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PHYSICAL AND CHEMICAL COMPOSITIONS OF COMMERCIAL AVAILABLE TABLE EGGS

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for higher degree to any universities and institutions.

Student Name:

Date:

I certify that the report of this final year project entitle "PHYSICAL AND CHEMICAL COMPOSITIONS OF COMMERCIAL AVAILABLE TABLE EGGS" by Nurathirah binti A Rahman, matric number F18A0168 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Animal Husbandry Science) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan.

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PHYSICAL AND CHEMICAL COMPOSITIONS OF COMMERCIAL AVAILABLE TABLE EGGS

ABSTRACT

There are many distinct varieties of commercial table eggs accessible in the retail market, but there is no comprehensive knowledge of their overall physical and compositional quality. A total of 21 eggs were collected and divided into 3 egg types and 3 grades. The weights of egg, albumen, yolk, and shell were used to determine the morphological egg quality. Egg shape index, yolk index, Haugh unit, shell thickness, albumen, yolk and shell percentage, albumen and yolk pH, chemical composition, crude protein, crude fat, ash, and moisture for both albumen and egg yolk were also examined. Omega-3 rich eggs showed significantly ($p<0.05$) higher egg weight (64.8g) followed by organic (55.8g) and traditional (50.4g). Grade A egg showed significantly ($p<0.05$) higher (62.0g) egg weight than grade B egg (57.7g). No significant ($p>0.05$) difference was observed on shape index among different sources of eggs. However, grade B egg showed significantly ($p<0.05$) higher shape index (80.4) than grade A egg. Organic (86.4) and omega-3 rich (85.9) eggs showed significantly ($p<0.05$) higher value of Haugh Unit than traditional egg (68.5). Organic egg showed significantly ($p<0.05$) higher DM of egg yolk (53.4%) followed by traditional (48.9%) and omega-3 rich egg (44.1%). However, omega-3 rich egg showed significantly ($p<0.05$) higher DM of egg albumen (84.7%) than organic (84.4%) and traditional (81.5%) eggs. Traditional egg showed significantly ($p<0.05$) higher CP of egg yolk (45.3%) followed by organic (44.1%) and omega-3 rich (44.6%) eggs. However, organic egg shows significantly ($p<0.05$) higher CP of egg albumen (97.9%) followed by omega-3 rich (97.2%) and traditional (96.7%) eggs.

keywords: egg, traditional egg, organic egg, omega-3 rich egg

KOMPOSISI FIZIKAL DAN KIMIA MENGENAI TELUR YANG BERADA DI PASARAN SECARA KOMERSIL

ABSTRAK

Terdapat beberapa telur komersial yang tersedia untuk pengguna di pasaran runcit, tetapi tidak ada pemahaman yang jelas tentang kualiti fizikal dan komposisi keseluruhan jenis telur yang berbeza. Sebanyak 21 biji telur telah dikumpul dan dibahagikan kepada 3 jenis telur dan 3 gred. Kualiti telur morfologi termasuk berat telur, albumen, kuning telur dan kulit. Selain itu, indeks bentuk telur, indeks kuning telur, unit Haugh, ketebalan cangkerang, albumen, kuning telur dan peratusan cangkerang dan, pH albumen dan kuning telur dan untuk komposisi kimia, protein kasar, lemak mentah, abu, dan lembapan untuk kedua-dua albumen dan kuning telur adalah. diukur. Omega-3 menunjukkan secara signifikan ($p<0.05$) berat telur yang lebih tinggi (64.8g) diikuti oleh organik (55.8g) dan tradisional (50.4g). Telur gred A menunjukkan secara signifikan ($p<0.05$) lebih tinggi (62.0g) berat telur berbanding telur gred B (57.7g). Tiada perbezaan ketara ($p>0.05$) diperhatikan pada indeks bentuk antara sumber telur yang berbeza. Walau bagaimanapun, gred B menunjukkan secara signifikan ($p<0.05$) indeks bentuk yang lebih tinggi (80.4) berbanding telur gred A. Telur organik (86.4) dan omega-3 (85.9) menunjukkan secara signifikan ($p<0.05$) nilai Haugh Unit yang lebih tinggi berbanding telur tradisional (68.5). Telur organik menunjukkan secara signifikan ($p<0.05$) DM kuning telur yang lebih tinggi (53.4%) diikuti oleh telur tradisional (48.9%) dan telur omega-3 (44.1%). Walau bagaimanapun, telur omega-3 menunjukkan secara signifikan ($p<0.05$) DM albumen telur (84.7%) lebih tinggi daripada telur organik (84.4%) dan tradisional (81.5%). Telur tradisional menunjukkan secara signifikan ($p<0.05$) CP kuning telur yang lebih tinggi (45.3%) diikuti oleh telur organik (44.1%) dan omega-3 (44.6%). Walau bagaimanapun, telur organik menunjukkan secara signifikan ($p<0.05$) CP albumen telur yang lebih tinggi (97.9%) diikuti oleh telur omega-3 (97.2%) dan telur tradisional (96.7%).

kata kunci: telur, telur tradisional, telur organik, telur omega-3

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LIST OF ABBREVIATIONS AND SYMBOLS

List of Aberrations

CF	Crude Fat
CP	Crude Protein
DM	Dry Matter
EW	Egg Weight
HU	Haugh Unit
SW	Shell Weight
YD	Yolk Diameter
YH	Yolk Height
YI	Yolk Index

List of Symbols

g	Gram
mm	Millimetre
mL	Millilitre
°C	Celsius

CHAPTER 1

INTRODUCTION

1.1. Research Background

Consumers are becoming to be more health conscious and aware of their food choices, but, at the same time, they want to safe their budget. Moreover, the demand for animal origin products are increasing day by day and the concern now is quality rather than quantity. Among the animal products, eggs can give a significant amount of nutrients including protein, vitamin and mineral. The yolk of the eggs also contains cholesterol and essential fatty acids that can contribute a number of health benefits. Chicken eggs are one of the most common and abundant foodstuffs in the human diet. However, internal (protein, fat and mineral) and external (color of yolk and shell, weight, albumen density, bacteriological quality) hereditary, physiological, and environmental variables can all impact egg features, which is critical for economic and commercial viability. (Huyghebaert, 2006; Ahmadi & Rahimi, 2011). There are diversified ranges of commercial eggs in the market to meet the consumer desires such as traditional, organic and omega-3 rich eggs with different grades. Pricing for these various eggs might differ from one market to the next. It's possible that the price disparities are attributable to production-transportation expenses or egg quality (Jones et al. 2010).

To maintain specialised markets for speciality and designer eggs viable, highquality eggs were necessary. Egg quality refers to the characteristics of an egg that impact customer acceptability and preference. The cleanliness, strength, texture, and structure of the shell, as well as the relative viscosity of the albumen and the shape and hardness of the yolk, are all taken into account while grading eggs. While the consumer is concerned about the eggshell cracking or breaking upon purchase, the state of the internal egg, which starts to deteriorate after egg laying, is more essential. This goal can be achieved by collecting, cooling, and refrigerating eggs at the proper humidity level. As eggs mature in cold storage, the water gradient and pH of the yolk and albumen begin to change.

To assess egg size and content accuracy, as well as egg score, a variety of parameters are used. The structural consistency of an egg's shell and the integrity of the yolk membrane are inextricably related to food safety and possible economic harm. The value of the yolk and albumen in subsequent processing is influenced by the consistency of the yolk membrane (Kirunda and McKee, 2000). This study attempts to acquire a better knowledge of egg production in commercially accessible designer egg products vs traditional eggs using these consistency standards.

1.2 Problem Statement

The laying hen eggs are one of the most common and abundant foodstuff in the human and they contain important compound that human consumption, for example, lipids, vitamins and amino acid. The pattern of food consumption has been quickly changing in recent decades, with a rise in demand for food items of higher quality and safety, which is linked to an increase in wealth. Traditional, organic, and omega-3 rich eggs are among the commercial eggs available in the retail market to meet the needs of consumers. Moreover, these available commercial eggs in the market have been found in various grades: AA, A, B and C size grades. The cost of these varied eggs varies greatly from market to market. Jang et al. (2009) suggested that food qualities are one of the most important variables influencing customer decision-making when buying food in terms of morphological traits and chemical composition, there are several elements that might impact egg quality. However, little is known about the quality for egg attributes among various commercial egg types and grades in Malaysia. There are no comparable statistics on the chemical makeup of eggs, including regular, organic, and omega-3-rich eggs of various grades. Consumers are sometimes perplexed as to the sort of eggs they should purchase at the shop because there are so many options, such as egg varieties (traditional, organic and omega-3 rich eggs) and grades (such as AA, A, B,

C and jumbo).

