THE EFFECTS OF ANIMAL FAT TREATMENT AND STORAGE CONDITIONS ON AVIAN EGG QUALITY, AS WELL AS THE ACCEPTABILITY OF FAT-TREATED EGGS FOR PRODUCERS AND CONSUMERS.

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DECLARATION WITH REGARD TO THE INDEPENDENT WORK

I, Lepule E.M.C., do hereby declare that the research project submitted by me in fulfilment of the degree MAGISTER TECHNOLOGIAE: AGRICULTURE at the Technikon Free State is my own independent work and has not been previously submitted by myself or any other person in fulfilment of any qualification.

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Signature of Student

15/03/2004
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Central University of Technology, Free State

TO WHOM IT MAY CONCERN

This serves to certify that thesis of Ms E M C Lepule [The effects of animal fat treatment and storage conditions on avian egg quality, as well as the acceptability of fat-treated eggs for producers and consumers] has been edited in terms of language usage, spelling and syntax.

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ABSTRACT

The avian egg is a source of food that is nutritious, economical and versatile. Egg quality is a general term denoting a range of physical and chemical properties that optimise the value of eggs for various purposes. The present study was conducted to examine effects of animal fat treatment and storage conditions on egg quality, as well as to determine the acceptability of fat-treated eggs for producers and consumers.

A total of 960 eggs were used in the study. Eggs were collected randomly from Hi-Sex birds at a poultry farm in Bloemfontein-East. The age of the birds ranged between 34 and 72 weeks. Two studies were conducted and for each study 480 eggs were used. The first study was conducted in the winter season and the second was conducted during the summer season. After eggs were collected, they were weighed in grams and numbered. Eggs for treatment were rubbed with fat in the palm of a hand and they were stored in the cardboard boxes and the plastic bags for four weeks. Eggs were further kept in mud and cement-brick huts. Every week ten eggs from each treatment were weighed to determine the weight loss during storage, then broken into a flat plate to measure albumen height and to estimate the yolk index and the Haugh unit value.

The results showed that with time in storage there was a deterioration of egg quality. The mean mass difference of fat-treated eggs was statistically significantly different from the control eggs. The statistically significant difference was observed for the mean mass difference, albumen height, yolk index and Haugh unit of fat-treated eggs when compared with the control eggs that were stored in the mud hut ($p<0.05$). The results further indicated that the mean mass difference of poultry fat-treated eggs was

statistically significantly different from eggs that were treated with beef fat ($p<0.05$). The storage of eggs during winter exhibited a small decline in egg quality when compared with those that were stored in summer ($p<0.05$). Of the respondents 83% said that they would coat avian eggs with fat and 82% said they would eat fat-treated eggs. Moreover, of the respondents 75% mentioned that the lack of a cooling facility would not deter them from producing avian eggs.

The practice of fat treatment could thus be an economically important method for marketing eggs at farm level in areas where cold storage and ideal facilities are impractical.

Key words: animal fat, avian eggs, albumen (thick egg white) height, yolk index and Haugh unit.

OPSOMMING

Die voëleier is 'n voedsame, ekonomiese en veelsydige voedselbron. Eiergehalte is 'n algemene begrip wat verwys na 'n reeks fisiese en chemiese eienskappe wat die waarde van eiers vir verskeie doeleindes optimaliseer. Die huidige studie is onderneem om die effek van diervetbehandeling en bergingstoestande op eiergehalte te ondersoek, asook om te bepaal hoe aanvaarbaar vetbehandelde eiers vir produsente en verbruikers is.

Altesaam 960 eiers is in die studie gebruik. Eiers is ewekansig ingesamel van Hi-Sex hoenders op 'n pluimveeplaas in Bloemfontein-Oos. Die ouderdomme van die hoenders het gewissel van 34 tot 72 weke. Twee studies is onderneem, en 480 eiers is vir elke studie gebruik. Die eerste studie is gedurende die winterseisoen onderneem, en die tweede studie gedurende die somerseisoen. Nadat die eiers ingesamel is, is hulle in gram geweeg en genommer. Eiers wat behandel sou word, is in die handpalm met vet ingesmeer, en hulle is vier weke lank in die kartondose en plastieksakke geberg. Eiers is verder in modder- en sementsteenhutte gehou. Elke week is tien eiers uit elke behandelde groep geweeg om die gewigsverlies tydens berging te bepaal, en daarna is elke eier in 'n plat bord oopgebreek om albumenhoogte te meet en die dooierindeks en die Haugh-eenheidswaarde te beraam.

Die resultate het aangetoon dat 'n afname in eiergehalte mettertyd ingetree het tydens die bergingstyd. Die gemiddelde gewigsverskil van vetbehandelde eiers het statisties beduidend verskil van die eiers in die kontrolegroep. Die statisties beduidende verskil is waargeneem ten opsigte van die gemiddelde gewigsverskil, albumenhoogte, dooierindeks en Haugh-eenheid van vetbehandelde eiers in vergelyking met die eiers in die kontrolegroep, wat in die modderhut geberg is ($p<0.05$).

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Die resultate het verder daarop gedui dat die gemiddelde gewigsverskil van eiers wat met hoendervet behandel is, statisties beduidend verskil het van eiers wat met beesvet behandel is ($p<0.05$). Die berging van eiers gedurende die winter het 'n klein afname in eiergehalte getoon in vergelyking met dié wat gedurende die somer geberg is ($p<0.05$). Van die respondente het 83% gesê hulle sou voëleiers met vet bedek, en 82% het aangedui dat hulle vetbehandelde eiers sou eet. Verder het 75% van die respondente genoem dat die gebrek aan 'n verkoelingsfasiliteit hulle nie sou verhinder om voëleiers te produseer nie.

Die praktyk van vetbehandeling kan dus van ekonomiese belang wees vir die bemarking van eiers op plaasvlak in areas waar koelbewaring en ideale fasiliteite nie prakties uitvoerbaar is nie.

Sleutelwoorde: Diervet, voëleiers, albumenhoogte (hoogte van dik eierwit), dooierindeks en Haugh-eenheid.

DEDICATION

A special dedication goes to my family for their love and support.

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1. Introduction

1.1 The avian egg

The avian egg is a source of food that is nutritious, economical and versatile. According to the Department for Environment, Food and Rural Affairs (2001) eggs today are a staple food within the human diet, consumed by people throughout the world. Jacob, Miles and Mather (1998) reported that the avian egg is not only a vehicle for reproduction; it also serves as a source of food for human consumption. Consumers recognise avian eggs as versatile and wholesome because they have a natural balance of essential nutrients. The Food Safety Ohio Poultry Association (2002: Online) asserted that avian eggs pose no greater food safety risk than any other perishable food.

The size and shape of avian eggs differ among the various species of birds, although all have a yolk, albumen and shell. The avian eggs consist of 32% yolk, 56% albumen and 12% shell (Division of Animal Breeding, IAPI and Animal Improvement, [s.a.]a). The protein content of eggs is of great value for human nutrition and all the essential amino acids are found in the eggs. Eggs are not just an important source of protein; they are also calorie conscious (Oderkirk, 1990). According to the Division of Animal Breeding, IAPI and Animal Improvement [s.a.]a, avian eggs consist of a minute reproductive cell comparable to that found in mammals. In the case of chickens, this cell is surrounded by the yolk, albumen, shell membranes, shell and cuticles (Division of Animal Breeding, IAPI and Animal Improvement, [s.a.]a).

The ovary is responsible for the formation of the yolk, while the remaining portions of the egg originate in the oviduct. Both North (1984) and the Department for Environment, Food and Rural Affairs (2001) stated that when the yolk reaches its final size it breaks away from the ovary (process of ovulation) and the yolk enters the oviduct where the albumen and shell are added. This process, from ovulation to egg laying, takes around 24 or 26 hours. The egg yolk is the yellow inner part of an egg surrounded by egg white. The Division of Animal Breeding, IAPI and Animal Improvement [s.a.]a reported that the yolk is not the true reproductive cell, but a source of food material from which the minute cell (blastoderm) and its resultant embryo partially sustain its growth. The egg yolk is composed of fats (lipids), vitamins, minerals and proteins that combine to form the lipoprotein. The vitalline membrane (a transparent barrier) surrounds the yolk and prevents the yolk contents from leaking into the albumen. The colour of the yolk varies and is influenced by the diet of the hen.

The albumen (egg white) is very rich in proteins and vitamins and has a substance that can also protect the egg from the invasion of microorganisms through the eggshell (Passmore, 1975). The albumen is designed to provide support and protection to the yolk and to hold it centrally inside the egg. Passmore (1975) asserted that egg white or albumen forms a second line of defense against invasion of microorganisms because it is very alkalic. It also contains microbial inhibitors such as lysozyme and very few microorganisms can survive these conditions in fresh eggs. In fresh, good quality eggs, the albumen is jellylike and has a cloudy appearance. As the egg ages, carbon dioxide is lost through the shell pores, the egg contents become more alkaline and cause the albumen to be transparent and watery (Passmore, 1975).

Chicken eggs are naturally well protected from any type of microbial infection by their calcite shells. The cuticle coating that insulates the embryo chick conserves water and allows for gaseous exchange. This natural barrier has evolved to keep invading microorganisms out, so that the chick can develop in a sterile environment (Passmore 1975).

According to Passmore (1975) the spoilage and staling of shell contents occur because there are breathing pores in the shells through which the embryo chick exchanges gases. The avian eggshell thus has pores that permit evaporation from the egg. Gaseous exchange in an egg results in a watery egg with contents that spread over a wider surface when the egg is broken. A single avian eggshell may be perforated by between seven and seventeen thousand pores. In fresh eggs, however, most of these pores are covered by protective cuticle, which provides extra microbiological protection (Passmore, 1975). As the egg ages or when it is damaged, the cuticles are worn away, exposing the pores and allowing moisture to escape. Microorganisms may then enter and will spoil the egg (Passmore, 1975).

The natural longevity of eggs makes it advantageous to use them as food. We can keep eggs for ten to fourteen days and even longer (three to four weeks) if they are refrigerated to slow down the staling processes. However, eggs are characterised by deterioration in quality during storage. After the egg has been laid the internal contents and structure of the egg changes. This is a continuous, irreversible process and even the most carefully controlled storage conditions can do nothing other than slow down the rate of deterioration (Department for Environment, Food and Rural Affairs, 2001). Passmore (1975) maintained that the deterioration of quality begins the moment an egg is laid and this process includes proteolytic changes that will thin the white and weaken the chalazae so that the yolk is no longer suspended centrally. Dehydration and loss of carbon dioxide that increases the size of the air cell also occurs.

