Effect of Deep-Litter Floor and Battery Cages System on the Productive Performance of Commercial Layers in Elobied, Sudan.

By

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DEDICATION

To from tiredness to his finger to give us a moment of happiness to reap thorns from road to pave me through science (My dear father).

To suckle me of love and compassion a symbol of love and healing balm to the heart brilliant in white (My mother's beloved).

To the hearts immaculate kind and innocent souls to my life essence (Brothers).

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It is the right of grace appearance and less well-known penalty for Thanksgiving After thanking the Almighty, to do with great graces, and a great penalty. I must extend my deep gratitude and our profound gratitude to the candles that melted in pride to illuminate every step in our path to cringe every obstacle in front of us and they were messengers of science and ethics, and particularly so my administrator/supervisor (Dr. Dafalla Mohammed Mekki).

Can one be grateful to the sun that it lit up the world but I will try to answer part of yours favor to family Poultry Production Research Unit Department of Animal Production, University of Kordofan, Elobeid.

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ABSTRACT

This study was conducted in the Poultry Production Research Unit, Department of Animal Production, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Elobeid. The experiment extended from September 10^{th} to November 4^{th}, 2016. The objectives of this study were to determine the effects of deep litter floor and battery cages housing system on egg production and egg characteristics. Thirty two commercial hybrid layers (hy line) of 10 months production age were randomly selected and distributed equally in four deep litter ground cages. Thirty (hy line) layers were kept in battery cages. The battery system was consisted of triple deck cages, provided with automatic nipple watering system and front trough feeders. During the experimental period there were slight changes in live body weight, -0.01 kg and 0.04 kg were the overall average live body weight gain for layers housed in deep litter and layers kept in battery cages, were respectively. Differences in egg production percentage were significant differences ($p \leq 0.05$) through the whole production period except the first weeks. However, the average egg weights produced from deep litter housed layers were higher than that produced from battery cages, and significant ($p \leq 0.05$) occurred only in the fourth week. Averages egg shape index ranged from 71.21% to 76.59% and 72.01% to 75.33% for the eggs laid by layers housed in deep litter floor and layers kept in battery cages, respectively. Layers housed in deep litter system significantly ($p \leq 0.05$) consumed more feed compared to layers kept in battery cages during the experimental period except the first week. Best averages of feed conversion ratios were calculated for layers housed in deep litter than for layers kept in battery cages, differences were significant ($p \leq 0.05$) for second, third, fourth and fifth weeks of experimental period. The results obtained from this study showed that deep litter system could provide a good managerial system then battery cages system in open-sided houses.

Further large scale studies could be necessary to obtain sufficient and accurate information of different housing systems and their effects on production performance and egg characteristics.

المُلخص

أُجريت هذة الدراسة في وحدة بحوث أنتاج الدواجن قسم الإنتاج الحيواني، كلية الموارد الطبيعية والدراسات البيئية، جامعة كردفان –الابيض . إمتدت هذه التجربة من 10سبتمبر الي 4 نوفمبر2016م. الهدف من هذه الدراسة تحديد أثر نظام التربية في الفرشة العميقة و أقفاص البطارية علي أنتاج وخواص البيض .أُخذت 32 دجاجة بياضة تجارية (هاي لاين) عمرها الإنتاجي 10 شهور وزِعت عشوائيا بالتساوي علي أربعة أقفاص أرضية في الفرشة العميقة . رُبيت 30 دجاجة بياضة (هاي لاين) في أقفاص البطارية . يتكون نظام أقفاص البطارية من ثلاثة طوابق ، مزودة بنظام حلمات مائية أتوماتيكية ومعالف طولية أمامية. خلال فترة التجربة وجد أن متوسط معدل الزيادة في الوزن الحي بلغ -0.01 و 0.04 كجم للدجاج الذي رُبي علي الفرشة العميقة والدجاج الذي ربي في أقفاص البطارية علي التوالي . وجد إن هناك فروقات معنوية ($P\leq0\cdot05$) لنسبة الانتاج الاسبوعي طوال فترة التجربة بإستثناء الاسبوعين الاول والاخير. بالرغم من إن متوسط وزن البيض المنتج من الدجاج المُربى في الفرشة العميقة أعلي نسبيا من متوسط وزن البيض الناتج من نظام أقفاص البطارية، فإن الفرق في متوسط وزن البيضة كان معنويا ($P\leq0\cdot05$) حدث فقط في الاسبوع الرابع. متوسط دليل شكل البيضة يتراوح من 71.21% إلي 76.59% و72.51%الي 75.33% للبيض الناتج من الدجاج المُربى في الفرشة العميقة وأقفاص البطارية علي التوالي. أوضحت التجربة أن متوسط إستهلاك العلف للدجاج المُربى في نظام الفرشة العميقة كان أعلي من متوسط إستهلاك الدجاج الذي رُبي علي اقفاص البطارية، وقد كانت الإختلافات معنوية ($P\leq0\cdot05$) طوال فترة التجربة بإستثناء الاسبوع الاول. أفضل متوسط تحويل غذائي حُسب للدجاج المُربى في الفرشة العميقة مقارنة بالدجاج المُربى في أقفاص البطارية ،وقد كانت الإختلافات معنوية ($P\leq0\cdot05$) للاسبوع الثاني والثالث والرابع والخامس خلال فترة التجربة. وقد اوضحت نتائج هذه الدراسة ان نظام الفرشة العميقة قد يوفر نظام ادارة جيد مقارنة بنظام اقفاص البطاريات تحت ظروف البيوت المفتوحة. تعتبر هذه الدراسة كمؤشر لعمل دراسات اخري واسعة المدى لجمع معلومات دقيقة وفعالة للانظمة المختلفة وأثرها علي اداء وخواص الإنتاج في الدجاج البياض.

