the value of 1.3000 ($p<0.05$).For whole egg, omelatte made from fresh whole egg is more preferred which differed significantlywith the higher value of 1.6000 and omelatte made from reconstituted whole egg is second preferred with the value of 1.4000($p<0.05$).

Table4.9: Sensory evaluation on omelatte preference made from components of egg

Parameter	Respondent number	Mean	SEM
Fresh albumen	30	1.7000^{a}	0.0850
Reconstituted albume	30	1.3000^{c}	0.0850
Fresh yolk	30	1.3000^{c}	0.0850
Reconstituted yolk	30	1.7000^{a}	0.0850
Fresh whole egg	30	1.6000^{ab}	0.09093
Reconstituted whole egg	30	1.4000^{bc}	0.09093

Means with different superscripts within column differ significantly ($p<0.05$), SEM= Standard error of mean

4.10Sensory Evaluation of Omelattes Prepared fromFresh and Reconstituted Powdered Eggs

Table 4.10 shows the sensory evaluation of omelattes prepared from reconstituted powdered eggs. It shows from the result that, omelattes prepared from fresh and reconstituted powdered albumen differed significantly ($p<0.05$), with higher values of aroma, taste, texture and acceptability compared to colour which had less value for the fresh albumen. While for the reconstituted albumen, it differed significantly ($p<0.05$), with values higher in aroma, texture and acceptability compared to colour and taste. Meanwhile, for fresh and reconstituted whole egg there was no significant difference ($p>0.05$) as well as yolk.

Table 4.10: Sensory evaluation of omelatte prepared from fresh and reconstituted powdered eggs

Parameters	Colour	Texture	Aroma	Taste	Acceptability	P- value
Fresh albumen	1.44^{c}	2.25^{ab}	2.50^{a}	2.38^{ab}	2.13^{ab}	0.03
Reconstituted albumen	1.25^{c}	2.13^{ab}	2.19^{a}	1.81^{ab}	2.06^{ab}	0.04
Fresh whole egg	1.63	2.31	2.38	2.44	2.06	0.31
Reconstituted whole egg	1.69	1.69	2.25	2.00	2.31	0.16
Fresh yolk	1.75	2.38	2.75	2.50	2.56	0.22
Reconstituted yolk	2.31	2.50	2.56	2.31	2.69	0.91

^{abc}Means within rows having different superscripts differed significantly ($P<0.05$)

CHAPTER FIVE

5.0.0 DISCUSSION

5.1.0Discussion

5.2.0Quality attributes, Awareness and Attitudes of the Consumers towards Powdered Egg

The quality attributes of egg products (price, colour, taste, texture, aroma, food safety, convenience of packaging and ease of preparation) were evaluated in order of importance (very important, important, somewhat important and not important).It is shown in this study that, consumers have different perceptions on the quality attributes for eggs.Convenience of packaging, colour, aroma and ease of preparation were perceived to be very important quality attributes of egg products with the highest values of 60%, 45%, 49.2% and 59.2% respectively. This indicated, consumers prioritise the former quality attributes to the later ones. This preference may be due to differences from the individual perceived experiences and choices as it is a subjective evaluation not objective evaluation. Price, food safety, texture and taste were perceived to be important quality attributes of egg products with the highest values of 60%, 60.8%, 65.8% and 53.3%respectively.

Mnyandu 2014 reported that, consumers expressed their willingness and acceptability to reconstituted powdered egg. Even though the powdered reconstituted egg was accepted but the fresh egg was more acceptable and this may be due to unfamiliarity of the utilisation of powdered egg by the consumers.

This indicates that powdered egg has marketing potential especially if it is standardised;furthermore, a study conducted by Mnyandu (2014), reported that, consumers are willing to be utilising powdered egg as the familiarisation increases. It was reported that None of the respondents in rural Mkhambathini were familiar or had knowledge of egg powder. However, focus group discussions revealed that respondents were willing to learn more about egg powder in relation to producing it at a household level (Khoza 2014).