When the egg is laid, it is warmer than its surroundings and as it cools down the egg contents contract and a small air space is formed between the inner and outer shell membranes. The air space is normally formed at the broad end of the egg, as more pores are present there. As the egg ages, moisture and carbon dioxide continue to be lost through the shell pores. Air moves in and the air space increases in size at a rate determined by temperature and relative humidity. When the air is warm and dry, the loss of moisture from the egg is quicker (Department for Environment, Food and Rural Affairs, 2001).

1.2 Avian egg quality

Avian egg quality is a general term denoting a range of physical and chemical properties that optimize the value of eggs for various purposes (Poultry Bulletin, 1997). This includes shell quality, grade or albumen quality (Haugh units), yolk quality, nutritional value to the consumer, freedom from defects such as blood spots and egg size. The egg quality is at its maximum at the moment when the egg is laid. Hunton (1984) asserted that the term *avian egg quality* means different things to people at different points in the marketing chain.

For consumers, egg quality includes aspects such as cleanliness of the product and attractive packaging. Consumers are also concerned with the absence of cracks, uniformity of size, colour and freshness, an attribute which they find difficult to define. Egg quality is mostly reflected by consumer's satisfaction (Oderkirk, 1982; Division of Animal Breeding, IAPI and Animal Improvement, [s.a]b).

In attempts that have been made to define egg quality, the problem has been to find a factor that is rapidly quantifiable and at the same time is associated with perceivable difference in quality. This problem, however, appears to have been solved by referring to the yolk quality (Hunton, 1987). This is simply defined by the colour of the yolk, which is important principally for consumer acceptance, but could be manipulated by dietary means (Leeson and Summers, 1991; Division of Animal Breeding, IAPI and Animal Improvement, [s.a]a). To the egg producers, egg quality reduces itself to three basic considerations (Hunton, 1984).

- Absence of dirt and stains.
- Absence of cracks.
- Internal quality of albumen.

The Department for Environment, Food and Rural Affairs (2001) asserted that, for the quality standards of the European Union Marketing Regulations and other controls, there are three classes of egg quality intended for human consumption:

- Class A: Fresh eggs.
- Class B: Second quality or preserved eggs.
- Class C: Non-graded eggs intended for the manufacturing of foodstuffs.

Egg quality is influenced before laying by the condition of individual birds and after laying by conditions the eggs are exposed to (Oderkirk, 1982). According to the Division of Animal Breeding, IAPI and Animal Improvement [s.a]b, eggs can be separated into four grades: Grade 1, Grade 2, Grade 3 and Undergrade. With relevance to quality, requirements for each grade are as follows:

Grade 1:

- No cracks may appear on the shells.
- The eggs must be clean.
- The eggshells must be uniform and strong.
- No blood, blood spots, meat spots, blood rings, scattered blood, fungus, mouldiness or

absorbed odours and flavours may be present in the eggs.

- The egg yolk should have a fine colour without any spots and should not be flat or enlarged. It should be located near the centre of the egg.
- The albumen (white of the egg) should be clear and firm, with a Haugh value of at least 55 units.
- No air bubbles with a depth of more than 6 mm may appear in the egg, provided that the air bubble may be shaky and may not move more than 6 mm in any direction when the egg is turned from the vertical position.
- No decay or germ development may appear in the egg.
- The eggs must have a minimum mass of 43 g each.

Grade 2:

- No cracks may appear on the eggshells.
- The eggs must be clean.
- The eggshells must be uniform and strong.
- No blood, blood spots, meat spots, blood rings, scattered blood, fungus, mouldiness or absorbed odours and flavours may be present in the eggs.
- The egg yolk should have a fine colour.
- The albumen (white of the egg) should be clear and firm, with a Haugh value of at least 35 units.
- No air bubbles with a depth of more than 9 mm may appear in the egg, provided that the air bubble may be shaky and may not move more than 12 mm in any direction when the egg is turned from the vertical position.
- No decay or germ development may appear in the egg.
- The eggs must have a minimum mass of 43 g each.

Grade 3:

- The eggs should have minimum mass of 35 g each and they do not meet the requirements of the first two grades.

Undergrade:

- The eggs do not meet the requirements of any of the other grades.

1.3 Measurement of avian egg quality

Silversides and Villeneuve (1994) asserted that egg quality is measured in order to describe the differences in fresh eggs produced by hens submitted to different genetic, nutritional or environmental treatments or to describe the deterioration in egg quality with different storage times or conditions. Avian egg quality can be measured externally as well as internally.

1.3.1 External method

The most frequently used method for external measurement of avian egg quality is candling (Jacob *et al.*, 1998). This technique takes its name from the original source of light that was used (the candle). The candling method is the process of testing egg quality without breaking the shell. The method involves viewing the eggs in front of a light sufficiently strong enough to penetrate the shell and to outline the contents by contrast. A beam of light is thus shone through the shell so that the internal content of the egg is visible. Jacob *et al.* (1998) asserted that accurate candling is best done in a darkened room by means of passing a light through each egg. Candling equipment may range from a simple homemade unit, to a mechanical device that is part of the mechanised washing, grading, sizing and packing unit.

A candler can detect freshness, blood spots and defects in the egg. Baker and Vadehra (1972) as well as Jacob *et al.* (1998) reported that candling is still a common and practical way to determine the internal quality of the shell eggs for the poultry industry. The Department for Environment, Food and Rural Affairs (2001) mentioned that egg candling has played a fundamental role in the marketing of eggs in the United Kingdom for at least 70 years. Candling is a quality control procedure that allows the assessment of internal egg quality and easy identification of faults and defects, in particular the hairline shell cracks. In addition, grading can be done through candling on the basis of the size of the air space at the blunt end of an egg (Department for Environment, Food and Rural Affairs, 2001).

Larger producers make use of a conveyer belt on which the eggs move over a light source in a dark room. As the egg quality decreases, the yolk moves more freely and casts a darker shadow because it floats closer to the shell. This difference is, however, due to changes in the albumen rather than changes in the yolk (Jacob *et al.*, 1998). The thinner the albumen, the closer the yolk will be to the shell. A darker shadow may also occur if the yolk is enlarged.

"Since the candling method relies on human judgement and skills, it is thus subject to inaccuracies" (Baker and Vadehra, 1972). The limitations of egg candling have long been recognised, but for years it has provided the best way of identifying faults in eggs. Jacob *et al.* (1998) reported that candling has the advantage of being rapid but not destructive.

1.3.2 Internal method

Internal egg quality is based on the air cell size, albumen quality, yolk quality and the presence of blood or meat spots (Jacob *et al.*, 1998).

According to Oderkirk (1982), egg quality can be measured by:

- Appearance of yolk and albumen

The egg yolk should not be flat or enlarged. It should be located near the centre of the egg, without any spots. The albumen should be clear and firm (Division of Animal Breeding, IAPI and Animal Improvement, [s.a]b).

- Air cell size

The depth of the air cell is the distance from its top to bottom when the egg is held with the air cell up. Jacob *et al.* (1998) mentioned that in fresh eggs the air cell is small.

- Yolk colour

Yolk colour depends on the diet of a hen. Hens fed on mashes containing yellow corn and alfalfa meal lay eggs with yellow yolk, while those fed on white corn, grain sorghum or wheat, yield light coloured yolk (Jacob *et al.*, 1998).

- Haugh unit score

The Division of Animal Breeding, IAPI and Animal Improvement [s.a]b maintained that the internal egg quality is best indicated by the Haugh unit. Hunton (1984) stated that the Haugh unit is a measure of the height of the albumen correct for egg weight. The egg is broken and the height of the albumen is determined in millimetres approximately 5 mm away from the egg yolk.

According to Williams (1992) the Haugh unit measure is accepted as the measure of choice for egg quality. According to Silversides, Twizeyimana and Villeneuve (1993) the use of Haugh unit to determine egg quality is universal due to its ease of application and the correlation with the appearance of the egg when broken onto a flat surface. The Haugh unit is described as the standard measure of egg quality used by the poultry industry. It could also be a measure of visual appearance, because it shows the appearance of the egg when it is broken onto a flat surface (Williams, 1992).

- Odour and flavour

In a fresh egg, one should not be able to detect any absorbed odours or flavours.

- Nutritional value

Trace elements such as iron, zinc and manganese improve the albumen quality, while low amounts of vitamin A may increase blood spots in the egg (Oderkirk, 1982).

1.4 Preservation of avian egg quality

Avian egg quality is preserved by methods similar to those that are generally used for preservation of other foodstuffs. These methods mainly entail storage at low temperature, the use of chemical agents of various types, and dehydration (Seth, Gangwar, Mohan and Guru, 1973).

1.4.1 Methods for preserving avian egg quality

The following methods are used to slow down the staling process of avian eggs during storage:

- Oil dipping: eggs are dipped in oil (Murthy and Maurer, [s.a]).
- Refrigerator: eggs are kept in the refrigerator (Onwudike and Sonaiya, 1983).
- Waterglass (Sodium Silicate): eggs are packed, pointed pole downwards, in a cold Sodium Silicate solution (Passmore, 1975).

- Lime solution: eggs are packed, pointed pole downwards in a lime solution (Passmore, 1975).
- Oteg: eggs are dipped in an Oteg solution (Passmore, 1975).
- Greasing with white Vaseline, lard or butter: eggs are rolled carefully in fat in palms of the hands (Passmore, 1975).
- Borax and lard: are creamed together and applied by hand (Passmore, 1975).

According to Koelkebeck (2002: Online), the interior egg quality can be preserved by the following:

- Storing eggs at a relatively cool temperature (to reduce the loss of carbon dioxide from the albumen and retard the flow of water from the albumen to the yolk).
- Maintaining high relative humidity in the storage area (high relative humidity will slow down the process of moisture loss from the eggs).
- Storing eggs in a sealed container will reduce the loss of carbon dioxide and moisture.
- Oiling to help maintain the interior egg quality.
- Not storing eggs where they will pick up strong odours.

Furthermore, Passmore (1975) said that staling, microbial invasion and spoilage could be prevented and storage life of avian eggs prolonged by artificial preservation. Eggs destined to be preserved should never be washed, as this may damage the cuticles and may result in organisms entering the eggs through the shell pores. Passmore (1975) reported that experiments have shown that spoilage microorganisms invade eggs at the blunt pole around the air cell, so preserved eggs should be stored with the pointed pole downwards. This helps to prolong the storage life further, because the yolk remains suspended in the centre, away from the contaminated shell air space.

Limiting evaporation or gaseous exchange from avian eggs assists in the preservation of egg quality (Passmore, 1975). Swanson, Froning and Hendrickson (1958) point out that preserving egg with oil plays an important role in slowing down the rate of evaporation. Hinton (1968) and Passmore (1975) reported that the aim of preserving egg quality by applying oil to the eggshell is to prevent the entry and growth of spoilage, or pathogenic, microorganisms which would make the egg unpalatable or dangerous to health. Similarly, Sabrani and Payne (1978) mentioned that oil applied to the eggshell reduced the decline of the albumen height a great deal when compared to the decline of albumen height for the unoiled eggs, both were stored at 12°C. Hunton (1984) also mentioned that a factor that could delay the deterioration of egg quality is coating the eggshell with oil.