CHAPTER ONE

INTRODUCTION

1.1 Background

Poultry is an important farm species in almost all countries. It is an important source of animal protein, and can be raised in situations with limited feed and housing resources. Poultry meat and eggs are widely available, relatively inexpensive and can be of central importance in helping to meet shortfalls in essential nutrients, particularly of impoverished people. The incidence of several common metabolic diseases associated with deficiencies of critical dietary minerals, vitamins and amino acids can be reduced by the contribution of poultry products rich in all essential nutrients except vitamin C (Cherian *et al*., 2005).

The chicken egg is one of the finest foods, offering men an almost complete balance of essential nutrients with proteins, vitamins, minerals and fatty acids of great biological value (Brugalli *et al*., 1998). In addition to being one of the foods of lowest cost, it increases the consumption of food of high nutritional value for the low-income population Pascoal *et al*. (2008).

Feed and housing are two main factors of successful poultry farming business. Housing is important for raising layer poultry commercially and in small scale.

A good layer poultry house system keeps the bird safe, well growing, productive and protects the poultry birds from adverse weather condition, injury and predators (Kuit *el al*., 1989).

The management recommendations, most of which have been followed since many years in the management of layer and broiler parent flocks, draw on results from scientific studies as well field experience and should help poultry farmers to optimize results under their specific conditions (Lohmann, 2008).

It is apparent that every system has advantages and disadvantages in relation to animal health, welfare and performance. Although the cage system of housing laying hens is the most economical and limits sanitary problems. The productivity and health of birds are better than in other systems, there are serious welfare disadvantages in the cage systems (Elson, 1992). The lack of free movement, comfort, shelter, suitable flooring and freedom to display most normal patterns of behavior has aroused many discussions about poultry welfare (FAWC, 1997). Housing laying hens in cages is a controversial animal welfare issue for the egg industry with impacts on public acceptance of current industry practices and the potential to lead to imposed changes which may be associated with increased capital costs (Petek, 2004; Elson, 1992).

Several alternative systems as deep litter, preacher, aviary, free range and enriched cages systems has been proposed and increasingly practiced in the past two decades. These alternative housing systems accommodate most of the welfare concerns that are found in battery cage housing systems. They provide physical space and greater environmental complexity including litter, perches, dust-bathing, pecking, scratching behaviors and egg laying facilities (Elson, 1992). Scientists have made various conflicting reports about the contamination of eggs under different housing systems. The majority of commercial laying hens in the world are housed in cage systems in contrast to non-cage systems such as aviaries, barns or free range (Van Horne and Achterbosch, 2008).

Cage poultry-houses are difficult to clean and disinfect (Valancony *et al*., 2001) and with Salmonella contamination has been shown to be more persistent in successive flocks housed in cages than on-floor due to poor standards of cleaning and disinfection in cage farms (Davies and Breslin, 2001).

In recent years, there has been a rapid improvement in poultry husbandry. As a result of the rapid improvements in the management, disease control, nutrition, genetics of layers, in addition to advances in technology in recent year , egg quality and composition have undoubtly changed (Sorensen *el al*., 2006).

1.2 The objectives of the study

The general objective of this study is to determine the effects of two different housing systems (deep litter, and cage) on performance of small scale of commercial layer flocks and whit the specific objective were:

1. To determine the effect of deep-litter and cages housing systems on egg production performance and egg characteristics (egg weight, egg shape index and egg shell thickness).
2. To determine the effect of the two systems on feed consumption and feed conversion ratio.