1.3 Objectives

i) To investigate the morphological characteristics (egg weight, albumin height, yolk height, yolk index, Haugh unit, shell thickness, shell weight and shape index) of different types (traditional, organic and omega-3 rich) and grades (A, B and C) of eggs;

ii) ii) To determine the chemical composition (total solids, crude fat, protein and ash) of different types (traditional, organic and omega-3 rich) and grades A of eggs.

1.4 Hypothesis

H_0: The types and grading of eggs have no effect on morphological characteristics and chemical composition of commercial eggs.

H_1: The types and grading of eggs have an effect on morphological characteristics and chemical composition of commercial eggs.

1.5 Scope of Study

The study focuses on the commercial table eggs that are available in the retail markets. Traditional, organic and omega-3 rich eggs with different grades (A, B and C) being collected from local market. Morphological characteristics of experimental eggs being investigated at the Laboratory of Faculty of Agro Based Industry, UMK. Besides, chemical composition of experimental eggs also be determined at the Laboratory of Faculty of Agro Based Industry, UMK.

1.6 Significant Study

Through the conclusion of this study, a greater knowledge of how egg kinds and grading impact the morphological attributes and chemical composition of commercial table eggs were gained. Furthermore, the results of this study can assist customers to select the best varieties of eggs for their consumption. The egg quality assessments used in this study are critical for assessing the speciality market's supply to consumers, and they might imply that better quality metrics are needed to reliably discern between different egg shapes and their quality.

1.7 Limitation of Study

The limitations in this study were low sample size, because there was not enough time to do the samples analyses in the laboratory due to covid-19. Besides, the Covid-19 pandemic has restricted all of us from going to outside to obtain a larger sample size and for Traditional and Omega-3 rich fatty acid did not available grade C of eggs in store in Kelantan. In addition, some equipment for measurement of external egg quality was not available in the Laboratory of Faculty of Agro Based Industry, UMK such as digital Haugh Tester.

CHAPTER 2

LITERATURE REVIEW

2.1 Chicken eggs

Chicken eggs are an essential part of the human diet, providing calcium, fat, and other nutrients. For sales purposes, chicken eggs may be ranked by scale. The egg shell will account for up to 9% of the total weight of the egg. A chicken egg is made up of two-thirds white and one-third yolk. Lipids, proteins, minerals, and carotenoid colours are also found in the yolk. It's high in the bioavailable carotenoids lutein and zeaxanthin, which are exclusively present in egg yolks. Membranes separate the egg whites (albumen) and the egg yolk within a calcium carbonate-based hard shell that accounts for around 11% of the weight of chicken eggs. Eggs are nutritionally significant because they include high-quality proteins, cholesterol, lecithin, vitamins, and minerals. The microbiological dangers (Salmonella) of raw egg-based meals, as well as the cholesterol content, which is roughly 0.21 g in one medium-sized egg, are all possible difficulties.

2.2 Egg product

The contents of eggs that have been removed from their shells, with or without additional additives, that are meant for human consumption. In order to give egg products unique characteristics and or ensure purity, food ingredients and food additives may be used. Under the Codex Alimentarius Commission's regulations on foodstuffs, additives should be accepted as edible and allowed for use in importing countries.

2.3 Egg yolk

The yolk of broken-out hen eggs-in-shell is separated into a homogeneous material using good production practises. Limited quantities of egg albumen may be added to the yolk to help standardise the meal.

2.4 Table eggs

Table eggs are also referred to as shell eggs or eggs in their most typical form, which is fresh and in shell (Aakanksha Gaur, 2020) . Although commercial table eggs can be produced from a variety of birds, and many of the techniques are identical, this article will focus on chickens. Small companies are often highlighted, including those that market directly to customers or to local restaurants and retailers.

Table 2.5.1 Chicken egg sizes

For the purpose of sales, chicken eggs are ranked by scale. The egg shell makes up between 8% to 9% of the total weight of the egg. There is different size of eggs with others country. The following egg sizes, mass and percentage of development of eggs in Malaysia.

Egg grade	Mass per egg	Percentage of egg development
AA	More than 70g	4%
A	65 – 70g	12%
B	60 – 65g	28%
C	55 – 60g	31%
D	50 - 55g	18%
E	45 – 50g	5%
F	Below 45g	2%

Source: United States Department of Agriculture

2.6 Egg Grade

Scoring eggs is the process of categorising them into one of three grades: Grade A, Grade B, or Grade C. To determine these classifications, the egg's exterior and internal consistency were measured at the time of packaging. The eggs are then weighted and packaged properly, with a dozen eggs per carton being the most common container.

2.7 Egg graded of exterior and interior quality

The quality on the outside is determined by the outside quality. Shells must be clean, smooth, and free of faults, holes, or rough regions; irregular shells do not fulfil these requirements. If the shells are not cracked, they must be round in form and somewhat broader at one end. Because these criteria are not met, limited eggs cannot be sold to food suppliers, shops, or consumers.

The quality of the interior. The interior design standard. Though evaluating an egg's insides without shattering it is difficult, candling, or putting an egg over a flame, is a viable option. Using a gentle light, candling analyses the egg yolk, egg white, and the size of the air cell. Egg yolks must be clear, free of blood spots or embryo development, and egg whites must be clean and thick enough to hold the yolk in place. As the egg grade rises, the air cell gets shallower.

2.8 Importance of egg grading

In both home and industrial kitchens, eggs are one of the most commonly used foods. The USDA grades are trusted and relied upon by food producers, suppliers, and consumers to faithfully uphold certain requirements for the health and welfare of millions of people.

2.9 The size impacts for an egg

The age and weight of the chicken are the most important factors in egg size. In general, the bigger the shell, the older and larger the hen. However, other factors such as breed, diet, and living conditions may affect egg size. Since each hen is different in size, breed is a big factor. For example, chicken breeds like New Hampshire Red, Leghorn, and Ancona lay bigger eggs. Another factor is diet. Significant quantities of calciumrich, nutritious feed will aid in the processing of larger, healthier eggs. The working standards are the final consideration. Crowing, heat stress, or a lack of water availability are the most common factors that cause egg size reduction.

2.10 Difference among Grade A, Grade B and Grade C

Grade A

It is the top rated and biggest egg offered at the local grocery shop, weighing an average of 65g. Aside from weight, a variety of other factors are considered to determine if an egg is deserving of this categorization. Eggs must have a clean, sterile shell that is devoid of filth, sludge, feathers, and hairline cracks to receive a "A" rating. When cracked, the egg white should be firm and thick, not runny or watery. The yolk must be perfectly round, undamaged, and retained within the egg white. Grade A eggs are the greatest option for the best sunny-side up because of their flawless look.

Grade B

Grade B eggs are smaller than Grade A eggs, with an average weight of 60 grams per egg. Although little amounts of dirt or grit on the shells of Grade B eggs are uncommon, the two categories are almost identical in nature. After being split, the egg white remains firm and thick, but the yolk is not totally spherical or intact.

Grade C

They are the most commonly used eggs in local diners and restaurants due to their inexpensive cost. In terms of appearance, Grade C eggs are nearly indistinguishable from Grade A and B eggs. Shells usually do not have cracks, but they have a stretched look and a gritty or sandy feel to them. When cracked, egg whites are fluid and liquid, yet the yolk separates easily and has an odd shape. Grade C eggs are nearly as healthy as eggs of higher grades, pound for pound.

2.11 Organic egg

Natural methods are used in the processing of chickens, as well as in the production of organic feed for poultry that eats organic feed. Organic ensures that the laying hens must have access to the outside and cannot be raised in pens, according to the United States Department of Agriculture. Organic eggs must come from chickens who are only given antibiotics in the case of an infection, and no hormones or other medications should be used in the manufacture of organic eggs. The only natural moulting that may take place inside the flock is artificial moulting, which is not permitted.

2.12 Traditional egg

Traditional egg or conventional eggs are the standard supermarket egg. The hens of this egg types mostly lay these eggs by usually feed grain, supplemented with the vitamin and minerals source.

2.13 Omega-3 rich

Omega-3 eggs are produced by hens fed a flaxseed-based diet. Any of the ALA in the flax is broken down into DHA in the hens' digestive system, and all fatty acids are transferred to the yolk. 340 milligrams of ALA and 75 to 100 milligrams of DHA are contained in one omega-3 eggs.

Table 2.14.2 Nutrient composition of an egg

Nutrient composition	
Protein composition	Content 6-7g with highest quality
Fat composition	Content 5-6g with readily digestible
Carbohydrate composition	Low in calories content
Vitamins composition	Generous quantities except Vitamin C
Yolk composition	High in cholesterol content

Source: Mithu Mehr, (2015).