5.3.0 Products Yield, Proximate Compositions of Egg Products (fresh and powdered yolk, albumen and whole eggs)

The yield of the whole egg 2.30ml/g, 2.00ml/g and 4.30ml/g is compared to that reported by Abdullahi (2016) using oven dried chicken eggs and also to that reported by Daramola 2018 using Dehydrator.The results of the proximate compositions of the fresh and powdered whole, albumen and yolk are not similar to the ones reported by Daramola (2018). There was increase as an in the crude protein of the yolk from 10.37% of the fresh yolk to 27.56% of the powdered yolk. The crude protein in yolk from the fresh yolk to the dried yolk has increased by 17.19%. There was also an increase in the ash content of the fresh yolk (1.73%) compared to the powdered yolk (7.90%). The ash content in yolk from the fresh yolk to the dried yolk has increased by 6.17%. The lipid content decreased from 64.40% in the fresh yolk to 49.53% in the powdered yolk. The lipid content in yolk of the fresh yolk to the dried yolk has decreased by 14.87%.

Similarly, there was also a difference between the fresh and the powdered egg whites in terms of their proximate principles. The crude protein of the fresh egg white, having 32.80% increased to 49.53%. The crude protein in egg white from the fresh egg white to the dried egg white has increased by 16.73%. The lipid content of the egg white has increased from 1.85% to 2.40%. The lipid content in egg white from the fresh egg white to the dried egg white has increased by 0.55%. There was also an increase in the ash content from the fresh egg white of 1.00% to the powdered egg white of 9.25%. The ash content in egg white from the fresh egg white to the dried egg white has increased by 8.25%.

More so, there was also a difference between the fresh and the powdered whole eggs in terms of their proximate principles. The crude protein of the fresh whole egg 23.00% has increased to 35.68% of the dried whole egg. The crude protein in whole egg from the fresh whole egg to the dried whole egg has increased by 12.6%. The lipid content of the whole egg has increased from 31.50% to 51.60%. The lipid content in the whole egg from the fresh whole egg to the dried whole egg has increased by 20.10%. There was also an increase in the ash content from the fresh whole egg of 4.35% to the powdered whole egg of 7.85%. The ash content in the whole egg from the fresh whole egg to the dried whole egg has increased by 3.50%. The increase or decrease in the proximate principles of the egg products might be due to the processing and reduction in moisture content. Also source of the egg which might be affected by the type of feed ingredient fed to the chickens as well as other management differences could be associated to the differences in the proximate principles.

5.4.0 Functional Properties of Fresh and Reconstituted eggs

The functional properties of emulsifying activity, foaming capacity and foaming stability in fresh albumen, yolk and whole eggs have all decreased in terms of values to their respective powdered eggs. The results are within the range of the results of Daramola (2018). The increase or decrease in the functional properties of the chicken eggs might be due to drying processing effects and the devices used in the processes. Foaming stability, foaming capacity and emulsifying activity of whole fresh egg (76.40, 35.00 and 41.30%, respectively) compared to 70.32, 33.20 and 38.50% respectively in reconstituted whole chicken egg.

5.6.0 Microbial load of Fresh and Powder Eggs

The microbial load of fresh and powdered whole, yolk and albumen eggs were safe for consumption. Total aerobic count and total aerobic plate count were less in the eggs. Salmonella was found only in the fresh albumen. But in the process of drying, the salmonella was killed. These may be due to subjecting the eggs to heat treatments during drying.*E. coli, Staphyloccusspp, Bacillus spp, Lactose bacillus* and *Clostridium spp* as all were all found to be negative. This is supported by the result of Daramola (2018), who stated that, over 99% of salmonella organisms in liquid egg were killed on drying in an experimental spray dryer. It may also be associated with the source of the eggs at the farm level and also during the handling and processing of the eggs care was taken to maintain high level of hygienic condition which is essential in egg processing.

5.7.0 Sensory evaluation of omelattes preference made from Fresh and Reconstituted Powdered Eggs

The sensory evaluation of omelette prepared from fresh and reconstituted egg powders were accepted by the consumers. The omelatte of fresh albumen and whole eggs were more preferred to the omelatte of their respective reconstituted eggs. While the omelatte of the reconstituted yolk was more preferred to the omelatte of fresh yolk. This may be attributed to the drying and reconstitution processing effects which may make the yolk omelatte more firm and therefore have more sensory quality attributes.Mnyandu 2014 reported that scramble egg made from reconstituted egg powder is accepted but less preferred to the scramble egg made from fresh egg. The findings by Khoza (2014) reported that, generally, the sensory properties of relish made with egg powder and relish made with fresh egg were similar. Daramola(2018) also reported that preference results for fried egg were higher for raw egg than reconstituted egg.