CHAPTER TWO

LITERATURE REVIEW

2.1 Egg Production Performance of Commercial Layers

Egg production is a dependent variable and is influenced by several factors like strain of chicken (North Carolina Cooperative Extension service, 1984; Petek, 1999), feeding, mortality, culling, health and management practices, age at point-of-lay, and peak for lay and persistency of lay rate (Kristensen and Silleb-Kristensen 1996). Keeping higher egg production potentials of commercial layers aside, management would then be key factor to ensure high profitability (Van Eekeren, 2006). Some important factors from the managerial point of view are appropriate size of operation efficient, utilization of resources, economical feeding, improved housing and appropriate stocking rate. The development of the poultry industry from backyard production and into more specialized concentrated poultry companies took place in less than a century. This was done as a result of scientific achievements in poultry breeding and genetics, poultry nutrition, housing, management and disease control (Hunton, 1990). The number of breeds, varieties and strains used in poultry production declined and at the same time the number of breeding companies were reduced. Currently, few international corporations supply most of the breeds to the international market (Dunnington *et al*., 1994 and Hillel *et al*., 2003). Artificial selection was used in developing poultry with outstanding performance for the production of traits of economic importance such as meat and eggs. The breeds which currently dominate the world's poultry industry were all developed during the "hen craze" era late 19th to early 20th centuries (Dunnington *et al*., 1994 and Hillel *et al*., 2003). Single comb white leghorn was used as the producer of the industrial white shelled eggs. Eggs with brown shells are commercially produced from crosses of several dual purpose breeds developed after 1850 and the major contributors were Plymouth Rocks, New Hampshire, Rhode Island Red and Australorp. Also, a strain of brown Leghorn was developed and is also producing brown eggs. Modern broilers are based heavily on crosses of Cornish and White Plymouth Rocks. The Cornish was developed in England from Asiatic fighting stocks, and the white Plymouth Rock was derived as a mutant of American parent breed (Siegel *et al*., 1992, Crawford, 1990).

2.2 Eggs Characteristics

Several economic analyses have been made in an attempt to identify those characters of importance for egg production. It is appear that egg number alone can account for up 90% of the variation in economical returns (Bowmann, 1968). The number of eggs produced durning a certain period, is generally used as a measure for production capacity of a hen under specific environmental conditions; but sometimes the total weight of eggs is used as indicator for hen productivity. However, there is a negative correlation between egg number and average weight of egg (Smith, 1990).

2.2.1 Egg production

The laying cycle of a chicken flock usually covers a span of about 12 months. Egg production begins when the birds reach about 18-22 weeks of age, depending on s the breed and season. Flock production rises sharply and reaches a peak of about 90%, 6-8 weeks later. Production then gradually declines to about 65% after 12 months of lay. There are many factors that can adversely affect egg production. Unraveling the cause of a sudden drop in egg production requires a thorough investigation into the history of the flock (Van Eekeren, 2006). Egg production can be environmentally affected by such factors as feed quality and quantity, water intake intensity and light duration and diseases (Kekeocha, 1984). Egg production can be affected by such factors as feed consumption (quality and quantity), water intake, intensity and duration of light received, parasite infestation, disease, and numerous management and environmental factors (Van Eekeren,2006).

2.2.2 Eggs weight

Egg size, which is nearly always measured as weight, is at its lowest at the commencement of laying period, but it increase steadily for about seven to eight months, after wards is only slight increase if any at all. Egg weight is a fairy high heritable characteristic which is unfortunately negatively correlated with egg production (Smith, 1990). Egg weight increases during the production period (Anderson *et al*., 2004).

2.2.3 Eggs shape

Misshapen eggs have a shape which differs from the smooth normal shape. This can be caused by a number of factors such as age of birds, stress and diseases. The measurement of chicken egg shape is shape index (SI). Eggs are characterized by the SI as sharp, normal (standard) and round if they have an SI value of ≥72, between 72 and 76, and ≤76, respectively (Sarica & Erensayin, 2004). Normal chicken eggs have an elliptical shape. If the chicken eggs are an unusual shape; such as being long and narrow, round, or flat-sided; they are not regarded as Grade-AA or -A (USDA, 2000). Round and unusually long eggs have poor appearance, and they do not fit properly in preformed packaging. Further, they are less resistant than normal shaped eggs to rupture during shipping (Jacob *et al*., 2000).

2.2.4 Eggs shell thickness

Five hours after ovulation, the forming egg enters the red isthmus and uterus where the eggshell calcification process (lasting 18–19 h) takes place. During mineralization, the incomplete egg bathes in a cellular milieu (the uterine fluid) that contains ionized Ca and bicarbonate necessary for the eggshell formation. The process consists in controlled precipitation of calcium carbonate on the outer eggshell membrane fibers, and occurs in the extracellular space between the dilated shell membranes that envelope the hydrated albumen and the mucosa of uterine wall (Gautron *et al*., 2014).