2.2 Chemical Composition of egg

Table 2.15.3 Chemical composition of egg

	Percentage	Water	Protein	Fat	Ash
Whole egg	100	65.6	11.8	11	11.7
White egg	58	88	11.0	0.2	0.8
Yolk egg	31	48	17.5	32.5	2.0

Source: College of Veterinary Science, Rajendranagar, Telangana, India (2017).

2.2.1 Dry matter

The dry matter or dry weight of something is an indicator of its mass when fully dried. Carbohydrates, fats, and protein provide calories in foods that can account for up to 90% of the diet's dry weight. Boiling eggs have a water content of 73.2 %. The moisture content represents the amount of water contained in the feed product, while dry matter corresponds to the substance left after water has been removed.

Microwaves can be used to dry feedstuffs in a very short amount of time. The risk of burning is the most significant disadvantage of using a microwave. Microwave dried samples should not be sent to a laboratory for nutrient analysis due to the risk of burning. The use of a microwave necessitates constant attention. As a result, doing other things when drying samples in the microwave is impossible.

2.2.2 Crude protein

A method for calculating the protein content of a meal. In animal diets, crude protein is determined by multiplying mineral nitrogen by 6.25. (It is assumed that proteins in conventional animal meals contain on average 16 percent nitrogen). The mineral nitrogen value is calculated using the Kjeldahl technique, or a method that produces comparable values after correction, such as the Dumas method.

2.2.3 Ether extract

Crude fat removed without direct hydrolysis using diethyl ether or petroleum ether.

2.2.4 Ash

After the water and organic components have been dissolved by heating in the presence of oxidising agents, the inorganic material that remains is ash. It may be used to figure out how many minerals are in a meal. The most widely used methods are based on the premise that minerals are unaffected by fire. Fresh meals seldom have ash concentrations higher than 5%, while some processed foods can have ash contents as high as 12%.

CHAPTER 3

METHODOLOGY

3.1 Materials

3.1.1 Raw Materials:

This study was conducted in the Animal Science Laboratory, Faculty of Agro Based Industry, Universiti Malaysia Kelantan (UMK), Jeli Campus. Local grocery shop was selected to purchase commercial table eggs for each of the following egg types and grades: traditional (grades A, B and C); organic eggs (grades A and B) and omega-3 rich eggs (grades A and B).

a) Traditional eggs (grades A, B and C)
b) Organic eggs (grades A and B)
c) Omega-3 rich eggs (grades A and B)
d) Egg tray
e) Filter paper
f) Beaker

3.1.2 Chemicals and Reagents

The chemicals used in this experiment were as follows:

a) Sodium metaphosphate
b) Potassium chloride
c) Sodium hydroxide
d) Ammonia acetate
e) Potassium sulphate
f) Magnesium oxide
g) Hydrochloric acid
h) Sulphuric acid
i) Kjeldahl catalyst

3.1.3 Equipment

Equipment that used in this experiment were as follows:

a) 250 ml beaker
b) Tripod micrometre
c) Vernier scale
d) Weighing balance
e) Microwave
f) Conical flask
g) Volumetric cylinder
h) Stirring rod

3.2 Experimental design

A trip to nearby grocery stores was undertaken on a single day to acquire commercial table eggs of each of the following egg types and grades: conventional (grades A, B, and C); organic eggs (grades A, B); and omega-3 rich eggs (grades A, B) (grades A, B). The study used a totally randomised design with 9 treatments in a 3 x 3 factorial arrangement (main treatment: traditional, organic, and omega-3 rich eggs; sub treatments: grades A, B, and C), each with three replicates.

Eggs were purchased and kept at 4°C until they were analysed the next morning. Each treatment had three eggs with the same morphological traits. During the tasting, cracked eggs were not allowed. For each treatment, the chemical composition was assessed in triplicate from 1 pool (3 eggs/pool) of eggs that had been individually evaluated for morphological traits.

The age of the eggs was determined by the time between the processing date on the carton box and when they were purchased. The morphological egg quality was determined by weighing the egg, albumen, yolk, and shell. The egg shape index, yolk index, Haugh unit, shell thickness, albumen, yolk, and shell percentage, as well as the albumen and yolk pH, were all calculated. The chemical composition of albumen and egg yolk was assessed using crude protein, total lipids, total solids, ash, and moisture.

Figure 3.2: Commercial table eggs of each of the following egg types and grades: traditional (grades A, B and C); organic eggs (grades A and B) and omega-3 rich eggs (grades A and B).

3.3 Sample preparation and analysis

3.3.1 Morphological characteristics measurements

3.3.1.1 Egg weight

Individual egg weight (EW) was measured to the nearest 0.001 g using an electronic balance. Albumen, yolk and eggshell percentage were determined based in egg weight.

3.3.1.2 Albumen height

Albumen height of an egg was measured using appropriate tools.

3.3.1.3 Yolk height and yolk index

Using proper instruments, the height of the yolk was measured. By dividing the yolk height by the yolk diameter of an egg cracked onto a flat surface, the yolk index (YI) was computed. The yolk index score lowers as the egg deteriorates because the vitelline membrane's fibre structure loosens and the membrane strength reduces with time. The formula for yolk index is as follows:

Yolk index = (YH/YD)

Where,

YH = Height of egg yolk

YD = Diameter of egg yolk

3.3.1.4 Haugh unit

Haugh unit represents the quality of the egg and it was measured by using the following formula:

$$HU = 100 \times \log_{10} (H - 1.7 \times W^{0.37} + 7.6)$$

Where:

HU = Haugh unit

H = Observed height of albumen (mm)

W = weight of egg (g)

3.3.1.5 Shell thickness

Shell thickness was measured as described by Chowdhury (1990) by using a micrometre. Normally the shell is the thickest on the pointed side (small end), a few thinner on the blunt slide and the thinnest on the sides. Therefore, the shell was measured on the following places: (i) one time at the blunt end, (ii) one time between the blunt and the pointed ends (side), and (iii) three times at the pointed end. The shell thickness of an egg was calculated by the average of 3 parts (as mentioned above) of shell thickness. The thickness of the shell is very important during handling of the egg such as collecting, packing, candling, etc. The shell thickness at 3 locations of the egg around the equator of the shell was measured using a Vernier scale.

Figure 3.3.1.5: Vernier scale and balance scale

3.3.1.6 Shell weight

The shell weight (SW) was calculated using the formula (Harms et al., 1990), where EW is the weight of the egg in grams and SG is the egg specific gravity in g/cm^3

$$SW = (2.034 \text{ x } EW) - \left(\frac{2 \cdot 1014xEw}{SG}\right)$$

3.3.1.7 Shape index

A Vernier scale was used to measure the length and breadth of the eggs to the closest 0.01 mm. According to Reddy et al. (1979) and Anderson et al. (2004), the egg shape index was calculated from these measures given with the following formula:

$$\text{Shape index (\%)} = (\text{egg width}/\text{egg length}) \times 100$$

3.4 Chemical composition of egg

Jones' (2007) techniques were used to determine the chemical content of eggs (dry matter, ash, crude fat, and protein). The pH of albumen and yolk was also determined.

3.4.1 Dry matter or total solids

About 2 g of a sample were weighed in a clean previously dried aluminium basin, then placed it with lid in the oven at 105℃ for 24 hours, and then it was cooled the basin with lid in a desiccator for 30 min to cool. Finally, it was weighed the basin. The dry matter (DM) was calculated using the following formula:

Moisture% = (weight of fresh sample – weight of dried sample)/weight of sample taken × 100

DM% = 100-moisture%

3.4.2 Protein

Protein content in sample was determined by using Kjeldahl method which involved digestion, distillation and titration process.

Digestion: About 1g of dried silage sample was weighted and placed it in the digestion tube. 10 mL distilled water and 1 Kjeltab tablet were added to the digestive tube. The digestion tube was then filled with 12 mL of concentrated H_2SO_4 solution and put in the fume chamber's digestion rack. Before putting the digestion rack, switch on the

Gerhardt Kjeldatherm digestion block and heat it to 400°C for pre-heating. The rack was placed in a rack holder and allowed to cool after the digesting process.

Distillation: In the alkali tank of the Gerhardt Vapodest distillation plant, around 40% of NaOH was deposited. After that, the digested samples were diluted with 80 mL distilled water and 50 mL 45 percent NaOH. In the receiver flask, 30 mL of receiver solution was added. Place a 250 mL Erlenmeyer titration flask on the receiving platform and fill it with 4% boric acid (H^3BO^3) and an indicator before placing it in the receiver solution tank. For 5 minutes, the samples were distilled. There has been a colour change.