CHAPTER SIX

6.0.0SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1.0 Summary

The study was evaluated to compare egg powder comprising of fresh albumen, yolk and whole egg and powdered or reconstituted albumen, yolk and whole eggs was determined for the purpose of measuring consumers' acceptability and functional properties of reconstituted eggs. This was done to address the problem of egg glut. Consumers showed more preference for fresh eggs to powdered eggs while some never used powdered eggs. Only 5.8 % have known about powdered egg and 15.1 % were aware of powdered egg and 67.5 % of the consumers did not care if the product is of fresh or powdered when buying. Hence there is a market potential for powdered egg as 66.7 % were willing to buy powdered eggs. The results of the evaluation showed that, there were no significant differences between the fresh and powdered eggs.

6.2.0 Conclusion

From the result findings of this study, it is concluded that:

1. Differences were observed in the proximate and functional properties of fresh and reconstituted powdered eggs.
2. Out of 120 respondents, only 5.8% have knowledge on powdered egg and 15.1% were aware of powdered egg. Consumers showed more preference on fresh egg than on powdered egg, while most of the consumers never used powdered egg.
3. For thesensory evaluation, omelattes prepared from reconstituted eggs were accepted similar to those of fresh eggs.

6.2.0Recommendations

It is recommended from the study that:

1. Fresh egg should be processed into powder as separate albumen, yolk or whole in order to solve egg glut problem, giving attention to value addition, like better packaging, colour, taste and price.
2. More awareness on processing and utilisation of powdered egg should be done through extension services to producers and consumers.
3. Better processing methods of egg to powder along the value chain should be studied like value addition to make powdered egg as acceptable as fresh one.

REFERENCES

Abdullahi A. A. (2016). Quality characteristics and processing yield of egg powder fromdifferent poultry species. MSc. Thesis submitted to the Department of Animal Science, University of Ibadan. 1-62.

Aboki, E., Jongur A. A. U. and Onu J. I. (2013). Productivity and Technical Efficiency of Family Poultry Production in Kurmi local Government Area of Taraba State, Nigeria. *Journal ofAgriculture and Sustainability* 4(1):52-66.

Association of Official Analytical Chemists (AOAC) (2000). Official Methods of Analysis of the Association of Official Analytical Chemists, 17thed. Washington, D.C.

Audic, J.L., Chaufer, B. andDaufin, G. (2005). Non-food applications of milk components and dairyco-products:*A Review*. *Lait*, 83:417–438.

Barmore, M.A. (2000).Home Economics.In:The influence of chemical and physical properties factors on dried eggs. *Chapter,*48:420-421.

Bartram, J., Balance R. and Pedley, S. (1996). Microbiological Analyses: Water Quality-Monitoring – A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. Published on behalf of United Nations Environmental Programme and the World Health Organization. © 1996 UNEP/WHO ISBN 0 419 22320 7 (Hbk) 0 419 21730 4 (Pbk), 10:7.

Bell, D. D. (2002) Modern Breeds of Chickens. In: Bell, D. D. and Weaver, W. D., Eds., *Commercial Chicken Meat andEgg Production*, Springer Publication, New York, 31-40.

Berry D. (2005). Food product concepts-through thick and thin. *Food product design concepts*. 1-13.

Board R. G., Hall N. A. (1973). The cuticle: a barrier to liquid and particle penetration of the shell of the hen's egg. British Poultry Science 14: 69–97.

Brennan, R. F. (2005). Food Technology. Types of dryer in the food industry.*Chapter 2,* Pp. 65-74.

Bueschelberger, H.G. (2004). Lecithins.Edited by Whitehurst, J.R; Emulsifiers in Food Technology. Oxford: Blackwell Publishing Ltd. Pp.1-22.

Bunchasak C. and Kachana S. (2009). Dietary folate and vitamin B12 supplementation and consequent vitamin deposition in chicken eggs. *Tropical AnimalHealth and Production* 41(7): 1583-1589.

Caboni, M. F., Boselli, E., Messia, M. C., Velazco, V., Fratianni, A., Panfili, G. and Marconi, E. (2005). Effect of processing and storage on the chemical quality markers of spray-dried whole egg. *Food Chemistry.* 92:293–303.

Chavez, B. E. and Ledeboer, A.M. (2007). Drying of probiotics: Optimizationofformulation and process to enhance storage survival.*Dry Technology,*25:1193-1201.

Cherian G. (2008). *Complementary and Alternative Therapies and the Aging Population: an evidence based approach,* Armsterdam, The Netherlands, Elsevier, Inc.