Egg shell quality is important because it affects market value through resistance to cracking and for its effect on hatchability. Factors that contribute to shell quality and strength are shell thickness, porosity, membrane thickness, mineral content and protein matrix. The problem of shell quality has attracted increasing interest. Dietary manipulation seemed to be unsatisfactory in improving shell quality (Arad and Malder, 1982). A considerable effect on egg shell quality is associated with housing system. However, results of the effect of housing system on egg shell quality are mixed with genotype, age, ovilation time and mineral nutrition (Ketta and Tumova, 2016).

2.3 Factor Affecting Eggs Production

Many factors influence egg production during the egg production cycle. To provide maximum output and profitability the cycle must be managed effectively and efficiently through controlling most of these factors (Hunton, 1995).

2.3.1 Genetic factors

The egg production of a chicken is a result of many genes acting on a large number of biochemical processes, which in turn control a range of anatomical and physiological traits. With appropriate environmental conditions (nutrition, light, ambient temperature, water, sound health, etc.), the many genes controlling all the processes associated with egg production can act to allow the chicken to express fully its genetic potentials (Fairfull and Gowe, 1990).

The terminology used to describe poultry and chickens in particular is sometimes confusing, as they are referred to as “indigenous”, “native”, “local” or“traditional”. However, according to Mogesse (2007), these terms are defined as: Indigenous - living naturally in an area, not introduced; Native - belonging by birth to a specific area, country; Local - native inhabitant and; Traditional – customary. Although altering and improving the environment, or physiological situation or manipulation of the chickens contribute immensely towards improvement of their production qualities, the possibility remains that variation nevertheless still exists after optimum non-hereditary conditions have been established. This is because some of the variations in the economic traits are genetic in character and improvement brought about by heredity tends to be permanent (Fairfull and Gowe, 1990).

2.3.2 Non-genetic factors

Egg production is a normal part of chicken reproduction in healthy, young hens. Many factors influence egg production during the egg production cycle. To provide maximum output and profitability the cycle must be managed effectively and efficiently through controlling most of these factors (Kekeocha, 1984). Egg production can be environmentally affected by such factors as feed quantity and quality, water intake, intensity and light duration and diseases (Kekeocha, 1984). Additionally, age influences egg production especially within the first laying cycle and over the subsequent laying cycles, In other words most traits deteriorate with advancing age. McMillian *et al*., (1986) and Yang *et al*. (1989) stated that within egg production cycles, egg production declines with increasing age while its variation increases.

2.3.2.1 Nutrition

Chemical composition (crude protein, metabolizable energy and minerals content) of the feeds should meet the requirements of the chickens for its optimum performance (Msami, 2007). Age, feed, protein levels and temperature are some of the factors that affect egg size in chickens (Banerjee, 1992).

Good water is the most important part of the diet for all animals, including laying chickens. To ensure health and optimum egg quality the water supplied to the hens should be of potable standard (Lohmann, 2008). A continuous supply of clean fresh water must be available so that nutrients can be absorbed and toxic materials removed from the body. This is especially vital for young chicks. A lack of water will reduce feed intake, seriously retarding growth and impairing egg production. Water is also essential for birds to control their body temperatures in hot weather (Van Eekeren, 2006).

The energy intake means the calories that are taken in by the chicken with its feed. The amount of energy contained in feedstuffs is normally expressed in units of metabolisable energy (ME) per unit weight (kcal/d) (Van Eekeren, 2006). Dietary energy comes mainly from carbohydrates but also from fat and protein. The control of intake is based primarily on the amount of energy in the diet. Recommended energy levels in poultry diets are about 2800 kcal/kg for layers and about 3000 kcal/kg for broilers (Kinh, 2006).

Protein is made up of amino acids, and birds obtain these amino acids from their feed to build up their own proteins in the body. Poultry birds are good converters of feed into usable protein in meat and egg (Abanikannda *et al*., 2009). The excess protein is broken-down and used as an energy source, and the excess nitrogen is excreted as uric acid. The synthesis of protein in the body tissues requires an adequate supply of about twenty different amino acids in the proper proportions. Ten of these cannot be synthesized by the bird's metabolism and must therefore be supplied by the diet. These are called essential amino acids, the main ones being lysine and methionine. A shortage of essential amino acids will limit production (Van Eekeren, 2006).

Vitamins play a role in the enzyme systems and natural resistance of poultry. Vitamin deficiency can lead to serious disorders. Natural vitamins are found in young and green plants, seeds and insects. All vitamins may be purchased in a synthetic form at a commercial price, and may be added to the mixed feed as a premix. The important vitamins that are needed by layers are (A, B1 thiamine, B2 riboflavin, B12cyanocobalamin, Biotin, Niacin, Pantothenic acid, choline, K, D3, E (Van Eekeren, 2006).