Titration: Boric acid receiving solution was titrated with standard 0.1 M HCl until it becomes pink colour. The volume of HCl used recorded and CP was calculated by using formula below:

$$N\% = \frac{[V - V(blank)] \times n \times 14.007}{W}$$

V= Volume of acid neutralised sample (ml)

n= concentration of HCl

W= Weight of sample (in mg)

$$Protein\% = N\ (\%)\ x\ 6.25$$

3.4.3 Crude fat

The weight of the fat recovered after extracting the fat from the sample using a solvent was used to assess the crude fat content. The equipment that involved in this procedure is analytical balance (at least 1 mg sensitivity). The determination of crude fat was done by undergo the standard operating procedure by used the Soxtec extraction.

Firstly, the aluminium cups was heated for 30 minutes at 103°C and dried in the desiccators for 20 minutes to cool it down. The cups were weighted and the readings were recorded by 4 decimal places (W1). 2g of sample was weighted into the thimble and the weight of sample was recorded (W2). The thimbles moved into the thimble stand and covered the sample with a layer of defatted cotton. The thimbles were then placed on the thimble support. The thimbles were attached to the magnets and put into the extraction device. Each cup was filled with 80mL petroleum ether and put into the extraction apparatus using the cup holder. The machine was started after the button was pressed. After the extraction finished, the cups removed and heated for 30 minutes at 103°C. The cups then allowed to cool down in the desiccators for 20 minutes. The cups were weighted and the final weight was recorded and noted as W3. The crude fat% was calculated using the formula below:

$$\text{Crude fat}\% = \frac{W3-W1}{W2} \times 100$$

Where;

W1 = Weight of empty cup (g)

W2 = Weight of sample (g)

W3 = Weight of residue after extraction process (g)

3.4.4 Ash

Ash was determined by burning off the organic matter of egg sample at 600^0C for 8 hours in a muffle furnace. Empty crucible was weighed and noted as W1, and 2g of sample was weighed and noted as W2. The sample incinerated in furnace at 600^oC for 8 hours. Then, the sample was let to be cool down inside the desiccator. The final residue inside the crucible was weighed and noted as W3. Ash was calculated by using formula below:

$$\text{Ash\%} = \frac{\text{W3} - \text{W1}}{\text{W2}} \times 100\%$$

Where,

W1= Weight of empty crucible (g)

W2= Weight of sample (g) in DM

W3= Weight of crucible and ash (g)

3.5 Statistical analysis

Data were analysed as a completely randomized design in a factorial arrangement 3×3, three egg types (traditional, organic and mega-3 rich eggs) and three grades of eggs (A, B and C), with three replicates per treatment. All data were analysed using one-way ANOVA by using Microsoft Excel and SPSS software. Duncan Multiple Range test (DMRT) was used to compare the differences between treatments at $p<0.05$.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Physical characteristics measurement

4.1.1 Egg weight

As shown in Table 4.1.1, egg weight was significantly ($p<0.05$) varied among the treatments. Regardless of egg grading, grade A of Omega-3 rich egg showed significantly ($p<0.05$) higher egg weight value (72.0g) followed by grade A of Organic egg (59.3g) and grade A of Traditional egg (54.7g). However, grade B of Omega-3 rich egg showed significantly ($p<0.05$) higher egg weight value (57.7g) followed by grade B of Organic egg (52.3g) and Traditional egg (51.7g). There was a consistent increase in egg weight with increasing grade from grade C, B and A egg source. The result of this study is similar with the findings of Travel et al. (2011) who reported that the weight of an egg fluctuates between 50 and 70 g, depending on the hen's age and, to a lesser extent, the genotype.

Table 4.1.1 Effect of egg grading on egg weight value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional eggs	54.7 ± 0.58^{aC} (3)	51.7 ±0.58^{bB} (3)	45.0 ± 1.0^{c} (3)	50.4 ± 4.33 (9)	0.000
Organic eggs	59.3 ± 1.15^{aB} (3)	52.3 ± 1.15^{bB} (3)	-	55.8 ± 3.97 (6)	0.002
Omega-3 rich eggs	72.0 ± 1.0^{aA} (3)	57.7 ± 1.15^{aA} (3)	-	64.8 ± 7.91 (6)	0.000
Overall	62.0 ± 7.81 (9)	57.7 ± 2.98 (9)	-	56.1 ± 8.02 (21)	0.129
p-value	0.000	0.001	-	0.129	-

*abABC Means within rows followed by different lower case letters and within columns and parameters followed by different upper case letter differ ($p<0.05$). Figures in parentheses represent number of observation.

4.1.2 Albumen height

As shown in Table 4.1.2, albumen height was significantly ($p<0.05$) varied among the treatments. Regardless of egg grading, grade A of Omega-3 rich egg showed significantly higher ($p<0.05$) of albumen height value (7.8mm) followed by grade A of Organic egg (7.6mm) and Traditional egg (4.8mm) sources. However, grade B of Omega-3 rich egg showed significantly higher ($p<0.05$) of albumen height (7.4mm) followed by grade B of Organic egg (7.2mm) and grade B of Traditional egg (4.4mm) sources. There was no significantly ($p>0.05$) difference on albumen height between grade A of Organic egg and grade A Traditional egg. The higher the number of albumen height, the better the quality of the egg and the greater the amount of thick albumen, the more nutritious the egg (Jeffrey Kluger et al., 2010). According to Pradeepta Kumar Rath et al. (2015), the increased albumen height (8.41 mm) is due to the freshness of the eggs and the suitable age of the chickens. Albumen height is a measure of how fresh and good an egg is (Stadelman et al., 1995).

Table 4.1.8 Effect of egg grading on albumen height (mm) value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional egg	4.8 ± 0.32^{aB} (3)	4.4 ± 0.03^{bB} (3)	4.3 ± 0.05^{c} (3)	4.5 ± 0.24 (9)	0.018
Organic egg	7.6 ± 0.14^{B} (3)	7.2 ± 0.61^{B} (3)	-	7.4 ± 0.45 (6)	0.320
Omega-3 rich egg	7.8 ± 0.13^{aA} (3)	7.4 ± 0.02^{bA} (3)	-	7.6 ± 0.22 (6)	0.007
Overall	6.7 ± 1.45 (9)	7.4 ± 1.47 (9)	-	6.3 ± 1.56 (21)	0.699
p-value	0.000	0.000	-	0.699	-

^{*abcAB} Means within rows followed by different lower case letters and within columns and parameters followed by different upper case letter differ ($p<0.05$). Figures in parentheses represent number of observation.

4.1.3 Shell thickness

As shown in Table 4.1.3, shell thickness was significantly ($p<0.05$) varied among the treatments. Regardless of egg grading, grade A of Traditional egg showed significantly higher ($p<0.05$) of shell thickness value (0.167mm) followed by grade A of Organic egg and Traditional egg (0.104mm). However, grade B of Traditional egg showed significantly higher ($p<0.05$) of shell thickness value (0.13mm) followed by Organic egg (0.104mm) and Omega-3 rich (0.1mm) egg sources. The shell thickness shown non significantly ($p>0.05$) difference on shell thickness between Traditional egg of grade A and grade B. Grade A of Organic egg and grade A of Omega-3 rich egg showed non significantly ($p>0.05$) difference on shell thickness. However, grade B of Traditional egg and grade B of Organic egg also showed non significantly ($p>0.05$) difference on shell thickness. According to Bright Science et al. (2018) stated that average shell thickness (0.4mm) with minimum acceptable of (0.3mm). When comparing the shell percentages of different weight egg categories, it was discovered that the bigger size eggs have the lowest shell percentage (Casiraghi et al., 2005; Hidalgo et al., 2008). In contrast to Patterson et al. (2001), the proportion of shell egg surviving did not change between heavy egg production and light egg production since only one egg weight group was examined. Shell cracks arise as a result of a combination of shell content, thickness, strength, and integrity, as well as the degree of damage experienced during egg handling (Hunton, 2005).

Table 4.1.3 Effect of egg grading on shell thickness (mm) value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional eggs	0.167 ± 0.01^{aA} (3)	0.13 ±0.02^{aA} (3)	0.115 ± 0.01^{b} (3)	0.137 ± 0.03 (9)	0.004
Organic eggs	0.104 ± 0.06^{B} (3)	0.104 ± 0.006^{A} (3)	-	0.100 ± 0.01 (6)	1.000
Omega-3 rich eggs	0.104 ± 0.06^{B} (3)	0.1 ± 0.0^{B} (3)	-	0.100 ± 0.00 (6)	0.374
Overall	0.125 ± 0.033 (9)	0.111 ± 0.017 (9)	-	0.118 ± 0.024 (21)	0.506
p-value	0.000	0.026	-	0.506	-

^{*abAB} Means within rows followed by different lower case letters and within columns and parameters followed by different upper case letter differ ($p<0.05$). Figures in parentheses represent number of observation.