1.5 Present state of problem

1.5.1 Farming Sector

In South Africa there are farming communities who have the skills to produce eggs, but they are often limited by the lack of facilities. The communities of Kaalspruit and Rust en Vrede in Bloemfontein-East, in the Free State Province of South Africa, are such two examples. These communities produce eggs on a small scale. The Kaalspruit community has ninety laying hens, while Rust en Vrede has sixty laying hens. The main enterprise for Kaalspruit is dairy, however, and for the Rust en Vrede it is beef production. Both communities have diversified to egg production and could expand this industry to ensure a more reliable income.

These communities, conversely, lack the necessary cooling facilities to keep eggs after they have been collected from the laying houses. Most inhabitants of the Kaalspruit community live in mud huts and the eggs are kept in the huts after they are collected. The community of Rust en Vrede live in cement-brick houses and they keep the eggs in their houses. The eggs are kept at room temperature, for a period ranging from one to four weeks, until they are sold out. There is often a surplus of eggs as these farms are situated in remote areas. The consumers have to travel to the farms to buy the eggs, or the producers have to transport the eggs to the consumers. Lack of transport thus obstructs the sale of eggs.

According to Hunton (1984) storage conditions on the farm are vital for good albumen quality and coating eggs with oil can slow down the deterioration of egg quality. Bowes (1998) concurs that fat treatment of eggs preserves egg quality during storage. Furthermore, Van der Merwe (1999) asserted that there are farmers in Bloemfontein-West who treat avian eggs with fat at farm level, in order to limit the deterioration of egg quality during storage. The fat that was used for treatment was extracted from cooked poultry and beef.

1.6 Aim of the study

This study was conducted to examine the effects of animal fat (fat extracted from cooked beef and poultry meat) treatment and storage conditions on the avian egg quality, as well as to determine the acceptability of fat-treated eggs for the producers and consumers.

1.7 Objectives of the study

The following objectives were identified:

- to evaluate the effectiveness of animal fat treatment as a preservation method for egg quality during the storage period and to compare the effectiveness of beef and poultry fat respectively;
- to evaluate the possible influence of different storage conditions on egg quality (mud versus cement-brick hut and plastic bags versus carboard boxes);
- to determine the effect of storage duration on the avian egg quality;

- to observe seasonal effects (summer and winter season) on the mass difference, albumen height, yolk index and Haugh units; and
- to evaluate the acceptability of fat treated eggs by producers and consumers.

2. Materials and Methods

2.1 Introduction

This chapter describes the materials and procedures used to conduct the study. Poultry eggs from Hi-Sex birds were used in the study to evaluate the effects of animal fat treatment and storage conditions on the egg quality. The following parameters were evaluated: egg mass; albumen height; yolk index and Haugh units. A questionnaire was also used to determine the producers' and consumers' acceptance of fat treated eggs.

2.2 An overview of the procedures

2.2.1 Experimental

A total of 960 poultry eggs were used in the study. Eggs were collected from Hi-Sex birds at a poultry farm in Bloemfontein-East. The ages of the birds ranged between 34 and 72 weeks. The project was conducted at Kaalspruit farm in Bloemfontein-East, in the Free State Province of South Africa. Two experiments were conducted, one in winter and one in summer. As shown in Table 2.1, eggs were randomly distributed into treatment groups.

Table 2.1: Treatment groups in the mud hut and the cement-brick hut

Treatment	Mud hut	Cement-brick hut
1	40 control eggs (plastic bag)	40 control eggs (plastic bag)
2	40 control eggs (cardboard box)	40 control eggs (cardboard box)
3	40 beef fat treated eggs (cardboard box)	40 beef fat treated eggs (cardboard box)
4	40 beef fat treated eggs (plastic bag)	40 beef fat treated eggs (plastic bag)
5	40 poultry fat treated eggs (cardboard box)	40 poultry fat treated eggs (cardboard box)
6	40 poultry fat treated eggs (plastic bag)	40 poultry fat treated eggs (plastic bag)

Eggs were numbered with a marking pen from one to forty per treatment group. The mass of each egg was measured with an electrical scale before storage. Fat extracted from cooked beef and poultry meat was used to preserve the egg. The eggshells were rubbed with either beef or poultry fat in the palm of a hand, to ensure complete cover.

Figure 2.1 exhibits the cement-brick hut that was used to store eggs during winter and summer.

Figure 2.1: Cement-brick hut

In Figure 2.2 the mud hut that was used to store eggs during winter and summer is displayed.

Figure 2.2: Mud hut

The mud and cement-brick huts were used to store eggs for four weeks. In each of the huts

480 eggs were stored during the wint[illegible]sons respectively. Eggs were further subdivided into subgroups. The control eggs were kept in either cardboard box or plastic bag (n= 40 per group); the beef fat treated eggs were kept in either cardboard box or plastic bag (n= 40 per group), as were the poultry fat treated eggs (n= 40 per group). Eggs were stored with the pointed pole downward, to prevent microorganisms from invading the eggs through the blunt pole. (n = number of eggs per treatment group).

2.2.2 Survey

A survey was conducted to evaluate the acceptability of animal fat treated eggs for producers and consumers. A structured interview was conducted by means of a questionnaire (attached as Addendum 1).

2.3 Procedures

2.3.1 Experimental

Every seven days ten eggs were collected from each treatment and control group to evaluate the parameters of the eggs. The measurements regarding egg mass, albumen height, yolk index and Haugh unit were recorded.

2.3.1.1 Egg mass

An electrical scale (Figure 2.3) was used to determine the egg mass.

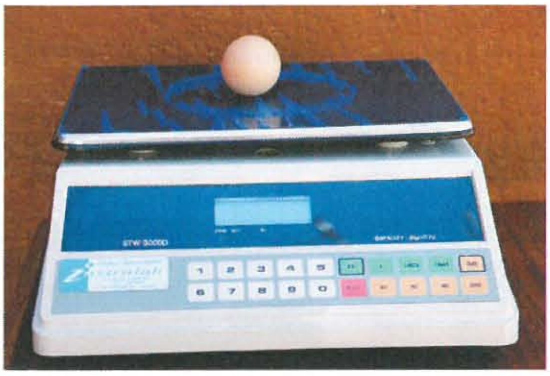

Figure 2.3: An electrical scale measuring the egg mass

The scale was calibrated each time before it was used. The egg mass of each of the eggs was determined before and after storage. The mass of ten eggs from each treatment group was determined every week up to week four, thus, a total of 120 eggs per week. Thereafter, the mass was recorded in a tabulated format.

2.3.1.2 Albumen height

The albumen height, that is the height of the thick egg white surrounding the yolk, was measured with a micrometre. The micrometre was mounted on a specially designed and built stand. Each egg was broken onto the flat plate on the stand to measure the albumen height. The flat plate with the egg contents was put under the micrometre and the point at which the micrometre touched the albumen was read on the sleeve and thimble of the micrometre as the height of the albumen in millimetres. The albumen was measured 5 mm away from the yolk.

2.3.1.3 Yolk index

The yolk index was estimated as the ratio of the width of broken out yolk to the height multiplied by 100. The yolk width was measured with a measuring ruler in centimetres and the yolk height was measured with the micrometre. Figure 2.4 shows a micrometre mounted on a stand.

Figure 2.4: Micrometer measuring the height of egg yolk

The flat plate with egg contents was placed under the micrometre and the point at which the micrometre touched the yolk at the centre was read on the sleeve and thimble of the micrometre as the height of the egg yolk.

2.3.1.4 Haugh unit

The Haugh unit was estimated using the albumen height corrected for egg mass. After the albumen height and egg mass of each egg was recorded, a Haugh unit table (Haugh, 1937) was used to determine the Haugh unit value for each egg. The point at which the egg mass in grams converges with the albumen height in millimeters, was estimated as the Haugh unit value for an egg.

Throughout the experimental phase of the study, the general observations regarding the appearance of the eggs were recorded. After measuring the yolk width, albumen and yolk height of each egg, the egg contents were given to individuals for home consumption.

2.3.2 Survey

2.3.2.1 Population

A sample to perform a survey was taken from two groups, namely:

(a) land reform farms in Bloemfontein-East (egg producers), and

(b) Agricultural Centre in Bloemfontein (consumers).

The two groups represented three different types of respondents: a farming community that produces eggs on a small scale, and a peri-urban as well as an urban community representing the consumers.

2.3.2.1.1 Land Reform Farming Community

The beneficiaries of the land reform farms in Bloemfontein-East were selected on the basis that:

- they were emerging egg producers;
- they were prospective egg producers;
- they were guided by a constitution for the poultry farm;
- they had a title deed to the farm; and
- they were living and working on the farm.

Ten such farms that met the criteria were identified. Four of the farms (Kaalspruit, Rust en Vrede, Lakeview and Honingkop) were situated far apart and six (Waterpas, Waterval, Khosi, Portion, Diepwater and Khama) were very close to each other.

2.3.2.1.2 Agricultural Centre

The employees of the Agricultural Centre live in an urban area (Bloemfontein), as well as in a peri-urban area (Botshabelo) respectively. The personnel comprised Extension officers, Administrative Clerks, Cleaners and Messengers. The employees were selected on the basis that:

- they normally buy eggs directly from the farmers, and
- they interact with farmers.

2.3.2.2 Questionnaire

The questionnaire has fifteen questions (Addendum 1). It was compiled in English and translated into the languages of the respondents (Sesotho, isiXhosa, Afrikaans and Setswana) by the researcher. Some of the respondents were unable to read, and in these cases a structured interview had to be conducted. The interviews took place during visits to the farms and the Agricultural Centre.

2.3.2.2.1 Land Reform Farming Community

A meeting was arranged with the respondents from the different farms. One farm was visited per day. The respondents were Sesotho and isiXhosa speaking. A face-to-face interview was conducted with a group of respondents from each of the respective farms. The respondents were informed about the reasons for the research. Questions from the questionnaire were clarified in either the Sesotho or the isiXhosa language. Of the respondents fifteen completed the questionnaires independently, while ten were assisted in completing the questionnaires.

2.3.2.2.2 Agricultural Centre

The respondents from the Agricultural Centre were Sesotho, Setswana and Afrikaans speaking. A meeting was arranged at their work-place. The respondents were interviewed as a group in one day. They were informed about the reason for the research. Questions were clarified for the respondents who needed clarity. Of the respondents 20 completed the questionnaires independently.

At the end of the interviews a total of 45 completed questionnaires were collected from the respondents (land reform farmers and employees at the Agricultural Centre).

2.4 Statistical Analysis

2.4.1 Experimental

The main aim of this study was to compare the means of the variables and to determine whether significant differences in the means could be ascribed to particular factors or combination of factors.