Minerals, Calcium is the most widely distributed mineral in the body and is in great demand from the daily diet in chickens (Vries, 2010). Calcium (Ca) and phosphorus (P) are chiefly needed for the bones; enzyme systems are also often dependent on trace elements of certain minerals, such as iron, copper, zinc and iodine. Calcium and phosphorus both primarily add to the structure and maintenance of the chicken bones. The skeleton accounts for about 99% of the calcium and 80%

of the phosphorus in the body. During egg production, calcium needs are more than the double amount (Van Eekeren, 2006). Hens actively laying eggs require Ca for maintaining the integrity of the skeleton as well as for egg shell formation. A laying hen needs about 10 to 15 times more Ca than mammals of equivalent body size (Graveland and Berends, 1997). Calcium stored in the skeleton is in the form of hydroxyapatite (Whitehead and Felming, 2000); and in the egg shell it is deposited as calcium carbonate (Bar, 2009). Calcium also serves as a regulator (or a messenger) and playing critical roles in muscular contraction and many other biochemical reactions in living organisms (Matos, 2008). In chickens, following Ca intake from the diet, part of the absorbed Ca is transferred directly to the shell gland for shell formation and part is stored in the skeletal system, from where it can be released and transported to the shell gland during egg production (Gilbert, 1983). Bar (2009) reported that up to 40% of the egg shell Ca is derived from bone reserves. Chickens are able to maintain a satisfactory level of production if they are provided with diet of satisfactory level of dietary Ca. The National Research Council (NRC, 1994) estimates that the Ca requirement for brown laying hens is 36 g/kg of feed based on 110 g of feed consumed/hen/d. For white hens consuming a similar quantity of feed, the Ca requirement is approximately 35 to 38 g/kg of feed (NRC, 1994). Vitamins and minerals can be added as premixes to the diets of laying hens and broilers. Other ingredients to be considered include coccidiostats as preventive medicine and antioxidants as preservative (Van Eekeren, 2006).

2.3.2.2 Layer housing system design

Current intensive poultry production systems that aim to maximize profit offer increasingly new technological solutions which facilitate labour and increase productivity. However, these systems do not always meet the natural needs the birds. Ignoring welfare of animals is not only an ethical issue but also a practical issue because well-being and housing comfort translate into better weight gains, health and productivity of the birds Newberry *et al*. (2001). Modern egg laying strains of chickens have experienced many quantitative and qualitative alterations in their physical and physiological characteristics over thousands of generations during domestication Newberry *et al*. (2001). Improvements to poultry housing systems in developing countries have focused on providing an environment that satisfies the birds' thermal requirements. Newly hatched birds have a poor ability to control body temperature, and require some form of supplementary heating, particularly in the first few days after hatch. Many developing countries are located in tropical areas where minimal heating is required. Indeed, the emphasis in these countries – particularly for meat chickens – is on keeping the birds cool (Glatz and Bolla, 2004). For controlled-environment housing of layers, multi-tier cage systems are common. Most large-scale commercial farms use controlled-environment systems to provide the ideal thermal environment for the birds (Glatz and Bolla, 2004). Birds' performance in controlled-environment sheds is generally superior to that in naturally ventilated houses, as the conditions can be maintained in the birds' thermal comfort zone. Achieving the ideal environment for birds depends on appropriate management of the poultry house (Appleby and Hughes, 1991). Many poultry flocks are kept in controlled environment houses, which can give accurate control over microclimate. In recent years, there has been a significant trend to develop and use litter housing systems rather than conventional cages regarding the well-being of animals utilized for food production (Lohmaan, 2008). The first step in planning to build new houses or converting existing buildings to deep-litter is to consult experts with sufficient experience. The construction of deep litter and preacher housing has to meet different and often higher standards than cage housing. The lower stocking density per m² of floor space compared with conventional cages and the corresponding reduction in heat production by the hens must be taken into account when designing ventilation and air-conditioning installations. Nests must be easily accessible and preferably positioned in a central location in the laying house. Eggs laid outside the nest are hygienically compromised and have to be marketed at discounts. In deep litter housing dust is generated by hens using the scratching area and moving about. The design of the building and its installations should be user-friendly to allow easy servicing (Lohmann, 2008). Modern houses are fully automated, with fans linked to sensors to maintain the required environment. Some commercial operators use computerized systems for the remote checking and changing of settings in the houses. Forced-air furnaces and radiant heating are the main methods of providing heat to young chicks. In developing countries, most medium- scale and small-scale commercial layer and broiler houses rely on natural airflow shed (Daghir, 2001). Houses of various shapes and dimensions are typically constructed using local building materials. Such poultry house should have feeders; they can be made in different ways (Van Eekeren, 2006). Drinkers in tropical areas are very important to supply chickens with enough water cold. Perches chickens like to spend the night on high perches. Each chicken needs approximately 15 cm (or more) of sitting space, depending on its size (Van Eekeren, 2006). Litter type and quality of the litter are important for the hens and the house climate. Different materials may be used, sand or gravel up to 8 mm granule size, Wood shavings Wheat, spelt, rye straw, Bark mulch, coarse wood chips (Lohmann, 2008).