Coffman, C.F. and Garcia, V.V. (1977). Functional properties and amino acid content of protein isolate from mung bean flour. *Journal of Food Technology,* 12: 473

Correa, E. C., Diaz-Barcos, V., Fuentes-Pila, J., Barreiro, P., and Gonzalez, M. C. (2008) Modeling ovoproduct spoilage with red LED light. Acta Horticulturae 802: 265-272.

Daramola E. I. (2018). Comparative evaluation of differently processed whole egg powder. MSc. Thesis submitted to the Department of Animal Science, Ahmadu Bello University Zaria. 1-73.

Deman, J. M. (1999). Principles of Food Chemistry.3. Ed. Gaithersburg: Aspen Publishers, 520 p. (A Chapman & Hall food science book).

De Reu, K., Grijspeerdt, K., Heyndrickx, M., Zoons, J., De Baere, K., Uyttendaele, M., Debevere, J. and Herman, L. (2005) Bacterial eggshell contamination in conventional cages, furnished cages and aviary housing systems for laying hens. British Poultry Science 46: 149-155.

De Reu, K., Messens, W., Heyndrickx, M., Rodenburg, T.B., Uyttendaele, M. and Herman, L. (2008) Bacterial contamination of table eggs and the influence of housing systems. Worlds Poultry Science Journal 64: 5-19.

De Reu, K., Rodenburg, T.B., Grijspeerdt, K., Messens, W., Heyndrickx, M., Tuyttens, F.A.M., Sonck, B., Zoons, J. and Herman, L. (2009) Bacteriological contamination, dirt, and cracks of eggshells in furnished cages and noncage systems for laying hens: An international on-farm comparison. Poultry Science 88: 2442-2448.

Desrosier, N.W. (1977). Elements of food technology.India:AVI Publishing Coy.

Egg Farmers of Canada.(2008) Eggs…so many choices. *Egg Farmers of Canada (CEMA),* Retrieved 12/01, 2008 from http://eggs.ca/Resources/pdf/en/egg-choices-e.pdf

FAO. (2010a) FAO Statistical Yearbook 2010. Available from: http://www.fao.org/economic/ess/esspublications/ess-yearbook/ess-yearbook2010/yearbook2010 production/en/[Accessed 21 January 2012.

FAO. (2010b) Food security data and definitions. Food consumption – quantities by food items – 13.09.2010. Available from: http://www.fao.org/economic/ess/essfs/fs-data/ess-fadata/en/ [Accessed 8 January 2012.

Fearne, A. and Lavelle, D.(1996). Perceptions of food "quality" and the power of marketing communication: results of consumer research on a branded-egg concept. *Journal of Product & Brand Management* 5(2) 29-42.

Fisinin V.I., Papazyan, T.T. and Surai, P.F. (2008).Producing specialistpoultry products to meet human nutrition requirements: seleniumenriched eggs. World's *Poultry Science Journal*,64: 85–98.

Fisinin V. I., Papazyan T. T., Surai P. F. (2009). Producing selenium-enriched eggs and meat to improve the selenium status of the general population. *Critical Reviews in Biotechnology* 29 (1):18-28.

FMI (1996). Trends in the United States: Consumer attitudes and the supermarket. Available:http://www.fmi.org/forms/store/ProductFormPublic/search?action=1&Product_produ
ctNumber=2020 [Accessed 5 January 2013].

Frazier, W. C. and Westhoff, D. C. (1988). Food Microbiology.2nd ed. McGraw-Hill Publisher Inc., New Delhi, India.

Froning, G. N. (2008). Egg products industry and future perspectives.In: Mine Y. (ed) Egg Bioscience and Biotechnology.New Jersey: John Wiley, pp. 307–325.

Goddard, E., Boxall, P., Emunu, J.P., Boyd, C., Asselin, A. and Neall, A. (2007) Consumer attitudes, willingness to pay and revealed preferences for different egg production attributes: analysis of Canadian egg consumers. Project report *(*07-03) published by *Department of Rural Economy, University of Alberta*.

Heldman D. R. (2004). Identifying food science and technology research needs. *Food Technology* 58: 32-34.

Herron, K. L. and Fernandez, L. M. (2004), ''Are the current dietary guidelines regarding egg consumption appropriate?'', Journal of Nutrition, Vol. 134 No. 1, pp. 187-90.

Health. Available at:http://www.enconline.org.

Hincke M. T., Nys, Y., Gautron J., Mann K., Rodriguez-Navarro A. B., McKee M. D. (2012). The eggshell: structure, composition and mineralization. *Frontiers in Bioscience* 17: 1266–1280.