The measured variables were:

- mass difference (mass before and after storage);
- albumen height;
- Haugh unit; and
- yolk index.

The factors under investigation were:

- shell treatment (beef fat, poultry fat and control);
- environment (mud hut and cement-brick hut);
- containers (cardboard box and plastic bag);

- storage duration (week one, two, three and four); and
- season (winter and summer).

When comparing two means, the t-test was used after investigating the homogeneity of variances and normality of distributions when the assumptions were met. The non-parametric equivalent, such as the Mann-Whitney test, was used when the assumptions were not met.

When more than two means were compared, an ANOVA (one way, two factor, three factor, etc.) was used. Once again the homogeneity of variance and normality assumptions had to be met. The Wilcoxon test, as a non-parametric equivalent, was appropriate when these assumptions were not met. When the ANOVA showed a significant ($p<0.05$) difference in means, attributed to the particular factors, the Post Hoc comparisons were performed, to determine which means differed significantly. The Tukey HSD test (highest significant difference for equal sample sizes) was used, as opposed to the less powerful LSD (lowest significant difference) test.

When performing ANOVAs and looking at the factor effects simultaneously, there was marked interaction at most levels. For this reason the researcher proceeded with the cumbersome, but valid technique of fixing a level of a particular factor (for example, consider only summer seasons or only cement-brick hut) and testing for the effect of other factors on each of the selected variables. The main emphasis was on the treatment factor, namely fat versus control and where fat made a difference, poultry fat versus beef fat versus control.

The data for both winter and summer projects were recorded in the computer (Microsoft Excel was used to capture the data). The data was analysed statistically by means of the analysis of variance namely a four way factoral design ANOVA. The MANOVA was not used due to colinearity between the variables. The relationship between the mass difference, albumen height, yolk index and Haugh unit of fat-treated and control eggs stored in the mud and cement-brick hut for a four week period, was analysed.

2.4.2 Survey

The aim of the questionnaire was to determine the acceptability of animal fat treated eggs for producers and consumers. The method of analysis employed for the questionnaire was appropriate for percentages. Since working with multivariate tables, Yates correction was essential in the calculation of Chi-square (x^2) statistics. The Yates Chi-square was used when the degree of freedom was one, while the Pearson Chi-square was used when the degree of freedom was three.

3. Results

3.1 Introduction

The results regarding different variables measured in terms of the eggs are presented following results on general observations. The effects of various factors on variables were analysed according to appropriate statistical techniques. Factors under consideration were: shell treatment (beef fat, poultry fat and control); environment (mud hut and cement-brick hut); containers (cardboard box and plastic bag); storage duration (week one, two, three and four) and season (winter and summer). Results from the questionnaire regarding the producers' and consumers' acceptance of fat-treated eggs are subsequently presented after the results on variables measured on eggs.

3.2 General Observations

During the first two weeks of storage it was observed that the egg yolk was firm and that it was located near the centre of the egg. The yolk did not split when the egg was broken and the albumen was thick. However, during the last two weeks of storage the egg yolk was flat and was not located at the centre of the egg. The albumen was also flat.

3.3 Presentation of Results

3.3.1 Variables measured in terms of the eggs

The results regarding the measured parameters are summarised in tables in the following pages. Specific findings and interpretations are highlighted under each table.

Table 3.1 shows the means for the different variables, compared with respect to animal fat treatment versus control.

Table 3.1: The effects of fat treatment on egg quality

	Means		
Variables	Fat-treated eggs	Control eggs	p-value
Mass difference	0.40	1.40	.0000*
Albumen height	4.00	3.90	.12730
Haugh unit	65.14	64.42	.21470
Yolk index	21.63	21.98	.06640

*Statistically significantly different means (at a significance level of 0.05)

The mean mass difference of the fat-treated eggs was statistically significantly different from the mean mass difference of the control eggs; the p-value for the variable mass difference was <0.05.

In Table 3.2 the effects of fat treatment during winter and summer will be shown.

Table 3.2: Effects of fat treatment on egg quality during winter and summer seasons

		Means		
Variables	Season	Fat-treated eggs	Control eggs	p-value
Mass difference	W	0.30	1.10	.0000*
	S	0.40	1.70	.0000*
Albumen height	W	4.50	4.50	.72900
	S	3.50	3.30	.15590
Haugh unit	W	69.97	69.71	.75890
	S	60.31	59.13	.28590
Yolk index	W	19.20	20.05	.15700
	S	23.53	23.92	.13880

*Statistically significantly different means (at a significance level of 0.05)

W - Winter season
S - Summer season

It is equally apparent that the seasons influenced the egg mass, although not the albumen height, Haugh unit and yolk index, when the treated and control groups were compared.

The influence of winter and summer on the egg quality is presented in Table 3.3.

Table 3.3: The influence of season on egg quality during storage

	Means Control eggs			Means Fat-treated eggs		
Variables	W	S	p-value	W	S	p-value
Mass difference	1.10	1.70	.0000*	0.30	0.40	.16550
Albumen height	4.50	3.30	.0000*	4.50	3.50	.0000*
Haugh unit	69.71	59.13	.0000*	69.97	60.31	.0000*
Yolk index	20.05	23.92	.0000*	19.72	23.53	.0000*

*Statistically significantly different means (at a significance level of 0.05)

W - Winter Season
S - Summer Season

There was a statistically significant difference in the mean mass difference, the albumen height, the yolk index and the Haugh unit for the control group. However, the fat-treated eggs showed a statistically significant difference in the mean albumen height, the yolk index and the Haugh unit ($p<0.05$).

The means and statistically significant levels for the influence of storage conditions on egg quality are shown in Table 3.4.

Table 3. 4: The influence of storage conditions on egg quality

	Means			Means		
	Fat-treated eggs			Control eggs		
Variables	C	M	p-value	C	M	p-value
Mass difference	0.40	0.30	.0247*	1.60	1.30	.0026*
Albumen height	3.80	4.30	.0000*	3.80	4.00	.31390
Haugh unit	62.88	67.40	.0000*	63.87	64.97	.54000
Yolk index	22.82	20.43	.0000*	22.94	21.98	.0000*

*Statistically significantly different means (at a significance level of 0.05)

C - Cement-brick hut
M - Mud hut

There was a statistically significant difference in the mean mass difference, the albumen height, the yolk index and the Haugh unit of fat-treated eggs when the two types of environment were compared, i.e. mud and cement-brick hut. In addition, mean mass difference and yolk index of the control eggs in the mud versus the cement-brick hut were statistically significantly different ($p<0.05$), but not for the mean albumen height or the Haugh unit.

Table 3.5 presents the effects of fat treatment on egg quality for eggs that were stored in the mud and cement-brick hut.

Table 3.5: Effects of fat treatment on egg quality for eggs stored in the mud hut and the cement-brick hut

	Mud hut			Cement-brick hut		
	Means			Means		
	Fat-treated eggs	Control	p-value	Fat-treated eggs	Control	p-value
Mass difference	0.34	1.31	.0000*	0.46	1.60	.0000*
Albumen height	4.30	4.04	.0289*	3.80	3.88	.88630
Haugh unit	67.40	64.97	.0498*	62.88	63.87	.83970
Yolk index	20.43	21.03	.0198*	22.82	22.94	.45300

*Statistically significantly different means (at a significance level of 0.05)

In the mud hut there was a statistically significant difference in the mean mass difference, the albumen height, the yolk index and the Haugh unit of treated and control eggs ($p<0.05$). In the cement-brick hut the mean mass difference of fat-treated eggs was statistically significantly different from the control eggs, but not the mean albumen height, the Haugh unit or the yolk index at a significance level of 5%.

The influence of storage period on egg quality is shown in Table 3.6.

Table 3.6: The effects of storage duration on egg quality

		Means		Means		Means		Means	
Variable	Treatment	Week 1	p-value	Week 2	p-value	Week 3	p-value	Week 4	p-value
Mass difference	Fat-treated eggs	0.30	.0000*	0.20	.0000*	0.40	.0000*	0.40	.0000*
	Control eggs	0.70		1.20		1.70		2.10	
Albumen height	Fat-treated eggs	4.30	.18540	3.90	.94090	3.90	.0391*	3.90	.0266*
	Control eggs	4.50		4.00		3.60		3.60	
Haugh unit	Fat-treated eggs	67.67	.32060	64.69	.82430	64.15	.06470	64.04	.24250
	Control eggs	69.26		64.62		61.49		62.32	
Yolk index	Fat-treated eggs	20.20	.91510	21.71	.36530	22.45	.68590	22.15	.0133*
	Control eggs	20.16		21.98		22.50		23.29	

*Statistically significantly different means (at a significance level of 0.05)

Table 3.6 shows that there was a statistically significant difference in the mean mass difference of fat-treated and control eggs during week one, week two, week three and week four. Furthermore, in weeks three and four, there was a statistically significant difference in the mean albumen height. The mean yolk index of fat-treated and the control eggs in week four was also statistically significantly different ($p<0.05$). There was no statistically significant difference in the mean Haugh unit from week one to week four of storage, at a confidence level of 95%.

Table 3.7 exhibits the results regarding the effects of different types of fat, namely, beef and poultry fat treatment on the different parameters.

Table 3.7: The effects of different fat treatments on egg quality

Variables	Shell treatment	Means	p-value
Mass difference	BF	1.06	.0000*
	PF	0.40	
	CT	0.79	
Albumen height	BF	3.90	.02380
	PF	4.15	
	CT	4.01	
Haugh unit	BF	63.91	.03930
	PF	65.97	
	CT	64.82	

*Statistically significantly different means (at a significance level of 0.05)

BF - Beef fat treated eggs
PF - Poultry fat treated eggs
CT - Control eggs

There was a statistically significant difference in the mean mass difference of beef fat treated eggs, poultry fat treated eggs and control eggs ($p<0.05$), but not in the mean albumen height or the Haugh unit.

In Tables 3.8 and 3.9 the influence of seasons on fat-treated eggs (beef and poultry) is shown.

Table 3.8: The influence of fat treatment on variables measured in summer

Variables	Shell treatment	Means	p-value
Mass difference	BF	1.74	.0000*
	PF	0.49	
	CT	0.42	
Albumen height	BF	3.35	.03530
	PF	3.57	
	CT	3.45	
Haugh unit	BF	59.13	.21710
	PF	60.69	
	CT	59.93	

*Statistically significantly different means (at a significance level of 0.05)

BF - Beef fat treated eggs
PF - Poultry fat treated eggs
CT - Control eggs

Table 3.9: The influence of fat treatment on variables measured in winter

Variables	Shell treatment	Means	p-value
Mass difference	BF	0.37	.0000*
	PF	0.31	
	CT	1.17	
Albumen height	BF	4.45	.11840
	PF	4.73	
	CT	4.57	
Haugh unit	BF	68.68	.06670
	PF	71.25	
	CT	69.71	

*Statistically significantly different means (at a significance level of 0.05)

BF - Beef fat treated eggs
PF - Poultry fat treated eggs
CT - Control eggs

For the summer and winter seasons there was a statistically significant difference in the mean mass difference of beef fat treated eggs, poultry fat treated eggs and control eggs ($p<0.05$), but in the two seasons the fat treatment did not influence the mean albumen height or the Haugh unit, at a confidence level of 95%.