4.1.4 Shape index

Table 4.1.4 shows that shape index was no significantly (p>0.05) varied among the treatments. Regardless of egg grading, grade A of Traditional egg showed significantly higher (p<0.05) of shape index (78.9mm) followed by grade A of Organic egg (76.8mm) and grade A of Omega-3 rich egg (75.2mm) sources. However, grade B of Organic egg showed significantly higher (p<0.05) of shape index (82.6mm) followed by grade B of Traditional egg (81.3mm) and grade B of Omega-3 rich egg (77.2mm) sources. The eggs were classified with respect to shape index (SI), namely sharp eggs (SI <72), standard egg (SI =72-76) and round egg (SI >76) according to finding of M. Duman (2015). This is in line with the finding of Pradeepta Kumar Rath et al. (2015) who reported that the eggs were found to have optimum shape index (73.53 ± 0.18) as per its genetic potential.

Table 4.1.4 Effect of egg grading on shape index value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional eggs	78.9 ± 2.4 (3)	81.3 ± 2.43 (3)	75.86 ± 3.24 (3)	78.7 ± 3.35 (9)	0.121
Organic eggs	76.8 ± 2.63 (3)	82.6 ± 3.04 (3)	-	79.7 ± 4.07 (6)	0.068
Omega-3 rich eggs	75.2 ± 2.19 (3)	77.2 ± 6.0 (3)	-	76.2 ± 4.16 (6)	0.614
Overall	77.0 ± 2.65 (9)	80.4 ± 4.3 (9)	-	78.3 ± 3.87 (21)	0.269
p-value	0.241	0.308	-	0.269	-

Figures in parentheses represent number of observation.

4.1.5 Shell weight

Table 4.1.5 shows shell weight was non significantly ($p>0.05$) varied among the treatments. Regardless of egg grading, grade A of Organic egg showed significantly higher ($p<0.05$) of shell weight value (2.67g) followed by grade A of Traditional egg (1.0g) and grade A of Omega-3 rich egg (0.67g) sources. However, grade B of Organic egg and grade B of Omega-3 rich egg showed significantly higher ($p<0.05$) shell weight value (1.33g) followed by grade B of Traditional egg (0.67g) sources. There was no significant different ($p>0.05$) between Traditional egg of grade A and grade B, and also no significant different ($p>0.05$) between Traditional egg of grade A and grade C. Some data suggests that the chickens' failure to create an increased amount of egg shell is linked to the activity of 25-hydroxy-cholecalciferol-1-hydoxylase, an enzyme involved in calcium homeostasis. (Joyner et al., 1987; Elaroussi et al., 1994). Heat stress affects food intake and limits the amount of calcium in the blood that can be used to make eggshells. It's also possible that it'll reduce hydrogen carbonate's action. Enzyme that helps to the production of carbonate in egg shells by producing bicarbonate (Balnave et al., 1989). As a result, supplementing with sodium bicarbonate during heat stress may assist to increase egg shell quality (Altan et al., 2000).

Table 4.1.5 Effect of egg grading on shell weight value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional eggs	1.0 ± 1.0[ab] (3)	0.67 ± 0.58[b] (3)	2.33 ± 0.58[a] (3)	1.33 ± 1.0 (9)	0.072
Organic eggs	2.67 ± 1.53 (3)	1.33 ± 1.53 (3)	-	2.0 ± 1.55 (6)	0.345
Omega-3 rich eggs	0.67± 1.15 (3)	1.33 ± 0.58 (3)	-	1.0 ± 0.89 (6)	0.422
Overall	1.44 ± 1.42[a] (9)	1.11 ± 0.93[b] (9)	-	1.43 ± 1.16 (21)	0.021
p-value	0.190	0.661	-	0.330	

*ab Means within rows followed by different lower case letters differ ($p<0.05$). Figures in parentheses represent number of observation.

4.1.6 Yolk Index

Table 4.1.6 shows yolk index was significantly ($p<0.05$) varied among the treatments. Regardless of egg grading, grade A of Omega-3 rich showed significantly higher ($p<0.05$) yolk index value (0.531) followed by grade A of Traditional egg (0.468) and Organic egg (0.457). However, grade B of Omega-3 rich egg showed significantly higher ($p<0.05$) of yolk index value (0.536) followed by grade B of Traditional egg (0.459) and Organic egg (0.362). There was no significant ($p>0.05$) of yolk index of grade A of traditional egg and Omega-3 rich egg sources. According to Bright Science et al. (2018) stated that the yolk index of regular eggs is <0.28, fresh eggs is between 0.29 – 0.38 and extra fresh eggs >0.38. The reliable indicator of fresh egg will decrease with storage time and temperature.

Table 4.1.6 Effect of egg grading on yolk index value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional eggs	0.468 ± 0.01^{A} (3)	0.459 ± 0.02^{B} (3)	0.45 ± 0.01 (3)	0.459 ± 0.01 (9)	0.346
Organic eggs	0.457 ± 0.03^{aB} (3)	0.362 ± 0.02^{bC} (3)	-	0.409 ± 0.06 (6)	0.006
Omega-3 rich eggs	0.531 ± 0.02^{A} (3)	0.536 ± 0.01^{A} (3)	-	0.534 ± 0.01 (6)	0.657
Overall	0.485 ± 0.04 (9)	0.452 ± 0.077 (9)	-	0.466 ± 0.057 (21)	0.495
p-value	0.007	0.000	-	0.495	

*abAB Means within rows followed by different lower case letters and within columns and parameters followed by different uppercase letter differ ($p<0.05$).

4.1.7 Yolk Height

Table 4.1.7 shows that yolk height was significantly ($p<0.05$) varied among the treatments. Regardless of egg grading, grade A of Omega-3 rich egg showed significantly higher ($p<0.05$) of yolk height value (20.4mm) followed by grade A of Traditional egg (18.1mm) and grade A of Organic egg (17.5mm) sources. However, grade B of Omega3 rich egg showed significantly higher ($p<0.05$) value (18.8mm) followed by grade B of Traditional egg (17.1mm) and grade B of Organic egg (12.9mm) sources. There was no significant different ($p>0.05$) among Traditional egg of grade A and grade B. There was also no significantly different between grade B and grade C of Traditional egg. Table above also showed that no significant difference between grade A of Traditional egg and grade A of Omega-3 rich egg sources.

Table 4.1.7 Effect of egg grading on yolk height value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional eggs	18.1 ± 0.61^{aA} (3)	17.1 ± 0.94^{abB} (3)	16.5 ± 0.31^{b} (3)	17.2 ± 0.93 (9)	0.067
Organic eggs	17.5 ± 0.9^{aB} (3)	12.9 ± 0.44^{bC}(3)	-	15.2 ± 2.62 (6)	0.001
Omega-3 rich eggs	20.4 ± 0.74^{aA} (3)	18.8 ± 0.4^{bA} (3)	-	19.6 ± 0.99 (6)	0.034
Overall	18.7 ± 1.46 (9)	16.3 ± 2.7 (9)	-	17.3 ± 2.28 (21)	0.088
p-value	0.008	0.000	-	0.088	

*abcABC Means within rows followed by different lower case letters and within columns and parameters followed by different upper case letter differ (p<0.05). Figures in parentheses represent number of observation.

4.1.8 Haugh Unit

Table 4.1.8 shows Haugh Unit was significantly ($p<0.05$) varied among the treatments. Regardless of egg grading, grade A of Organic egg showed significantly higher ($p<0.05$) of Haugh Unit value (87.6) followed by Omega-3 rich egg (85.1) and Traditional egg (69.2) sources. However, grade B of Omega-3 rich egg showed significantly higher ($p<0.05$) of Haugh Unit value (86.8) followed by Organic egg (85.3) and Traditional egg (67.5) sources. There was no significant ($p>0.05$) between Traditional egg of grade A and grade B. This is supported by Castellini et al. (2006) that stated in his study found a higher score in Organic egg. According to finding of Pradeepta Kumar Rath et al. (2015) who reported that H.U (92.00) is the higher values for egg that will contributed as freshness of eggs and also proper age of hens. According to Bright Science et al., (2018) stated that value of Haugh Unit (35-100). This is line with Haugh et al (1937) that stated the higher HU indicates in the egg is better internal egg quality. There is evidence that the methods by which albumen quality deteriorates differ from changes that occur during egg storage and changes that occur as a result of other causes (Toussant and Latshaw el at. 1999). Many factors can influence HU levels, including the age and strain or breed of the hens, storage time and circumstances, food elements, and probable sickness (Williams., 1992; Roberts, 2004). The Haugh Unit can be used to determine whether a product is of high enough quality to receive an AA rating (Jones, 2012).