Holt, J.G. (1994). Bergeyes Manual of Determinative Bacteriology. 9th Edition., Williams and Wilkins Baltimore. 787

Hsu J., Liu K., Huang M. H. and Lee H. (2008). Consumer knowledge and risk perceptions of avian influenza. *Poultry Science* 87(8): 1526-1534.

Huang, J.F.; Lin, C.C. Production, composition and quality of duck eggs. In *Improving the Safety and Qualityof Eggs and Egg Products*; Nys, Y., Bain, M., Immersel, F.V., Eds.; Woodhead Publishing Limited: Cambridge, UK, 2011; Volume 2, pp. 487–508.

Institute for Agricultural Research Meteorological Unit, (2016). Annual Weather Report of the Meteorological Unit, Institute for Agricultural Research Ahmadu Bello University, Zaria.

Iannotti, L. R., Lutter, C. K., Bunn, D. A., and Stewart, C. P. (2014). Eggs: The uncracked potential for improving maternal and young child nutrition among the world's poor. Nutrition Reviews, 72, 355–368. https://doi. org/10.1111/nure.12107.

International Egg Commission – IEC. (2011). The global egg industry 2011: a statistical analysis. Available from: http://marketdata.internationalegg.com/2010/ [Accessed 28 January 2012].

Jafar, F. and Farid, M. (2003)."Analysis of Heat and Mass Transfer in Freeze Drying." *Drying Technology* **21**(2): 249 - 263.

Jay, M. J. (2000). Modern Food Microbiology**.** 6th ed. Aspen Publishers Inc.,Gaithersburg, Maryland.

Jirangrat W., Torrico D. D., No J., No H. K. and Prinyawiwatkul W. (2010). Effects of mineral oil coating on internal quality of chicken eggs under refrigerated storage. *International Journal of Food Science & Technology* 45(3): 490-495.

Kemp, S. E., Hollowood, T. and Hort, J. (2009). Sensory Evaluation A practical handbook. Wiley-Blackwell UK 196 p.

Khoza, S. L. (2014). Modelling with commercial egg powder to assess the potential of indigenous knowledge-processed egg powder to improve household food and nutrition security. M. A. Thesis submitted to the African Centre for Food SecuritySchool of Agricultural, Earth and Environmental Sciences (SAEES)College of Agriculture, Engineering and Science University of KwaZulu-Natal Pietermaritzburg. 1-120.

Kiosseoglou V. D. (1989). Egg yolk. In: Charalambous G., Doxastakis G. (eds) Food emulsifiers:chemistry, technology, functional properties and applications, Elsevier, London, pp 63–85.

Koç, M. (2011).Functional and physicochemical properties of whole egg powder: effect of spray drying conditions.*Journal of Food Science and Technology*, v. 48, n. 2, p. 141-149, 2011a.

Larsson, A., Karlsson-Parra, A. andSjoquist, J. (1991).Use of chicken antibodies in enzyme immunoassaysto avoid interference by rheumatoid factors. *Clinical Chemistry*, 37:411–414.

Lechevalier V., Croguennec T., Anton M. and Nau F. (2011). Processed egg products. In: Nys Y, Bain M. and Van Immerseel F. (eds.) *Improving the safety and quality of eggs and egg products volume 1 egg chemistry, production and consumption*. Cambridge: Woodhead publishing, 538-581.

Li - Chan , E.C.Y., Powrie, W.D. andNakai, S. (1995). The chemistry of egg and egg products. In: StadelmanW.J ,Cotterill O.J , eds. Egg Science and Technology , 4thed. New York. Food Products Press, Pp 105 – 175.

Liu, C.P. and Liu, S.D. (2009). Low-temperature spray drying for the microencapsulation of the Fungus Beauveriabassiana.*Dry Technology*, 27:747-753.

Luber P. (2009). Cross-contamination versus undercooking of poultry meat or eggs—which risks need to be managed first? *International Journal of Food Microbiology* 134(1): 21-28.

Martínez Michel, L., Punter, P. H. and Wismer, W. V. (2011) Perceptual attributes of poultry and other meat products: A repertory grid application. *Meat Science* 87:349-355.

Meister, K. (2002). *The Role of egg in the diet:* Update. American Council on Science and Technology.

Mine, Y. and Kovacs-Nolan, J. (2006). New insights in biologically active proteins and peptides derived from hen egg. *World's Poultry Science Journal*, 62(1): 87– 95.