Table 3.10 displays the effects of different fat treatments and storage duration on egg quality.

Table 3.10: Effects of different fat treatments and storage duration on egg quality during summer

Week	Shell treatment	Mean mass difference	p-value	Mean albumen height	p-value	Mean Haugh unit	p-value
Week 1	BF	0.84	.0000*	3.77	.9889	62.74	.9101
	PF	0.92		3.77		62.93	
	CT	0.17		3.80		63.53	
Week 2	BF	1.50	.0000*	3.30	.1149	57.88	.1267
	PF	0.32		3.54		60.51	
	CT	0.22		3.25		57.41	
Week 3	BF	2.19	.0000*	3.18	.0164	57.61	.1198
	PF	0.35		3.67		61.25	
	CT	0.60		3.27		58.26	
Week 4	BF	2.45	.0000*	3.16	.0892	58.30	.2259
	PF	0.36		3.31		58.10	
	CT	0.71		3.48		60.50	

*Statistically significantly different means (at a significance level of 0.05)

BF - Beef fat treated eggs
PF - Poultry fat treated eggs
CT - Control eggs

There was a statistically significant difference in the mean mass difference of beef fat treated eggs, poultry fat treated eggs and control eggs ($p<0.05$), but the fat treatment and storage duration did not influence the mean albumen height or the Haugh unit, at a significance level of 5%.

In Table 3.11 the effects of different fat treatments and storage duration on egg quality is exhibited.

Table 3.11: Effects of different fat treatments and storage duration on egg quality during winter

Week	Shell treatment	Mean mass difference	p-value	Mean albumen height	p-value	Mean Haugh unit	p-value
Week 1	BF	0.30	.0000*	4.58	.0090	69.61	.0103
	PF	0.15		5.17		74.62	
	CT	0.59		5.37		75.77	
Week 2	BF	0.30	.0000*	4.56	.6970	69.89	.7770
	PF	0.33		4.61		70.96	
	CT	0.90		4.77		71.36	
Week 3	BF	0.45	.0000*	4.30	.0914	67.33	.1244
	PF	0.44		4.57		69.76	
	CT	1.37		4.04		65.36	
Week 4	BF	0.46	.0000*	4.38	.2389	67.89	.3250
	PF	0.31		4.55		69.68	
	CT	1.81		4.12		66.35	

*Statistically significantly different means (at a significance level of 0.05)

BF - Beef fat treated eggs
PF - Poultry fat treated eggs
CT - Control eggs

The mean mass difference of beef fat treated eggs, poultry fat treated eggs and control eggs was statistically significantly different ($p<0.05$), whereas at a confidence level of 95% there was no statistically significant difference in the mean albumen height or the Haugh unit.

The effects of storage containers on the egg quality are shown in Table 3.12.

Table 3.12: The effects of fat treatment on egg quality for different storage containers

	Plastic bag			Cardboard box		
	Means			Means		
Variables	Fat-treated eggs	Control	p-value	Fat-treated eggs	Control	p-value
Mass difference	0.37	1.20	.0000*	0.42	1.71	.0000*
Albumen height	4.05	4.10	.67820	4.05	3.82	.0079*
Yolk index	21.62	21.92	.38010	21.63	22.05	.06720
Haugh unit	64.99	65.32	.74800	65.29	63.52	.0357*

*Statistically significantly different means (at a significance level of 0.05)

The mean mass difference of fat-treated eggs in the plastic bags and cardboard boxes respectively was statistically significantly different from that of the control eggs ($p<0.05$). Mean mass difference of the control eggs in the plastic bag was 1.20 g, whereas for the treated eggs it was 0.37 g. For eggs that were kept in the cardboard box, the mean mass difference of the control eggs was 1.7 g, while for the treated eggs it was 0.42 g.

The mean albumen height and the Haugh unit of fat-treated eggs in the cardboard box were statistically significantly different from that of the control eggs ($p<0.05$), but not for the mean yolk index. At a confidence level of 95%, there was no statistically significant difference in the mean albumen height, the yolk index or the Haugh unit of treated versus control eggs that were kept in the plastic bag.

3.3.2 Questionnaire

The results from the questionnaire are summarised in the tables and graphs. The findings and interpretations are highlighted under each table and graph.

3.3.2.1 Demographic Data

In Table 3.13 the residential areas of the respondents are exhibited.

Table 3.13: The residential areas of the respondents

	Residential area		
	Farm	Urban	Peri-Urban
Respondents	30 (67%)	11 (24%)	4 (9%)

Of the respondents 67% resided on farms, 11% in urban areas and 9% in peri-urban areas.

Table 3.14 shows the occupations of the respondents.

Table 3.14: Occupations of the respondents

	Occupation					
	Farm worker	Farmer	Extension officer	Receptionist	Cleaner	Unemployed
Respondents	31 (69%)	3 (7%)	1 (2%)	1 (2%)	1 (2%)	8 (18%)

Most of the respondents (69%) were farm workers, while 18% were unemployed.

Of the respondents 67% were male and 33% were female. The oldest respondent was 72 years and the youngest was 21 years old.

3.3.2.2 Consumers acceptability

Of the respondents at the Agricultural Centre, 82% said that they would eat eggs that are treated with fat, while 18% said that they would not eat fat-treated eggs, because they would have a bad taste.

In Figure 3.1 the response of consumers regarding fat treatment and acceptability of eggs is shown.

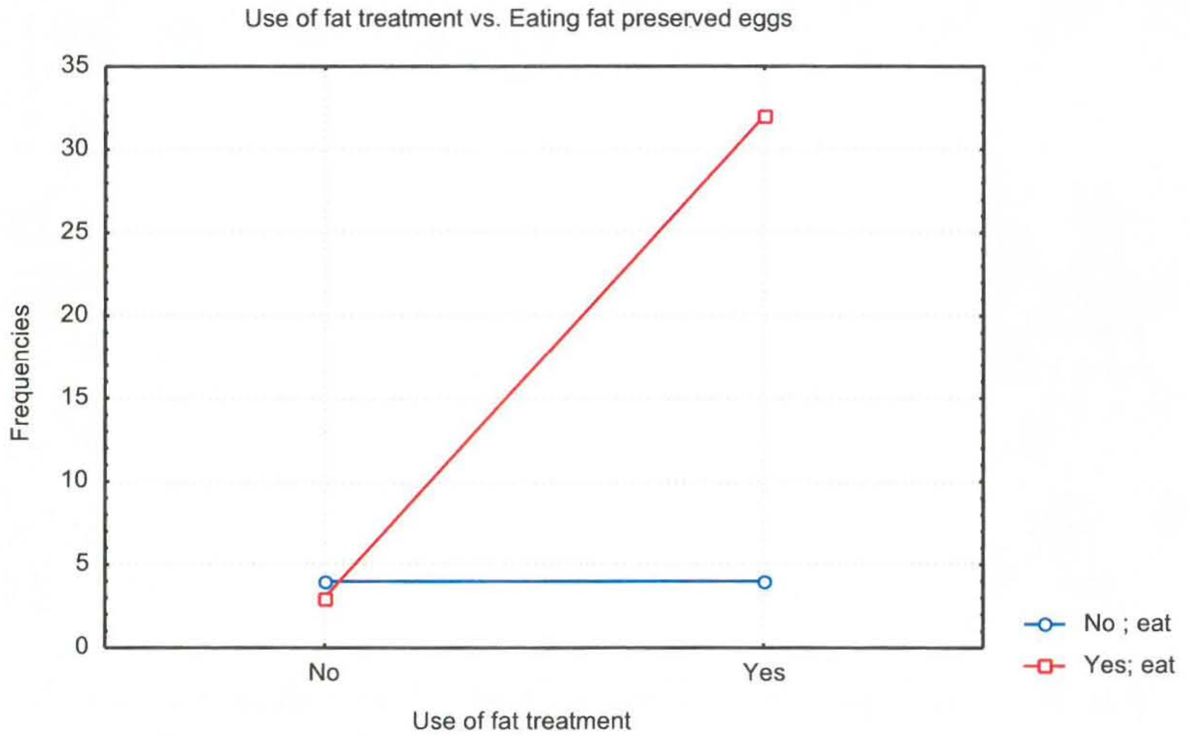

Figure 3.1: Fat treatment and acceptability of eggs

Based on the sample, there was a statistically significant relationship ($p<0.05$) between whether the people would treat eggs with fat and whether they would find fat treated eggs acceptable.

3.3.2.3 Producers acceptability

The response of producers regarding fat treatment of eggs during the storage period is presented in Figure 3.2.

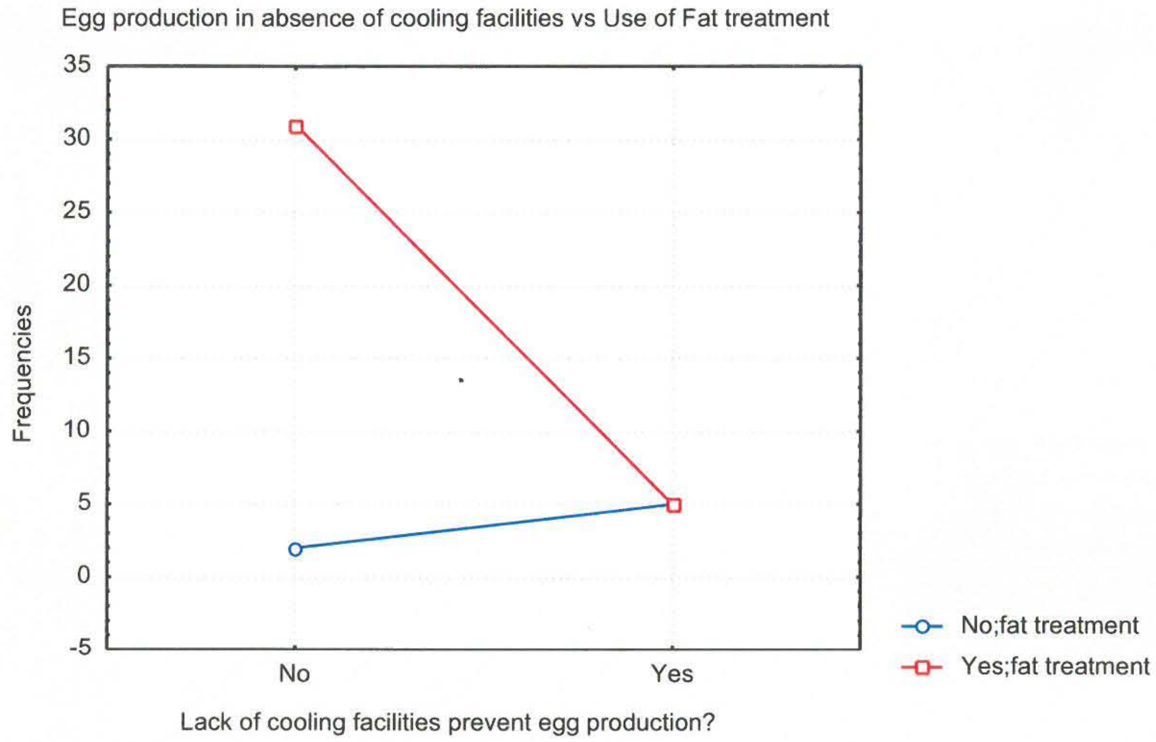

Figure 3.2: Lack of cold facilities and fat treatment of eggs

There was a statistically significant relationship ($p<0.05$) between persons who would not be prevented by lack of cold facilities from producing eggs and those who would treat eggs with fat.