Table 4.1.8 Effect of egg grading on Haugh unit value in different sources of eggs.

Parameter	Grading of egg (mean ± standard deviation)			Overall	p-value
	A	B	C		
Traditional egg	69.2 ± 0.49^{aC} (3)	67.5 ± 0.52^{bC} (3)	69.0 ± 0.79^{a} (3)	68.5 ± 0.98 (9)	0.026
Organic egg	87.6 ± 0.52^{aA} (3)	85.3 ± 0.2^{bB} (3)	-	86.4 ± 1.32 (6)	0.002
Omega-3 rich egg	85.1 ± 0.5^{bB} (3)	86.8 ± 0.35^{aA} (3)	-	85.9 ± 1.02 (6)	0.008
Overall	80.6 ± 8.67 (9)	79.8 ± 9.33 (9)	-	78.6 ± 9.01 (21)	0.845
p-value	0.000	0.000	-	0.845	-

^{*abABC} Means within rows followed by different lower case letters and within columns and parameters followed by different upper case letter differ ($p<0.05$). Figures in parentheses represent number of observation.

4.2. Chemical composition

4.2.1 Dry matter

Table 4.2.1 Dry matter (%) value in different sources of eggs.

Parameter	Egg types (mean ± standard deviation)			Overall	p-value
	Traditional eggs	Organic eggs	Omega-3 rich eggs		
Yolk	48.9 ± 6.95 (3)	53.4 ± 2.96 (3)	44.1 ± 5.69 (3)	49.0 ± 5.2 (9)	0.194
Albumen	81.5 ± 3.21 (3)	84.4 ± 2.95 (3)	84.7 ± 2.71 (3)	83.5 ± 2.99 (9)	0.404

Table 4.2.1 shows that dry matter content was significantly ($p<0.05$) varied among the treatments. For egg yolk, the dry matter (53.4%) of Organic egg source was significantly higher than the Traditional (48.9%) egg and Omega-3 rich fatty acid (44.1%) egg sources. In contrast, dry matter (84.7%) content of albumen for Omega-3 rich egg was significantly higher than the Organic (84.4%) and Traditional (81.5%) egg sources. However, dry matter content of yolk for Organic egg had higher because Organic egg is white egg shell that generally content higher dry matter content. This is in line with the findings of Wiebke Icken et al. (2013) who observed that in general white egg have a higher dry matter content as compared to brown eggs due to the higher yolk proportion of white eggs, the dry matter of white eggs also higher as compared to the brown eggs.

4.2.2 Crude protein

Table 4.2.2 Crude protein (%) value in different sources of eggs.

Parameter	Egg types (mean ± standard deviation)			Overall	p-value
	Traditional egg	Organic egg	Omega-3 rich egg		
Yolk	45.3 ± 0.65 (3)	44.01 ± 0.72 (3)	44.6 ± 0.38 (3)	44.7 ± 0.75 (9)	0.118
Albumen	96.7 ± 0.72 (3)	97.9 ± 0.52 (3)	96.9 ± 0.57 (3)	97.2 ± 0.78 (9)	0.100

Table 4.2.2 shows that crude protein (CP) of yolk egg and albumen yolk was significantly ($p<0.05$) varied among the treatments. For egg yolk (45.3%) of traditional egg was significantly higher than omega-3 rich (44.6%) and organic (44.01%) egg sources. However, for egg albumen (97.9%) of organic egg shows significantly higher than omega-3 rich (96.9 %) and traditional (96.7%) egg sources of CP. This is consistent with the findings of (Johnson et al., 2000), who reported that ovalbumin (54%) is the most abundant protein in egg albumen, followed by ovotransferrin (13%), ovomucoid (11%), - and - ovomucin (1.5-3.0%), and lysozyme (3.5 %).

4.2.3 Crude Fat

Table 4.2.3 Crude fat value (%) in different sources of eggs.

Parameter	Egg types (mean standard deviation)			Overall	p-value
	Traditional eggs	Organic eggs	Omega-3 rich eggs		
Yolk	57.3 ± 1.03 (3)	56.5 ± 0.74 (3)	55.8 ± 1.3 (3)	56.5 ± 1.13 (9)	0.303
Albumen	0.96 ± 0.01 (3)	1.0 ± 0.03 (3)	0.96 ± 0.03 (3)	0.97 ± 0.03 (9)	0.204

Table 4.2.3 shows that crude fat (CF) of yolk egg and albumen egg was significantly ($p<0.05$) varied among the treatments. For yolk the CF value (57.3%) of Traditional egg was shows significantly higher ($p<0.05$) followed by Organic egg (56.5%) and Omega3 rich egg (55.8%) sources. However, for albumen the CF value of (1.0%) of Organic egg was shows significantly higher ($p<0.05$) followed by Traditional egg (0.96%) and Omega-3 rich egg (0.96%) sources. In contrast with finding of Chaiyasit W el al, (2019) that found crude fat of chicken albumen (0.01). According to Kathleen M. Zelman el al., (2005) One egg contains just 75 calories, but it also contains 7 grams of high-quality protein, 5 grams of fat, and 1.6 grams of saturated fat, as well as iron, vitamins, minerals, and carotenoids.

4.2.4 Ash

Table 4.2.4 Ash value in different sources of eggs.

Parameter	Egg types (mean ± standard deviation)			Overall	p-value
	Traditional eggs	Organic eggs	Omega-3 rich eggs		
Yolk	1.8 ±0.12^{c} (3)	2.4 ± 0.04^{a} (3)	2.1 ± 0.09^{b} (3)	2.08 ± 0.24 (9)	0.001
Albumen	0.96 ± 0.05 (3)	0.92 ± 0.09 (3)	0.89 ± 0.08 (3)	0.92 ± 0.07 (9)	0.624
Shell	90.4 ± 0.96^{b} (3)	91.3 ± 0.3^{a} (3)	92.2 ± 0.99^{a} (3)	91.3 ± 0.99 (9)	0.058

^{*abc} Means with common superscripts are significantly different ($p<0.05$).

Table 4.2.3 shows that ash of yolk egg and albumen yolk was significantly ($p<0.05$) varied among the treatments. For yolk egg, the ash (2.4) of organic egg was significantly higher than the omega-3 rich egg (2.1) egg and traditional (1.8) egg sources. For albumen egg, the ash (0.96) of traditional egg was significantly higher than the organic (0.92) egg and Omega-3 rich (0.89) egg sources. For shell egg, the ash (92.2) of omega3 rich egg was significantly higher than Organic (91.3) and traditional (90.4) egg sources. However, there no significant ($p>0.05$) between organic egg and omega-3 rich egg sources. In a whole, raw and freshly laid egg content of 1.1% of ash represent.

4.3 Nutritional value

4.3.1 Nutritional value of yolk egg of different sources of eggs.

Table 4.3.1 Effect of egg sources on nutritional values of egg yolk.

Parameter	Sources of egg (mean ± standard deviation)			Overall	p-value
	Traditional egg	Organic egg	Omega-3 rich egg		
Dry matter (%)	48.9 ± 6.95 (3)	53.4 ± 2.96 (3)	44.1±5.69 (3)	49.0 ± 6.2 (9)	0.194
Crude protein (%)	45.3 ± 0.65 (3)	44.1 ± 0.72 (3)	44.6 ± 0.38 (3)	44.6 ± 0.75 (9)	0.118
Crude fat (%)	57.3 ± 1.03 (3)	56.5 ± 0.7 (3)	55.8 ± 1.34 (3)	56.5 ± 1.13 (9)	0.303
Ash (%)	1.8 ± 0.12^c (3)	2.4 ± 0.04^a (3)	2.06 ± 0.24^b (3)	2.1 ± 0.24 (9)	0.001

*abc Means with common superscripts are significantly different (p<0.05).

4.3.2 Nutritional value of albumen egg of different sources of eggs.

Table 4.3.2 : Effect of egg sources on nutritional values of egg albumen.