Moats, W.A. (1980) Factors affecting bacterial loads on shells of washed eggs. Poultry Science 59:1641-1641.

Moges F., Mellesse A. and Dessie T. (2010a). Assessment of village chicken production system and evaluation of the productive and reproductive performance of local chicken ecotype in Bure district, North west Ethiopia. *African Journal of Agricultural Research* 5(13): 1739-1748.

Moges F., Tegegne A. and Dessie T. (2010b). *Indigenous Chicken Production and Marketing Systems in Ethiopia: Characteristics and Opportunities for Market-oriented Development,* Addis Ababa, Ethiopia, ILRI (aka ILCA and ILRAD).

Moreki J. and Montsho T. (2011). A Review of Egg Production in Botswana. Available: http://jwpr.science-line.com/attachments/article/4/JWPR,%20A2,%204- 6,%202011.pdf [Accessed 15 October 2012].

Mnyandu E. (2014). *Assessing the feasibility of making egg powder at rural community level for improved household food security*. Masters thesis, University of KwaZulu-Natal.

Mosisi M. P. (2010). Can small-scale poultry production contribute to household food security in the Maphephetheni lowlands, KwaZulu-Natal? Masters in Food security, University of KwaZulu Natal, Pietermaritzburg, South Africa.

Mujumdar, A.S (1995). Handbook of Industrial drying. New York, Marcel Dekker.

Musgrove, M. T., Jones, D. R., Northcutt, J. K., Cox, N. A. and Harrison, M. A. (2005). Shell rinse and shell crush methods for the recovery of aerobic microorganisms and Enterobacteriaceae from shell eggs. Journal of Food Protection 68, 2144-2148.

Narayana, M., and Narasinga, S. (1984).Effect of partial proteolysis on the functional properties of winged bean.*Journal of Food Science*, 49: 944-947.

NPCS (2012). *Profitable farming and allied projects* (2nd ed.). Kamlanagardelhi: Niir project consultancy services.

Ojo, S. O. 2003. Productivity and Technical Efficiency of Poultry Egg Production in Nigeria. *International Journal of Poultry Science* 2(6): 459-464.

Okeno T. O., Kahi A. K. and Peters K. J. (2012). Characterization of indigenous chicken production systems in Kenya. *Tropical Animal Health and Production*: 1-8.

Okubo T., Akachi and Hatta H. (1997). Structure of hen eggs and physiology of egg laying. In: Yamamoto T., Juneja L. R., Hatta H., Kim M. (eds) Hen Eggs: Their Basic and Applied Science.
Boca Raton, F. L. : CRC Press, pp. 1–12.

Osei-Somuah, A., Otsyina, H.R., Arthur, C.T., Nortey, P.W.K. and Hammond, V. (2003). Microbial Quality of table eggs sold on selected markets in Accra. *Ghana Veterinary Medical Association Bi-Annual Newsletter*. 6(2): 314-318.

Prescott J. (2004). Psychological processes in flavour perception. In: Taylor and Roberts (eds.) *Flavor Perception*. Oxford: Blackwell Publ. Ltd, 256-270

Protais, J., P. Gerault, Queguiner, S., Boscher, E., Chidaine, B., Ermel, G., Rivoal, K, Salvat, G., Pages, J., Thuault, D., Huchet, V., Coignard, M., Bourion, F., Federighi, M., Jugiau, F., Thouvenot, D., Efstathiou, T., and Lorthioir, P. (2006) Identification et comportement des bactéries d'altération dans la matrice oeuf entier liquide. Sciences et Techniques Avicoles 57 : 4-13.

Rannou L., Texier F., Moreau M., Courcoux P. and Meynier A. (2013). Odour quality of spray dried hens egg powders: The influence of composition, processing and storage conditions. *Food Chemistry* 138: 905-914.

Rao Q and Labuza TP (2012). Effect of moisture content on selected physiochemical properties of two commercial hen egg powders. *Food Chemistry* 132: 137-184.

Re, M. I. (2006).Formulating drug delivery systems by spray drying.Dry technology. 24:433-446.

Ross S (2008). *Rationing*, Evans Brothers.

Ruxton, C.H.S., Derbyshire E. and Gibson, S. (2010). The nutritional properties and health benefits of eggs. *Journal of Nutrition and Food Science.* 40(3): 264. Retrieved 9th of June, 2018.