For Lighting there are two ways to try to raise the production of chickens by using artificial lighting. Laying hens usually prefer to lay eggs in protected nests, rather than simply on the floor of the house. In all poultry houses except battery cages, eggs are collected manually (Van Eekeren, 2006).

2.3.2.2.1 Deep litter housing system

A good layer poultry housing system keeps the bird safe, well growing and productive. Food and housing are two main factors of successful poultry farming business. Housing is also very important for raising layer poultry commercially and in small scale. Deep-litter system have been proposed and increasingly practiced in the past two decades. They provide physical space and greater environmental complexity including litter, perches, dust-bathing, pecking, scratching behaviors and egg laying facilities (Elson, 1992). It is apparent that every system has advantages and disadvantages in relation to animal health and welfare and performance. The lack of freedom of movement, comfort, shelter, suitable flooring and freedom to display most normal patterns of behavior has aroused many discussions about poultry welfare (FAWC, 1997). Scientists have made various conflicting reports about the contamination of eggs under different housing systems. Garber *et al*. (2003) reported that birds reared under deep litter floor systems had higher risk of infection with Salmonella compared to those kept under cage systems. In contrast, Namata *et al*. (2008) maintains that organic poultry production is threatened with salmonellosis as much as the other production systems. Local poultry houses meet some of the basic requirements like protection against inclement weather but rarely provide adequate space and ventilation. Kirunda and Mukiibi-Muka (2003) estimated that mortality of indigenous poultry under scavenging conditions is 70%and above in chicks up to 8 weeks of age, which greatly inhibit increase in the number of local poultry populations. Local poultry usually scavenge for most of their feed requirements and the feed resource in this system is limited to the available nutrients in the area that include insects, seeds, discarded grain and kitchen wastes. There is no provision of water by the farmer allowing flocks to get water from any available source. The floor is covered with litter to absorb the moisture of the chickens' faces. The most important condition for this type of housing is that the litter must remain dry. Moist litter produces too much ammonia, which damages the health of the birds. It also encourages all kinds of parasites. To keep litter dry, use litter which absorbs moisture in its particles. Avoid spilling water on the floor. It is best to place the drinkers on a small platform covered with slats or wire mesh. Turn the litter regularly and replace it once a week. Make sure the house is well ventilated (Van Eekeren, 2006). Feeding and watering facilities are usually located on the lower tiers, while the upper tiers serve as resting areas. Depending on the perchery type, the laying nests are either within the system or outside the perchery. A stocking density up to 18 hens per m² floor area is permitted. Lighting programs and feeding times can be designed to encourage the birds to move around the different levels (Lohmann, 2008). The superiority of layers housed in deep litter floor could be due to increasing feed intake and welfare in deep-litter (Hall, 2001; McLean et al., 2002; Bessei, 2005). Uniformity of body weight in pullets and layers is an important management concern (Ewa et. al., 2010).The average gain was different between housing could be due extra energy and heat production and moving (Preisinger, 2000).

Egg weight is a fairy high heritable characteristic which is unfortunately negatively correlated with egg production (Smith, 1990); layer production system has a considerable effect on egg weight and egg characteristics through its influence on feed consumption and body weight. Body weight and egg weight are two relevant productive traits in poultry (Sorensen et al., 1980).

Egg weight, egg length, egg breadth, shell weight and shell thickness shows superior or higher values of deep litter housing type over its counterpart in cage housing system (Ojedapo, 2013). The egg weight was higher in the deep litter system than battery cage (Voslafiova *el al*, 2006). The average egg laying capacity of the layers kept in deep-litter lowers than battery cages. Egg productivity of layers reared in barn was lower than those, kept in conventional and enriched cages (Gerzilov, 2012). Daily egg production was not different between hens housed in conventional cages and floor pens (Jiaying, 2013). Egg weight in birds kept in barn was lowers than battery cages (Gerzilov, 2012). Differences in egg weights could be attributed to slightly heavier body weight of layers housed in deep litter floor (Sorensen et al., 1980) and increasing feed intake (Bessei, 2005).

The feed conversion ratio in layers kept in deep-litter was high versus other both poultry housing systems (Gerzilov, 2012).