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In Figure 3.3 the response regarding storage duration and fat treatment is displayed.

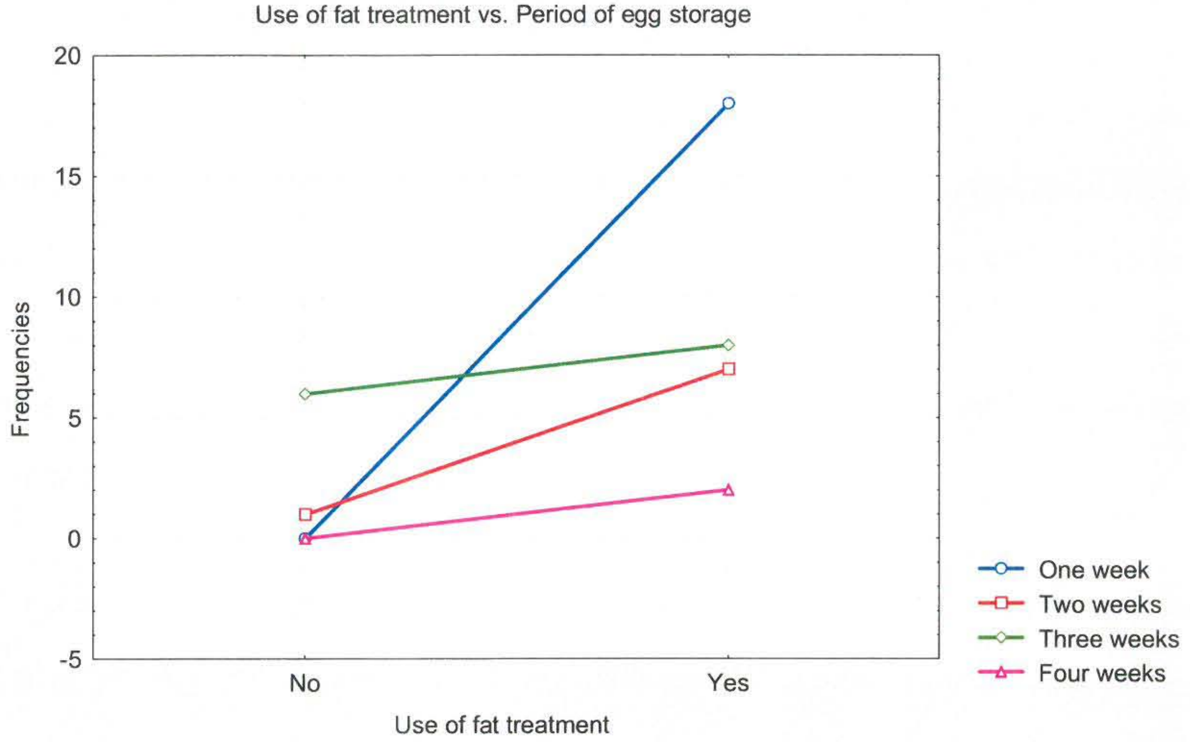

Figure 3.3: Egg storage and fat treatment

The statistically significant relationship ($p<0.05$) was observed between those who would keep eggs in storage for a specific period of time and those who would treat them with fat as a preservation method for egg quality.

4. Discussion

4.1 Introduction

Hunton (1984) suggested that poultry egg quality means different things to people at different points in the marketing chain. According to Oderkirk (1982) egg quality is mostly reflected by the satisfaction of consumers. Egg quality includes aspects such as albumen quality (Haugh units), yolk quality, nutritional value to consumers and freedom from defects like blood spots (Poultry Bulletin, 1997; Division of Animal Breeding, IAPI and Animal Improvement, [s.a]b).

The internal measurement of egg quality is based on the Haugh unit score, albumen and yolk quality (Oderkirk, 1982; Jacob *et al.,* 1998). Williams (1992) referred to the Haugh unit as the standard measure of egg quality that is used by the poultry industry. Onwudike and Sonaiya (1983) as well as Niemiec, Stepinska, Swierczewska, Riedel and Boruta (2001) used the egg mass, albumen (Haugh units) and yolk quality to measure the egg quality during storage. According to the Division of Animal Breeding, IAPI and Animal Improvement, [s.a]b the albumen of a high quality egg should be clear and firm, with a Haugh value of at least 55 units; the yolk colour should be fine without any spots; the yolk must neither be flat nor enlarged and should be located near the centre of an egg.

Egg quality deteriorates with storage time and adverse temperature (high temperature) increases the decline of egg quality during storage (Onwudike and Sonaiya, 1983). In rural areas, where cooling facilities are not always available, eggs are kept or stored at room temperature.

Most of the rural communities in Bloemfontein-East stay in mud huts and a few reside in cement-brick huts. These communities often use the huts for egg storage. Eggs are kept in the plastic bags or cardboard boxes during storage, in order to prevent direct exposure to adverse temperatures. The dwellings lack cooling facilities for keeping eggs in storage and this limits the potential of the rural communities to produce eggs commercially. Other means of preserving the egg quality in areas where cooling facilities are unavailable could therefore help to facilitate successful commercial farming of eggs.

As the egg ages, the cuticle wears away, exposing the pores and allowing moisture loss. Oil has been identified as essential for limiting the deterioration of egg quality during storage. Sabrani and Payne (1978), Hunton (1984) as well as Murthy and Maurer [s.a.] maintained that coating eggs with oil is a way of delaying the decline of egg quality during the storage period. Furthermore, Passmore (1975) reported that oil blocks the shell pores and reduces the decline of egg quality. According to Swanson *et al.* (1958) oil is the important feature in reducing the rate of evaporation during storage. Sabrani and Payne (1978) substantiated the view that coating eggs with oil is economically important for areas where cool storage is impractical.

In the present study the efficiency of fat as a shell coating medium was assessed, because of its accessibility and low cost. The aim was to evaluate to what extent fat could limit the deterioration of egg quality during storage. Due to the diversity of interests amongst the consumers, both beef and poultry fat were evaluated in the study to conform with the probable practices of consumers. In addition, a survey was conducted by means of a questionnaire to determine the acceptability of fat-treated eggs for producers and consumers. The small scale egg producers and consumers were interviewed on a (one-to-one) basis.

The objective of the present study was therefore, to evaluate the effectiveness of animal fat treatment and storage conditions on egg quality, as well as to evaluate the acceptability of fat-treated eggs for producers and consumers.

4.1.1 Mass difference

The mass difference is the mass loss of eggs during storage. This is calculated by subtracting egg mass after storage from the egg mass before storage. Mass loss during storage is attributed to shell porosity, temperature, relative humidity and air movement in the storage room (Seth *et al.*, 1973).

In the present study, egg mass for both treated and control eggs deteriorated during the storage period. In week one the mean mass difference of treated eggs was 0.30 g increasing to 0.40 g at week four, while the mean mass difference of control eggs was 0.70 g at week one increasing to 2.10 g at week four; there was thus a statistically significant difference in the means. Silversides and Villeneuve (1994) likewise noted a decline in egg mass during three weeks of storage at room temperature: there was a deterioration of 0.7 g per week of storage ($P<0.05$). In addition, Mather and Laughlin (1977) as well as Walsh, Rizk and Brake (1995) also confirmed that there was an increase in mass loss of poultry eggs as the number of days in storage increased.

According to Fasenko, Robinson and Hardin (1992) the deterioration of egg mass was higher for eggs that were stored for a longer period: the mass loss after seven and fourteen days of storage was 1.2 and 2.1 respectively. Subsequently, Walsh *et al.* (1995) observed that eggs that were stored for fourteen days at room temperature exhibited a decline during storage period, while Niemiec *et al.* (2001) reported a decline in egg mass during 20 days of storage period.

In the present study it is shown that there was a loss of egg mass during winter (at mean room temperature of 15°C) and summer season (at mean room temperature of 29°C). There was a statistically significant difference in the mean mass difference of control eggs during the winter and summer seasons. These findings are supported by Seth *et al.* (1973) who maintained that high temperature contributes to mass loss of eggs during four weeks of storage and that the mass loss followed a linear relationship (1.19, 1.47, 2.31 and 2.45% mass loss from week one to week four).

According to Romanoff and Romanoff (1963) as well as Kandlikar, Siddiqui, Reddy and Mathur (1972) the loss of egg mass during storage is caused by an increased loss of water. Sabrani and Payne (1978) reported that mass loss was greater at 28°C than at 18°C during storage. In contrast, Card (1961) as well as Onwudike and Sonaiya (1983), reported that an increase in percentage mass loss of eggs at room temperature was caused by lower shell thickness and shell porosity.

In the present study eggs were stored at room temperature in a mud and a cement-brick hut to isolate them from adverse exposure to air movement, temperature and relative humidity. The mud hut and the cement-brick hut were used, in order to evaluate their efficiency in limiting the deterioration of egg mass during storage. The mass loss of eggs in the cement-brick hut was higher than that of eggs in the mud hut and the means were statistically significantly different ($p<0.05$). The mean mass difference of fat-treated eggs in the mud hut was 0.30 g, while for the cement-brick hut it was 0.40 g. The control eggs in the mud hut lost less mass on average (1.30 g) compared to those in the cement-brick hut (1.60 g).

Eggs were furthermore kept in the plastic bags and cardboard boxes to reduce loss of water from the eggs and to prevent direct exposure to high temperature. The deterioration of egg mass was observed for eggs in the plastic bags, as well as in the cardboard boxes. This correlates with the report of Walsh *et al.* (1995) that when eggs were kept in a plastic bag during 14 days of storage, there was a deterioration of the egg mass that increased as the number of days in storage increased. There was no statistically significant difference at a confidence level of 95% for the mean mass difference of eggs that were kept in the cardboard boxes versus the plastic bags. The containers did not reduce the deterioration of egg mass during the storage period.