Sagar V. and Suresh Kumar P. (2010). Recent advances in drying and dehydration of fruits and vegetables: a review. *Journal of Food Science and Technology* 47(1): 15-26.

Schutz, H.G. andCardello, A.V. (2001). A labelled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies*, 16, 117–159.

Sim J.S. (2004). Designer eggs and their nutritional and functional significance. Available: http://animalscience.ucdavis.edu/avian/sim.pdf [Accessed 15 September 2012].

Song, W. O. and Kerver, J. M. (2000), ‘‘Nutritional contribution of eggs to American diets’’, Journal of the American College of Nutrition, Vol. 19 No. 5, pp. 556S-62S.

Sparks N. H. C. (1994) Shell accessory materials: structure and function. In: Board RG, Fuller R (eds) Microbiology of the Avian Egg. London: Chapman and Hall, pp. 25–42.

Sperber, W. and Doyle, M. (2009). Compendium of the microbiological spoilage of foods and beverages. Springer

Stadelman W. J., Cotterill O. J. (eds). Egg science and technology, 4th ed. Food Product Press,New York

Techer, C., Baron, F. and Jan, S. (2013). Microbial spoilage of eggs and egg products. World’s Poultry Science Journal, Volume 69.

Thapon J. L., Bourgeois W. G. (1994) L’oeufet les ovoproduits. Lavoisier, Paris

Tserveni-Goussi, A.; Fortomaris, P. Production and quality of quail, pheasant, goose and turkey eggs for uses other than human consumption. In *Improving the Safety and Quality of Eggs and Egg Products*; Nys, Y., Bain, M., Van Immerseel, F., Eds.; Woodhead

Publishing Limited: Cambridge, UK, 2011; Volume 2, pp. 509–537.

Tshikosi S. J. (2009). Evaluation of the impact of managerial factors on the sustainability of the poverty alleviation egg laying project in the Vhembe District, SouthAfrica. Masters Degree in Animal science, Stellenbosch university.

US Department of Agriculture (USDA) (2000) USDA Egg Grading Manual. www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3004502, accessed 22 November 2013.

World Poultry Congress 2012.

Whittow GC (ed) (2000) Sturkie's Avian Physiology, 5th edn. San Diego, CA: Academic Press.

Yamamoto, T., Juneja, L.R., Hatta, H.andKim, M. (1997).HenEggs: Their Basic and Applied Science. Boca Raton, FL:CRC Press.

Youssefi, S. H, Emam-Djomeh, Z. and Mousavi, S.M. (2009). Comparison of artificial neural network (ANN) and response surface methodology (RSM) in the prediction of quality parameters of spray-dried pomegranate juice. *Dry Technology*, 27:910-917.

Zaheer, K. (2015) An Updated Review on Chicken Eggs: Production, Consumption, ManagementAspects and Nutritional Benefits to Human Health. *Food and Nutrition Sciences*, **6**, 1208-1220.http://dx.doi.org/10.4236/fns.2015.613127

APPENDIX I: Consumers' Research Questionnaire

Dear Respondent**,**

This questionnaire will be used by a student of Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. Please, respond or tick where necessary. All information will be treated with utmost confidentiality and will strictly be used for the purpose of research only. Thanks for your cooperation.

SECTION A: BACKGROUND INFORMATION

Questionnaire No……..….. Name of Respondent……

Village…… .Area…… Date……../……../2018.

SECTION B:SOCIO-ECONOMIC CHARACTERISTICS OF THE CONSUMERS

1. Sex: Male ( ) Female ( )
2. Age of respondent (years): ……
3. Marital status: (a)Single ( ) (b) Married ( ) (c) Widow ( ) (d) Widower ( ) (e) Divorce ( )
4. Household size: ……
5. Level of education……..……..
   (a) No formal Education: ( )
   (b) Adult-Education: ……. Years
   (c) Primary Education: ……..…….Years
   (d) Secondary Education: ……..……..Years
   (e) Post-secondary Education : …… years
   (f) Qur'anic Education …… Years

6. Family Size (All the number of the people depending on you for living)…….

   (a) No of Adult Male ( ) (b) No of Adult female ( ) (c) Children >15yrs ( ) (d) Children <15yrs ( )

7. How long have you been in egg processing? (Years of experience)……

8. Do you belong to any co-operative/Association? Yes ( ) No ( )

9. If yes, (Years of participation) ----------

10. What benefit did you derive as a member?

Consumption Characteristics of egg consumers
Rating of egg type according to the Quality characteristics using the scores below