The cumulative egg size traits of length, width, and the shape index measured over 3 ages were not different between hens housed in floor pens as compared to cages, while shell % and shell thickness of eggs were poorer in cages than the floor pen respectively (Jiaying,20 13). Housing system has no conclusive effect on egg shape index (Pohle and Cheng, 2009). Shell quality, particularly shell thickness is an important economic trait that primarily breeders of egg lying stock incorporate into their breeding programme to reduce shell breakage (Grunder *et al*., 1989). Egg shells were dirtier in conventional cages compared to other cage types (Djukić, 2012). No differences were observed in the egg shell ash % and shell Ca concentrations between eggs laid by hens in the two housing systems respectively (Jiaying, 2013). Egg shell thickness and breaking strength usually decrease. Eggshell quality depends on egg size and weight. Egg properties such as SI and shell thickness affect the proportion of damaged eggs during handling and transport (Anderson *el al*., 2004). Eggs shall thickness was different in findings reported by Pohle and Cheng (2009), in all housing systems the eggshell stability was at the lowest point at the end of laying period. (Van den Brand *et al*., 2004). Egg size and the eggshell thickness are strongly related to each other (Harms *el al*., 1990).

2.3.2.2.2 Cages housing system

A good poultry house protects the birds from adverse weather condition, injuries and predators. Since the publication of Ruth Harrison's book "Animal Machines" in 1964, there has been widespread public pressure in Europe - supported by European institutions- to "ban the battery cage". By 1970, most hens kept for egg production in the developed world were housed in conventional laying cages, often called battery cages. According to animal welfare activists, the conventional cages cause many welfare problems (Craig and Adams, 1984; Appleby, 2003). Housing laying hens in cages is a controversial animal welfare issue for the egg industry with impacts on public acceptance of current industry practices and the potential to lead to imposed changes which may be associated with increased capital costs. Indeed, due to concern for the welfare of laying hens in different production systems in the European Union (EU) over the last few decades, EU Directive 1999/74/EC sets down minimum standards for the protection of laying hens in legislation (EU, 1999). Conventional cages are also considered to be the best system for prevention of infectious disease, especially diseases that are transmitted through the feces as the hen's fecal material falls through the wired floor of the cage and reduce cross contamination among the hens (Hulzebosch, 2006). The cage system of housing laying hens is economical and limits sanitary problems. However, Although the productivity and health of birds are better than in other systems, there are serious welfare disadvantages in the cage systems (Elson, 1992).These alternative housing systems accommodate for most of the welfare concerns that are found in battery cage housing systems (Elson, 1992). In this case it is recommended to provide a winter garden (Lohmann, 2008). There are a number of recent European reports regarding commercial egg production in furnished cage systems in which hen mortality, egg production, egg quality, feed consumption and other parameters have been evaluated (Tauson and Holm 2005; Hulzebosch, 2006). To quantify the benefits or otherwise of furnished cages under Australian conditions, an AECL- / DPI- co-funded research project (Barnett and Cronin, 2005) was conducted between 2002-2004 to evaluate the commercial Victors son Trivselburen 8-bird Furnished Cage (Sweden). Specifically. The project investigated the effects of the different components of the cage furniture, viz. nest box, dust bath, perch and their interactions via a factorial-design experiment, to determine the effects of the cage furniture on bird welfare, behavior and egg production (Barnett and Cronin, 2005). The project found that with the exception of tinting to improve bone strength, cage furniture provided no quantifiable welfare benefits compared to hens in cages without furniture, although the 'furniture' was well-used by the birds. The frequency of use of the perch and dust bath in the furnished cages were reported by Barnett and Cronin (2005), while these corresponded to data from on-farm surveys in Sweden by Tauson and Holm (2005). However, cages also have positive effects on welfare in that they provide clean, disease-free environment and small group sizes. The balance of these advantages and disadvantages has been assessed differently by different authors. For example, Craig and Adams (1984) considered that in high-density cages welfare suffered compared with low-density cages or floor systems, whereas Hill (1986) concluded physical measures of welfare were marginally worse in alternative systems. Laying cages are still the most economical way to produce eggs and the best system for disease prevention (Hulzebosch, 2006). Cannibalism is rare in battery cages, even among birds with untrimmed beaks, noted that beak trimming of pullets who will be housed in cages when mature is nevertheless usual, partly to reduce feather pecking (Appleby, 2003).

Egg, The average of egg laying capacity was highest for the layers kept in conventional cages followed by in enriched cages and in barn on slat flooring with manure pit and deep litter respectively (Gerzilov, 2012).

The birds in enriched cages laid significantly less eggs compared to other two cage type (Djukić, 2012). Hens in frame cages laid 7.7 more eggs/ hen-housed (Garner *el al.*, 2012). The first egg laid was earlier for hens of the floor pens than the caged hens while the type of the housing did not affect the age when 50% egg production was achieved (Jiaying,2 013). In furnished cages had over 90 % from 26 weeks of age on the layers reared on slat flooring .The layers gained peak egg lying capacity at 36 weeks of age – 95.9 % and at the 76 weeks of age, the egg laying capacity decreased to 81.1 % (Gerzilov, 2012). The highest laying percentage was achieved with white layers in enlarged conventional cages (Voslafiova *el al*., 2006, Djukić, 2012).