In this study, fat was used to limit the decline of mass during storage. The findings exhibited a small mass loss for treated eggs, when compared to the control eggs ($P<0.05$). The results are in accordance with the findings of Kandlikar *et al.* (1972), Seth *et al.* (1973), Sabrani and Payne (1978) as well as Murthy and Maurer [s.a.] who all found that oiling of eggs reduced the loss of mass during storage. Obanu and Mpieri (1984) also confirmed that oiling significantly limited mass loss during 36 days of storage. According to the report of Kumar, Panda, Sreenivasulu and Jagannatha (1969), Lohchuba, Kumar and Malik (1971) and Kandlikar *et al.* (1972) oil treatment has proven to be useful in reducing mass loss during storage, as high mass loss was observed in the control group when compared with the treated group.

In the present study eggs were treated with poultry and beef fat. The mean mass difference of eggs that were treated with poultry fat was statistically significantly different from that of the beef fat treated eggs ($p<0.05$). The poultry fat seems to be more efficient in preventing loss of egg mass. On observation, poultry fat had a lower melting point compared with beef fat; this could have enhanced its efficiency in limiting the decline in egg mass during storage.

4.1.2 Albumen height

Meuer and Baumann (1988) mentioned that albumen height is a relative measure of the albumen viscosity: the more viscous the albumen, the greater the barrier it presents to gaseous diffusion of oxygen to the blastoderm. According to Eisen, Bohren and McKean (1962) the visual appearance of the albumen has been used extensively to describe the egg quality. Albumen height has a major influence on the interior egg quality. The thinning of the albumen shows the loss of quality (Eisen *et al.,* 1962). Silversides *et al.* (1993) maintained that albumen height gives an indication of the egg condition or the storage length of the egg. When a fresh egg is carefully broken onto a flat surface, the round yolk is located centrally and it is surrounded by thick albumen, but when a stale egg is broken, the albumen surrounding the yolk is thin and watery (Jacob *et al.,* 1998).

In the present study, there was a deterioration of the albumen quality during storage. The mean albumen height of the treated eggs was 4.30 mm during the first week of storage and it dropped to 3.90 mm in the fourth week. The control eggs also showed a deterioration of the albumen height during storage period, in that there was a decline from 4.50 mm in the first week to 3.60 mm in the fourth week of storage. The means exhibited a statistically significant difference in weeks three and four of storage.

Silversides and Villeneuve (1994) as well as Walsh *et al.* (1995) substantiated these findings when they reported a decline of the albumen height during the storage period. Silversides and Villeneuve (1994) said that the albumen height decreased by 1.37 mm per week during the storage period. According to Jacob *et al.* (1998) there is thinning and flattening of the albumen structure during storage. In addition, Walsh *et al.* (1995) associated long term storage under different conditions with changes in albumen quality and water loss. Sharpe (1937) explained that the loss of carbon dioxide results in a slight alkalinity, which causes the long mucin fibres to break, resulting in a decline of albumen quality during storage. These findings substantiate the report of Becker, Spencer and Swartwood (1968) who pointed out that carbon dioxide improves the albumen quality during storage.

In this study, eggs that were stored during the winter season at 15°C displayed a lesser deterioration of the albumen height when compared to those that were stored in summer (29°C). The means were statistically significantly different. These findings are concomitant with the findings of Oderkirk (1982) as well as Sabrani and Payne (1978) who contended that higher temperatures could increase the carbon dioxide loss from the eggs, causing the breakdown of albumen structure, in turn causing it to spread thinly across a surface. Walsh *et al.* (1995) and Becker *et al.* (1968) also reported that temperature and carbon dioxide appeared to have an independent mode of action, and that the presence of carbon dioxide may be beneficial in maintaining albumen quality. According to Hunton (1984) the breakdown of albumen quality results from a combination of moisture loss through evaporation and chemical changes within the albumen. Low temperatures can slow down both the evaporation and the chemical changes in the egg.

In the present study, the albumen height of treated eggs that were stored in the mud hut was higher compared to that of eggs that were stored in the cement-brick hut: there was a statistically significant difference in the means ($p<0.05$). The albumen height of eggs in the mud hut was thick and firm when compared to the albumen height of eggs that were stored in the cement-brick hut. The albumen of eggs in the mud hut located the egg yolk centrally. Further, eggs were kept in either a cardboard box or plastic bag. Although not significantly different at a confidence level of 95%, it was found that the albumen height of eggs that were kept in a plastic bag was high when compared with that of eggs in the cardboard box.

The findings are in contradiction to the report of Walsh *et al.* (1995), who placed eggs in a plastic bag, measured the albumen height and discovered that the albumen height of eggs was statistically significantly greater than the albumen height of the control group. According to Hunton (1984) the most important factor affecting the albumen quality is the storage conditions, as, regardless of the storage environment, the deterioration occurs in the first few days after laying.

In this study, eggs were treated with fat in order to limit the deterioration of the albumen quality during storage. Animal fat was coated around the eggs to seal the shell pores, reduce the gaseous exchange and water loss from the eggs. There was a small decline in the albumen height of fat-treated eggs (4.30 mm), when compared to that of the control eggs (4.04mm) in the mud hut; the means were therefore statistically significantly different.

The results coincide with the findings of researchers who applied oil to the surface of the eggshell to reduce the decline of albumen quality during storage (Passmore, 1975; Sabrani and Payne, 1978; Hunton, 1984; Koelkebeck, 2002: Online). Kandlikar *et al.* (1972) reported that there was a statistically significant difference in the mean albumen height of eggs that were treated with oil when compared to that of the control eggs. According to Jacob *et al.* (1998) oiling of eggs within 24 hours of laying is effective in slowing down the decline of the albumen quality during the storage period.

4.1.3 Yolk index

The yolk index is defined as the measurement of the height of the egg yolk in relation to the width (http://www.indiaagronet.com/indiaagronet/foods%20technology/Eggs, 2000; Obanu and Mpieri, 1984; Onwudike and Sonaiya, 1983; Seth *et al.,* 1973). Factors that determine the yolk quality are distinctiveness of the outline, size and shape, as well as absence of defects such as blemishes or blood spots (Georgia Egg Commission, 2003). According to Hunton (1987) the yolk defines the egg quality, because it is associated with perceivable difference, rapidly quantifiable and it is important for consumer acceptance. Moreover, Jacob *et al.* (1998) claimed that the yolk quality relates to the appearance, texture, firmness and smell of the yolk. Lohchuba *et al.* (1971) asserted that during four weeks of storage there was a change in the yolk index, and in addition, Onwudike and Sonaiya (1983) concurred that with storage period the value of the yolk index increased.

Similarly, Onwudike and Sonaiya (1983) observed that the yolk index of eggs under room temperature increased from 25.24 in week one, to 61.42 after eight weeks of storage. Caudle and Shneyder [s.a: Online] recognised an increase in the yolk index as a sign of the deterioration of egg quality during storage. According to Kandlikar *et al.* (1972) an increase in the egg yolk is brought about by water from the albumen to the yolk, and shell treatment could possibly retard the process of water transfer. Onwudike and Sonaiya (1983) confirmed that the egg yolk became flatter with a longer storage period. Aged egg yolk absorbs water from the albumen and increases in size; this weakens the vitelline membrane and gives the yolk a flat shaped top or leads to a ruptured yolk (Jacob *et al.*, 1998; Damerow, 2002: Online).

In the present study it was observed that after two weeks of storage, the egg yolk became flat for both the treated and the control groups, and it was not firmly located near the centre of the egg, that leading to an increase of the yolk index value. The value of the yolk index increased with storage time. For treated groups, the mean yolk index was statistically significantly greater than that of the control group only in week four of storage ($p<0.05$). A decline in the yolk quality was attributed to an increase in the storage period. The results is in contrast with Seth *et al.* (1973) who reported that there was a decrease in the yolk index from week one to week four of storage and they maintained that there was a significant difference in the yolk index between different weeks of storage.

In this study, the mean yolk index of eggs that were stored during the winter season (15°C) was statistically significantly different when compared to those that were stored in the summer season (29°C), for both treated and control groups respectively. The winter season significantly limited a decline in egg yolk quality. The mean yolk index of treated eggs in winter was 19.72, as opposed to summer, when it was 23.53. It was observed in the present study that the yolks of eggs that were stored during the winter were not as flat as those stored in the summer; the low temperatures during the winter thus played a role in limiting the decline of yolk quality during storage.

The findings are similar to those in the report of Onwudike and Sonaiya (1983) who said that the yolk index of eggs stored at low temperature was not significantly affected by an increase in storage period, they further maintained that cold temperatures preserved the yolk quality even when eggs were stored for eight weeks.

In the present study it was furthermore discovered that the yolk structure of the eggs that were stored in the mud hut remained firm and thick for a longer period. The mean yolk index of the eggs in the mud hut was statistically significantly different when compared to those that were stored in the cement-brick hut. The temperature in the mud hut varied from 14°C to 28°C, while for the cement-brick hut it varied from 18°C to 29°C.

Lohchuba *et al.* (1971) stated that oil is the most efficient method for preserving yolk quality during storage: the yolk index of eggs that were treated with oil and stored for four weeks at room temperature exhibited a low decline when compared to those of the control group.

Obanu *et al.* (1984) maintained that oil treatment of eggs reduced the liquefaction of the egg yolk during 36 days of storage.

In the present study, fat was used as a possible means to limit a decline in yolk quality during the storage period. It was observed that there was a statistically significant difference in the mean yolk index of fat-treated versus the control group. The results are substantiated by Kumar *et al.* (1969), Kandlikar *et al.* (1972), Seth *et al.* (1973) as well as Obanu *et al.* (1984) who said that there was a statistically significant difference in mean yolk index of oil-treated eggs, when compared to the mean yolk index of the control eggs. In this study results showed that fat treatment on eggs during the winter yielded better results than during the summer: the mean yolk index of fat-treated eggs in winter was 19.72, which was lower than the mean yolk index of fat-treated eggs (23.53) in summer, the means were statistically significantly different. This increase in the yolk index value could be attributed to high temperatures during the summer season and a flat yolk structure.

4.1.4 Haugh unit

The purpose of using the Haugh unit as an indication of egg quality is to give a quantitative description for the appearance of the albumen (Haugh, 1937). Silversides and Villeneuve (1994) asserted that the function of the Haugh unit formula is to correct the albumen height for egg weight. The Haugh unit is an important measurement of the interior quality of the egg and it significantly correlates with most of the quality measurements (Onwudike and Sonaiya 1983). Silversides *et al.* (1993) reported that the Haugh unit could be used universally due to its ease of application and the correlation with the appearance of the egg when it is broken onto a flat surface. Moreover, Silversides and Villeneuve (1994) pointed out that the only use of the Haugh unit is to compare the albumen quality of eggs that are stored for various periods, it adds little to the precision of the measure and may detract from the accuracy.