Code	Name	Taste	Aroma	Colour	Swelling capacity	Texture	
1	Fresh egg						
2	Powdered egg						

Consumers' knowledge and patronage of powdered egg

11. Do you consume egg? Yes ( ) No ( )

12. If yes why? Enjoyment ( ) Protein ( ) other specify ( )

13. How do you prepare your egg? Boiling ( ) Frying ( ) Baking ( ) Other ( )

14. Have you purchased powdered egg for the last five months? Yes ( ) No ( )

15. If yes why do you purchase powdered egg?

Available ( ) Easy to consume (convenience) ( ) Delicious ( ),

Nutritious ( ) Cheaper price ( )

16. If no, please rank the reasons why you have not purchase powdered egg for the last five months. Enter a ranking for each with 1= most important, 2= second most important ... and 6 = least important.

Less availability compared to the fresh egg ( ) Taste is inferior ( )

Poor appearance ( ) Expensive ( ) Low nutrition ( )

I do not trust the quality of powdered egg ( )

17. When purchasing egg, do you normally care whether produce is of fresh or powdered? Yes ( ) No ( )

18. Are your satisfied with the quality of powdered egg at present as compared to the fresh egg?

Definitely yes ( ) Average ( ) Definitely no ( ) Indifferent ( )

19. What do you think of the current level of egg production in Nigeria?

Higher ( ) Slightly low ( ) Slightly high ( ) High ( ) Do not know ( )

Promotional information on powdered egg

21. Do you know of any powdered egg in Nigeria? Yes ( ) No ( ) Not sure ( )

22. f yes, have you ever bought some of the powdered egg before

Yes ( ) No ( ) Not sure ( )

23. Why do you buy powdered egg?

Nutrition of health promoting properties ( ) Not expensive ( )

Advertisements (any media) ( ) Premium and specialties offered by company/shop ( )

Product appearance ( ) Attractive packaging ( )

24. Have you received information promoting powdered egg before?

Yes ( ) No ( )

25. If yes, where did you get the promotional information on the powdered egg? (tick all that apply)

Radio ( ) TV ( ) Newspapers ( ) Magazines ( )

Friend/relatives ( ) others ( )

26. What were they promoting about the powdered egg? (tick all that apply)

Taste ( ) Quality ( ) Nutritional benefit ( ) Price ( )

Aroma ( ) Convenience ( )

27. If you are to receive more information about powdered egg, which would be best

Radio ( ) TV ( ) Newspaper ( ) Magazines ( )

Friends/Relatives ( ) others specify ----------

28. Are you willing to buy the powdered egg if they are more available?

Yes ( ) No ( ) Don't know ( )

29. Will you buy the powdered egg even if it is not yet certified?

Yes ( ) No ( ) Don't know ( )

30. In your opinion what do you think are some of the problems accounting for the low consumption of powdered egg in Nigeria?

a) .....

b) .....

c) .....

31.What are some of the key factors that would lead to increased consumption of powdered egg in Nigeria

a) .....

b) .....

c) .....

Consumer Perceptions about the Quality Attributes of Egg and Egg Products

In your decision to buy newly powdered egg, how will you rate the importance of the following characteristics (tick appropriately).

	Not important	Somewhat important	Important	Very Important
Price				
Convenience of packaging				
Food safety				
Aroma				
Texture				
Colour				
Taste (from past experience)				
Easy of preparation				

32. Others
specify……

APPENDIX I I

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY, ZARIA

TEST PANEL SCORE FORM ON

SENSORY EVALUATION OF FRESH EGG AND RECONSTITUTED EGG POWDER

FOR CONSUMER ACCEPTABILITY

You are provided with six samples of omelette, please score them for the quality attributes and acceptability by writing a number using the5-points hedonic scale

Sample	Colour	Texture	Aroma	Taste	Acceptability
351					
413					
819					
111					
569					
272					

1=like very much,
2=like moderately,
3=neither like nor dislike,
4=dislike moderately,
5=dislike very much.

APPENDIX I II

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY, ZARIA

TEST PANEL SCORE FORM ON

SENSORY EVALUATION OF FRESH EGG AND RECONSTITUTED EGG POWDER FOR CONSUMER PREFERENCE RANKING

You are provided with two samples of omelette, each of A, B,C, please rank them for preference by making a tick in the box in order of 1st or 2nd base on your perception of the product.

A

103	
621	

B

111	
313	

C

121	
579	

Comment on the products which you prefer most.....
by stating why.....