Parameter	Source of egg (mean ± standard deviation)			overall	p-value
	Traditional egg	Organic egg	Omega-3 rich egg		
Dry matter (%)	81.5 ±3.21 (3)	84.4 ± 2.95 (3)	84.7 ± 2.71 (3)	83.5 ± 2.99 (9)	0.404
Crude protein (%)	96.7 ± 0.72 (3)	97.9 ± 0.52 (3)	96.9 ± 0.57 (3)	97.2 ± 0.57 (9)	0.100
Crude fat (%)	0.96 ± 0.01 (3)	1.0 ± 0.03 (3)	0.96 ± 0.03 (3)	0.97 ± 0.03 (9)	0.204
Ash (%)	0.96 ± 0.05 (3)	0.92 ± 0.09 (3)	0.9 ± 0.08 (3)	0.92 ± 0.07 (9)	0.624

CHAPTER 5

CONCLUSION

5.1 Conclusion

Based on results of this experiment, it is concluded that physical characteristics of commercial available table eggs were significantly different among traditional, organic and omega-3 rich egg sources. Traditional egg showed the highest shell thickness (0.167mm), and organic and omega-3 rich eggs showed the lowest shell thickness (0.104mm). However, organic egg showed higher values of shape index, shell weight, Haugh Unit compared to other egg sources. Omega-3 rich fatty acid egg showed significantly higher egg weight, yolk index and yolk height compared to others egg sources. However, regardless of egg grading, grade A eggs represented significantly higher egg weight, shell thickness, shell weight, yolk height and Haugh Unit compared to grade B and grade C eggs. In contrast, grade B eggs showed the highest albumen height, shape index and yolk index.

Nutritive values of commercially available table eggs were significantly different among traditional, organic and omega-3 rich fatty acid eggs. Traditional egg showed the highest yolk's CF, albumen's CF, albumen's CP and also ash of shell, while organic egg showed the highest value of yolk's DM and albumen's ash. Omega-3 rich fatty acid egg exhibited the highest value of yolk's CP, yolk's ash and albumen's DM.

In this study, commercial egg of various conventional and specialty and specialty designation were showed high quality products. Overall, omega-3 rich fatty acid showed the higher albumen height because according Stadelman et al. (1995) stated that the indicator of freshness and quality egg is based on albumen height. Organic egg also showed that good greatest egg size that followed standard egg size, by that it easy to transportation because the egg size is important to followed the standard size of egg tray for avoid egg cracked during transportation.

5.2 Recommendation

This is the initial studies focused on the commercial chicken egg in different varieties of traditional, organic and omega-3 rich fatty acid egg sources, and which purchased from nearby store and super market. Thus, different sources of egg may come out with different results in future. To improves this research, the commercial chicken may be changed with other species of egg for example quail egg, duck egg, goose egg to study about physical and chemical composition of different types of egg in the future.

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APPENDIX A

Egg Weight

ANOVA					
Traditional egg					
	Sum of squares	df	Means square	F	sig
Between Groups	146.889	2	73.444	132.200	.000
Within Groups	3.333	6	.556		
Total	150.222	8			

ANOVA					
Organic egg					
	Sum of squares	df	Means square	F	sig
Between Groups	73.500	1	73.500	55.125	.002
Within Groups	5.333	4	1.333		
Total	78.833	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig
Between Groups	235.200	1	235.200	176.400	.001
Within Groups	4.000	3	1.333		
Total	239.200	4			

ANOVA

Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups	482.667	2	241.333	271.500	.000
Within Groups	5.333	6	.889		
Total	488.00	8			

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig
Between Groups	72.000	2	36.000	36.000	.000
Within Groups	6.000	6	1.000		
Total	78.000	8			

ANOVA					
Overall					
	Sum of squares	df	Means square	F	sig
Between Groups	187.611	2	93.806	2.179	.129
Within Groups	1420.944	33	43.059		
Total	1608.556	35			

Duncan

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Grade C Traditional Egg	3	45.000		
Grade B Traditional Egg	3		51.6667	
Grade A Traditional Egg	3			54.6667

Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade A	N	Subset for alpha = 0.05		
		1	2	3
Traditional Egg	3	54.6667		
Organic Egg	3		59.3333	
Omega-3 rich Egg	3			72.0000
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Treatment Grade B	N	Subset for alpha = 0.05	
		1	2
Traditional Egg	3	51.6667	
Organic Egg	3	52.3333	
Omega-3 rich Egg	3		57.6667
Sig.		1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Albumen Height

ANOVA
Traditional egg

	Sum of squares	df	Means square	F	sig
Between Groups	.149	2	.075	8.384	.018
Within Groups	.053	6	.009		
Total	.203	8			

ANOVA					
Organic egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.248	1	.248	1.285	.320
Within Groups	.772	4	.193		
Total	1.020	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.202	1	.202	25.156	.007
Within Groups	.032	4	.008		
Total	.234	5			

ANOVA					
Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups	16.912	2	8.456	726.868	.000
Within Groups	.070	6	.012		
Total	16.982	9			

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig

Between Groups	16.432	2	8.216	66.756	.000
Within Groups	.738	6	.123		
Total	17.171	8			

ANOVA					
Overall					
	Sum of squares	df	Means square	F	sig
Between Groups	1.655	2	.828	.362	.699
Within Groups	82.346	36	2.287		
Total	84.002	38			

Duncan

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Grade C Traditional Egg	3	4.2533		
Grade B Traditional Egg	3		4.4433	
Grade A Traditional Egg	3			4.7967
Sig.		1.000	1.000	1.00

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

Duncan

Treatment Grade A	N	Subset for alpha = 0.05	
		1	2
Traditional Egg	3	4.7967	

Organic Egg	3		7.6164
Omega-3 rich Egg	3		7.7667
Sig.		1.000	0.136

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade B	N	Subset for alpha = 0.05	
		1	2
Traditional Egg	3	4.4433	
Organic Egg	3		7.2100
Omega-3 rich Egg	3		7.400
Sig.		1.000	0.532

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Shell Thickness

ANOVA					
Traditional egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.004	2	.002	15.252	.004
Within Groups	.001	6	.000		
Total	.005	8			

ANOVA					
Organic egg					
	Sum of squares	df	Means square	F	sig

Between Groups	.000	1	.000	.000	1.000
Within Groups	.000	4	.000		
Total	.000	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.000	1	.000	1.000	.374
Within Groups	.000	4	.000		
Total	.000	5			

ANOVA					
Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups	.008	2	.004	65.247	0.000
Within Groups	.000	6	.000		
Total	.008	8			

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig
Between Groups	.002	2	.001	7.125	.026
Within Groups	.001	6	.000		
Total	.002	8			

ANOVA
Overall

	Sum of squares	df	Means square	F	sig
Between Groups	.001	2	.000	.694	.506
Within Groups	.022	36	.001		
Total	.023	38			

Duncan

Treatment	N	Subset for alpha = 0.05	
		1	2
Traditional Egg C	3	0.114833	
Traditional Egg B	3	0.129600	
Traditional Egg A	3		0.167400
Sig.		0.183	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade A	N	Subset for alpha = 0.05	
		1	2
Organic Egg	3	0.103700	
Omega-3 rich Egg	3	0.103700	
Traditional Egg	3		0.167400
Sig.		1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade B	N	Subset for alpha = 0.05	
		1	2

Omega-3 rich Egg	3	0.100000	
Organic Egg	3	0.103700	
Traditional Egg	3		0.129600
Sig.		0.680	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Shell Weight

ANOVA					
Traditional egg					
	Sum of squares	df	Means square	F	sig
Between Groups	3.556	2	1.778	4.000	.079
Within Groups	2.667	6	.444		
Total	6.222	8			

ANOVA					
Organic egg					
	Sum of squares	df	Means square	F	sig
Between Groups	8.167	1	8.167	3.769	.124
Within Groups	8.667	4	2.167		
Total	.16.833	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig
Between Groups	6.000	1	6.000	7.200	.055
Within Groups	3.333	4	.833		
Total	.9.333	5			

ANOVA					
Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups	8.222	2	4.111	2.176	.195
Within Groups	11.333	6	1.889		
Total	19.556	8			

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig
Between Groups	2.667	2	1.333	2.400	.171
Within Groups	3.333	6	.556		
Total	6.000	8			

ANOVA					
Overall					
	Sum of squares	df	Means square	F	sig
Between Groups	16.071	2	8.035	4.294	.021
Within Groups	67.365	36	1.871		
Total	83.436	38			

Duncan

Treatment	N	Subset for alpha = 0.05	
		1	2
Traditional Egg B	3	0.666667	

Traditional Egg A	3	1.000000	1.00000
Traditional Egg C	3		2.33333
Sig.		0.604	0.071

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade A	N	Subset for alpha = 0.05
		1
Omega-3 rich Egg	3	0.666667
Traditional Egg	3	1.000000
Organic Egg	3	2.666667
Sig.		0.107

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Treatment Grade B	N	Subset for alpha = 0.05
		1
Traditional Egg	3	0.666667
Organic Egg	3	1.333333
Omega-3 rich Egg	3	1.333333
Sig.		0.459