In the present study, it was observed that there was a deterioration of the Haugh unit value with an increased period of storage. A decline in the Haugh unit value is associated with a prolonged storage period and liquefaction of the albumen. The results showed that there was no statistically significant difference in the mean Haugh unit between different weeks of storage.

Pardio, Landin, Flores, Guzmán, Walizewski, Bringas and Pérez-Gil (2002), Sabrani and Payne (1978), Onwudike and Sonaiya (1983) as well as Murthy and Maurer [s.a], similarly averred that there was a decline in the Haugh unit value during storage period. According to Onwudike and Sonaiya (1983) as well as Murthy and Maurer [s.a] there was a decline of the Haugh unit value when eggs were stored for only one week at room temperature. Onwudike and Sonaiya (1983) said that the measurement of the Haugh unit was discontinued after three weeks of storage, because of the liquefaction of the albumen.

In the present study the findings revealed that there was a statistically significant difference in mean Haugh unit value of eggs that were stored in winter (15°C) versus the mean Haugh unit value of eggs stored in summer (29°C). The mean Haugh unit value of the control eggs in summer was 59.13 compared to 69.71 in the winter, while the treated eggs' mean egg mass was 60.31 in summer and 69.97 in winter.

The results are similar to the findings of Onwudike and Sonaiya (1983) who attested that there was a decline of the Haugh unit value at room temperature of 30°C during the storage period. In addition, when Hunton (1987) stored eggs at 12°C and at 28°C, a statistically significant difference was observed. An increase in the decline of the Haugh unit value for eggs that were stored at 28°C was associated with the increase in temperature. Murthy and Maurer [s.a] confirmed that the Haugh unit value dropped by 35 when eggs were stored at

22°C. In contrast, Pardio *et al.* (2002) reported that there was no statistically significant difference between the Haugh unit value of eggs that were stored at 4°C and at 28°C.

In the present study, the mean Haugh unit value of the treated eggs that were stored in the mud hut was statistically significantly different from the mean Haugh unit value of treated eggs in the cement-brick hut. There was no statistically significant difference at a confidence level of 95% between the mean Haugh unit value of the control groups in the mud hut and cement-brick hut. However, eggs that were treated with fat and stored in the mud hut exhibited a statistically significantly greater mean Haugh unit value when compared with the control eggs.

The findings affirm the reports of Murthy and Maurer [s.a], Kumar *et al.* (1969), Lohchuba *et al.* (1971), Kandlikar *et al.* (1972) as well as Sabrani and Payne (1978) who used oil to seal the egg shell pores and found that oil treatment can limit a decline in mean Haugh unit value during storage. In their study, Murthy and Maurer [s.a] reported that the mean Haugh unit value of oil- treated eggs was statistically significantly different from the Haugh unit value of the control group. Sabrani and Payne (1978) asserted that oiling reduced the deterioration of the Haugh unit by 61.9% during the storage period. Oil treatment is expeditious and it may be regarded as a preferential procedure in maintaining a higher score for the Haugh unit (Kandlikar *et al.*, 1972).

4.1.5 Acceptability of fat-treated eggs

The acceptability of fat-treated eggs for producers is the willingness of the producers to coat poultry eggs with fat as a preservation method for egg quality; acceptability of consumers is the willingness to eat eggs that have been coated with fat.

In Bloemfontein-East, the lack of infrastructure, facilities and resources is one of the predicaments faced by the emerging farmers in the egg industry. Nonetheless, there are communities that are determined to make ends meet with the facilities and resources that are available to them (keeping eggs in cement-brick and mud huts respectively, for periods varying between one and four weeks), although there are some who measure their success in the industry by the availability of facilities.

Onwudike and Sonaiya (1983) mentioned that in Nigeria, as in other developing countries, eggs for sale are kept at room temperature for periods varying from one to eight weeks before they are completely sold out. Some of the sellers keep eggs on the roadside where they are exposed to the sun. Under such environmental conditions it is possible that eggs may be appreciably reduced in quality with time in storage.

In the present study a survey was conducted to examine the acceptability of fat treated eggs for producers and consumers. According to Jacob *et al.* (1998) in any consumer survey of egg quality, the yolk ranks high. The internal quality problems (flat yolk structure and watery albumen or egg white) reduce the market acceptability of eggs (Keshavarz and Park, [s.a]).

In this study the respondents to the questionnaires were emerging egg producers as well as consumers who often buy eggs directly from the producers. Of the respondents 67% were living on the farms and their ages ranged between 21 and 72 years. The findings show that of the respondents 75% said that they would produce eggs despite the lack of cooling facilities, while 24% said that the absence of cooling facilities would prevent them from producing eggs because the eggs would deteriorate in quality and rot.

There was a statistically significant relationship between the people who would produce eggs and those who would treat them with fat, regardless of the lack of cold storage. The findings are in line with the report of Bowes (1998) who said that eggs could be produced in spite of the lack of cold storage.

The acceptability of fat treated eggs for producers and consumers was evaluated and the findings exhibited that of the respondents 83% would coat eggs with fat as a preservation method for egg quality, although 16% asserted that they would not coat eggs with fat, because fat-treated eggs would be unpleasant. In accordance with the report of Onwudike and Sonaiya (1983) an unpleasant taste in the egg contents during the storage period could be caused by increased chemical changes in the egg. Romanoff and Romanoff (1963) verified that the production of H^2S from the breakdown of egg contents during storage could be responsible for the unpleasant odour noted in the eggs.

In the present study, of the respondents 82% mentioned that they would eat eggs that are coated with fat, while 18% said they would not eat fat-treated eggs because they would have a bad taste: there was therefore a statistically significant relationship between the persons who said they would treat eggs with fat and those who said they would eat fat-treated eggs. This finding is similar to the study of Bowes (1998) who found that eggs that were coated with fat and stored at room temperature were acceptable.

There was a statistically significant relationship between the people who said that they would treat eggs with fat and those who said they would store eggs for one, two, three or four weeks. Of the respondents 5% said they would store eggs for four weeks, 32% said three weeks, 18% said two weeks, while 45% said they would store eggs for one week. In this present study the findings cannot be substantiated or refuted, because at present there are no related literatures.

4.2 Summary

The study was carried out to determine the effect of animal fat treatment and storage conditions on egg quality, as well as to evaluate the acceptability of fat treated eggs for producers and consumers.

The following quality factors were measured: mass difference, albumen height, yolk index and Haugh unit. The findings showed that under the conditions in Bloemfontein-East egg quality deteriorated with storage period, and fat treatment on eggs that were stored in the mud hut for four weeks reduced the decline of egg quality in comparison with the control group ($p<0.05$).

Egg storage during the winter season exhibited low deterioration in egg quality relative to eggs that were stored during the summer season ($p<0.05$). There was no statistically significant difference at a confidence level of 95% for the quality factors of eggs that were stored in the cardboard boxes as well as plastic bags. The poultry fat limited the decline of egg mass during storage, better than did the beef fat ($p<0.05$); this could have been due to the lower melting point of poultry fat.

Fat treatment on eggs during the storage period was acceptable to most of the respondents ($p<0.05$). There were respondents who disagreed with animal fat treatment of avian eggs during storage period; they stated that the avian eggs would be unpleasant in taste.

5. Conclusion and Recommendations

5.1 Conclusion

Eggs are versatile and they are made up of highly nutritious components (albumen and yolk). Egg quality declines from the moment an egg is laid. One important role of producers is to limit or slow down the deterioration of egg quality during the storage period.

- This study shows that coating eggs with animal fat can limit the decline of poultry egg mass during storage period. Poultry fat that was coated on the eggs significantly reduced the deterioration of egg mass better when compared to the beef fat ($p<0.05$).

- Fat-treated eggs that were stored in the mud hut exhibited a reduced deterioration of egg quality, in contrast to fat-treated eggs that were stored in the cement-brick hut ($p<0.05$).

- There was no statistically significant difference at a confidence level of 95% between eggs that were stored in the cardboard box and those stored in the plastic bag.

- There was a decline of egg quality during the storage period; the mass difference was statistically significantly different for every week from week one, to two, to three and to four of storage.

- Storage of eggs during winter exhibited a lower decline of egg quality; contrarily storage of eggs during summer increased the deterioration of egg quality ($p<0.05$).

- Of the respondents 83% accepted the coating of eggs with animal fat during storage period, while 82% of the respondents said they would eat eggs that are treated with animal fat.

5.2 Recommendations

The practice of fat treatment can be useful and economically important for marketing eggs at a farm level in areas where cold storage and ideal cooling facilities are impractical or unaffordable. This present study clears the way for further research with regard to microbial infection of fat treated eggs.

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ADDENDUM 1

Questionnaire concerning the accepability of fat-treated eggs.

Please use X to indicate you respond.

Code blocks

Questionnaire Number = [ ] **1**

1. Where do you stay? [ ] **2**

On a farm [ ] Urban area [ ] Peri-Urban area [ ]

2. What is your age? [ ] **3**

[ ]

3. What is your occupation? [ ] **4**

Farm worker [ ] Unemployed [ ]

Other (specify)..

4. Gender? [ ] **5**

Male [ ] Female [ ]

5. What do you do to preserve eggs, after buying them? [ ] **6**

[ ] **7**

Refrigerate [ ] Keep it at room temperature [ ] [ ] **8**

Other (specify)..

6. How many eggs do you eat per week? 9

None ☐ One ☐ Two ☐

Other (specify)................................

7. Where do you buy eggs? 10 11

Spaza Shop ☐ Supermarket ☐ Egg producer ☐ 12

Other (specify)..

8. Do you open the egg container before you buy eggs? 13 14

Yes ☐ No ☐ 15

If "yes" please indicate why? ....

9. Which egg size do you prefer? 16

Small ☐ Medium ☐ Large ☐ Extra Large ☐ Jumbo ☐

10. When you buy eggs, do you look at the expiry date on the carton? 17 18

Yes ☐ No ☐

If "yes" please explain why?..

11. What is the longest period you are prepared to store eggs, before eating them? 19

One week ☐ Two weeks ☐ Three weeks ☐

If more, specify.................................

12. Will you eat eggs preserved with fat? 20 21

Yes [ ] No [ ]

If "No" why?..

13. Do you think there will be a difference in taste, for eggs coated with fat compared to non coated eggs? 22

Yes [ ] No [ ]

14. Will you coat eggs with fat, as a preservation method? 23 24 25

Yes [ ] No [ ]

If "yes" will you consider: Beef fat; Poultry fat; Cooking oil

15. Will the absence of a cooling facility limit you from producing eggs? 26 27 28

Yes [ ] No [ ]

If "yes" please explain why?..