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Yolk Index

ANOVA					
Traditional egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.000	2	.000	1.274	.346
Within Groups	.001	6	.000		
Total	.002	8			

ANOVA					
Organic egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.014	1	.014	27.649	.006
Within Groups	.002	4	.000		
Total	.016	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig
Between Groups	.000	1	.000	.229	.657
Within Groups	.001	4	.000		
Total	.001	5			

ANOVA					
Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups	.010	2	.005	12.907	.007
Within Groups	.002	6	.000		
Total	.012	8			

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig
Between Groups	.046	2	.023	107.730	.000
Within Groups	.001	6	.000		
Total	.047	8			

ANOVA					
Overall					
	Sum of squares	df	Means square	F	sig
Between Groups	.005	2	.002	.716	.495
Within Groups	.124	36	.003		
Total	.129	38			

Duncan

Treatment	N	Subset for alpha = 0.05
		1
Traditional Egg C	3	0.449600
Traditional Egg B	3	0.459100
Traditional Egg A	3	0.467633
Sig.		0.174

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Treatment Grade A	N	Subset for alpha = 0.05

		1	2
Organic Egg	3	0.457067	
Traditional Egg	3	0.467633	
Omega-3 rich Egg	3		0.530833
Sig.		0.526	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Organic Egg	3	0.361600		
Traditional Egg	3		0.459100	
Omega-3 rich Egg	3			0.536167
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Yolk Height

ANOVA					
Traditional egg					
	Sum of squares	df	Means square	F	sig
Between Groups	4.069	2	2.034	4.380	.067
Within Groups	2.787	6	.464		
Total	6.856	8			

ANOVA

Organic egg					
	Sum of squares	df	Means square	F	sig
Between Groups	32.202	1	32.202	64.189	.001
Within Groups	2.007	4			
Total	.34.208	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig
Between Groups	3.527	1	3.527	9.981	.034
Within Groups	1.413	4	.353		
Total	4.940	5			

ANOVA					
Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups	13.487	2	6.743	11.716	.008
Within Groups	3.453	6	.576		
Total	16.940	8			

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig
Between Groups	55.849	2	27.924	65.278	.000
Within Groups	2.567	6	.428		
Total	58.416	8			

ANOVA
Overall

	Sum of squares	df	Means square	F	sig
Between Groups	25.881	2	12.940	2.600	.088
Within Groups	179.178	36	4.977		
Total	205.059	38			

Duncan

Treatment	N	Subset for alpha = 0.05	
		1	2
Traditional Egg C	3	16.4667	
Traditional Egg B	3	17.1000	17.1000
Traditional Egg A	3		18.1000
Sig.		0.298	0.122

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade A	N	Subset for alpha = 0.05	
		1	2
Organic Egg	3	17.5333	
Traditional Egg	3	18.1000	
Omega-3 rich Egg	3		20.3667
Sig.		0.396	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Organic Egg	3	12.9000		
Traditional Egg	3		17.1000	
Omega-3 rich Egg	3			18.8333
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Haugh Unit

ANOVA					
Traditional egg					
	Sum of squares	df	Means square	F	sig
Between Groups	5.726	2	2.863	7.330	.033
Within Groups	1.953	6	.391		
Total	7.678	7			

ANOVA					
Organic egg					
	Sum of squares	df	Means square	F	sig
Between Groups	8.037	1	8.037	51.918	.002
Within Groups	.619	4	.155		
Total	8.656	5			

ANOVA					
Omega-3 rich egg					
	Sum of squares	df	Means square	F	sig

Between Groups Within Groups Total	4.415 .753 5.168	1 4 5	4.415 .188	23.445	.008

ANOVA					
Grade A					
	Sum of squares	df	Means square	F	sig
Between Groups Within Groups Total	600.260 1.527 601.787	2 6 8	300.130 .254	1179.302	.000

ANOVA					
Grade B					
	Sum of squares	df	Means square	F	sig
Between Groups Within Groups Total	694.655 .872 695.528	2 6 8	347.325 .145	2389.135	.000

ANOVA					
Overall					
	Sum of squares	df	Means square	F	sig
Between Groups Within Groups Total	27.471 2921.253 2948.724	2 36 38	13.736 81.146	.169	.845

Duncan

Treatment	N	Subset for alpha = 0.05	
		1	2
Traditional Egg B	3	67.4506	
Traditional Egg C	3		69.0247
Traditional Egg A	3		69.1525
Sig.		1.000	0.808

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade A	N	Subset for alpha = 0.05		
		1	2	3
Traditional Egg	3	69.1533		
Omega-3 rich Egg	3		85.0867	
Organic Egg	3			87.5967
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Duncan

Treatment Grade B	N	Subset for alpha = 0.05		
		1	2	3
Traditional Egg	3	67.4500		
Organic Egg	3		85.2800	
Omega-3 rich Egg	3			86.8033

Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Dry Matter Yolk

ANOVA					
Yolk					
	Sum of squares	df	Means square	F	sig
Between Groups	130.107	2	65.053	2.184	.194
Within Groups	178.733	6	29.789		
Total	308.840	8			

Duncan

Treatment	N	Subset for alpha = 0.05
		1
Omega-3 Egg	3	44.0600
Traditional Egg	3	48.9300
Organic Egg	3	53.3700
Sig.		0.090

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

Dry Matter Albumen

ANOVA					
Albumen					
	Sum of squares	df	Means square	F	sig
Between Groups	18.601	2	9.300	1.058	.404
Within Groups	52.767	6	8.794		
Total	71.368	8			

Duncan

Treatment	N	Subset for alpha = 0.05
		1
Traditional Egg	3	81.5000
Organic Egg	3	84.4000
Omega-3 Egg	3	84.6800
Sig.		0.251

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

Crude Protein Yolk

ANOVA					
yolk					
	Sum of squares	df	Means square	F	Sig.
Between Groups	2.265	2	1.132	3.121	.118
Within Groups	2.177	6	.363		

Total	4.441	8			

Duncan

Treatment	N	Subset for alpha = 0.05	
		1	2
Traditional Egg	3	2.4803	
Organic Egg	3	2.5643	
Omeg-3 Egg	3		3.4627
Sig.		0.815	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

Crude Protein Albumen

ANOVA					
Albumen					
	Sum of squares	df	Means square	F	Sig.
Between Groups	2.602	2	1.301	3.472	.100
Within Groups	2.248	6	.375		
Total	4.850	8			

Duncan

Treatment	N	Subset for alpha = 0.05
		1
Omega-3 Egg	3	8.577

Organic Egg	3	9.3067
Traditional Egg	3	9.4589
Sig.		0.266

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

Crude Fat Yolk

ANOVA					
Yolk					
	Sum of squares	df	Means square	F	sig
Between Groups	3.330	2	1.665	1.468	.303
Within Groups	6.805	6	1.134		
Total	10.135	8			

Duncan

Treatment	N	Subset for alpha = 0.05
		1
Omega-3 Egg	3	0.2743
Organic Egg	3	0.3083
Traditional Egg	3	0.3612
Sig.		0.400

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

Crude Fat Albumen

ANOVA					
Albumen					
	Sum of squares	df	Means square	F	sig
Between Groups	.002	2	.001	2.094	.204
Within Groups	.004	6	.001		
Total	.006	8			

Duncan

Treatment	N	Subset for alpha = 0.05
		1
Omega-3 Egg	3	0.2045
Organic Egg	3	0.2460
Traditional Egg	3	0.3630
Sig.		0.182

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

ASH Yolk

ANOVA					
Yolk					
	Sum of squares	df	Means square	F	Sig.
Between Groups	.417	2	.208	26.680	.001

Within Groups	.047	6	.008		
Total	.463	8			

Duncan

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Traditional Egg	3	1.832900		
Omega-3 Egg	3		2.055533	
Organic Egg	3			2.357867
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

ASH Albumen

ANOVA					
Albumen					
	Sum of squares	df	Means square	F	sig
Between Groups	.006	2	.003	.510	.624
Within Groups	.035	6	.006		
Total	.041	8			

Duncan

Treatment	N	Subset for alpha = 0.05

		1
Omega-3 Egg	3	0.894967
Organic Egg	3	0.915767
Traditional Egg	3	0.957033
Sig.		0.374

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000

ASH Shell

ANOVA					
Shell					
	Sum of squares	df	Means square	F	sig
Between Groups	4.784	2	2.392	4.768	.058
Within Groups	3.010	6	.502		
Total	7.794	8			

Duncan

Treatment	N	Subset for alpha = 0.05	
		1	2
Traditional Egg	3	90.379067	
Organic Egg	3	91.339300	91.339300
Omega-3 Egg	3		92.163200
Sig.		0.148	0.204