Egg production from conventional cage layers is higher than in alternative systems such as aviary, floor management or free-range system (Tauson et al., 1999; Leyendecker et al., 2001). Other studies conducted in several European countries indicate that egg production in furnished cages is comparable to that in conventional cages (Abrahamson and Tauson, 1997; Meanwhile, Pohle and Cheng, 2009).

The laying hens reared in the three types of poultry management systems did not reach 50 % intensity of egg laying at 144 days of age, as recommended for ISA brown commercial layers, but from 30 weeks of age to the end of the production period, their egg laying capacity was higher than the recommended (Gerzilov, 2012). Cage and house design risk factors affecting egg production included tier arrangement, mean cage height, waste removal, and source of lighting (Garner *el al*., 2012).

Hens reared in cages produce heavier eggs and less fearful at the end of production cycle than floor reared hens (Anderson and Adams, 1994). The highest weight of eggs was observed in layers kept in enriched cages followed by those kept in conventional cages and finally, in a barn poultry system (Gerzilov, 2012). Case weight of eggs also increased with greater light intensity, with a maximum weight achieved (Garner *el al*., 2012). The egg weight was higher in caged hens than that of hens housed in the floor pen (Jiaying, 2013).

Leeson and Summers (1987) and Harms and Russell. (1982) noted that there was a negative significant relationship between feed consumption and body weight and feed consumption and lying rate. As body weight and production rate increased, feed consumption of hens also increased. Highest feed consumption of layers housed in deep litter floor could be attributed to their relatively high production and slightly heavier weight. The best-feed conversion ratio was observed in layers reared in enriched cages and on slat flooring with manure pit and deep litter respectively. The feed conversion ratio in layers kept in conventional cages was lower than in other both poultry housing systems (Gerzilov, 2012).

The worst feather damage was observed in standard cage system. The degree of feather damage in neck region of white layers in conventional cages was slightly less. It has been confirmed, that there is possibility of cannibalism, feather pecking and aggressive behavior with the increase of the group size but this has not been confirmed in this work (Djukić, 2012). To aid interpretation, risk factors were divided into those predominantly describing then physical design of the house and cage followed by those predominantly describing the provision of resources to the hens within the cage. Removing manure from a house during the laying cycle increased eggs/hen-housed in frame cages. Cage resource risk factors affecting eggs/hen-housed included drinker position, feeder type, feeder space, and floor space allocation (Garner *el al*., 2012).

CHAPTER THREE

MATERIALS AND METHOD

3.1 Location

This experiment was conducted in the Poultry Production Research Unit, Department of Animal Production, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Elobeid. The experiment extended from 10 September to 4 Nove. 2016. Elobeid city (latitudes 13^{O} 14/ 35.3^{O} N and 13^{O} 05/43.2 N and longitudes $30^{O}15$ / 12.0 and $30^{O}10/54.5^{O}$ E. Elobeid is the capital of North Kordofan State with population that was estimated at 398993 (Central Bureau of Statistics; population estimates 2010). Most of North Kordofan lies within arid and semi-arid ecological zones. The mean annual rainfall ranges from some 75mm in the extreme north to about 500 mm in the south (Techno serve Organization, 1987).The area has hot to warm weather. The mean annual maximum temperatures are recorded during the months of April and May and amounted to 38-39.40c whilst minimum temperatures are recorded in winter during the months of December and January which were recorded being 12.9-170c (Sudan Metrological Department, Elobeid Office, 2006). These temperatures are modified by rain during the humid rainy season that extends from mid-June to mid-October. According to the same source, mean relative humidity ranges from 20% in winter to 75%in August at the middle of the rainy season (Walsh, 1991).

3.2 Experimental Flock

Sixty two of commercial hybrid layers (High line) were randomly selected from layer flock at production age of ten months. The flock was purchased from Khartoum as growers and vaccinated against New castle and Fowl pox diseases and treated against round and tape worms. The experimental birds were fed commercial layer ration ad. Libutum (Table3.1).

3.3 Housing and Experimental Procedure

The experimental birds were raised in an open-sided pen with dimension of 12x6x3 m. After one week of adaptation period birds were individually weighed and randomly distributed into two groups. A total of 32 birds were reared in deep litter floor system internally divided into four groups A, B, C and D. Each ground deep litter cage (130x140 cm) was consisted of 8 birds and covered by about 5-6 cm of smooth sand as bedding and provided by plastic tube feeder, plastic fountain drinker and egg nest. The stocking density in the deep litter system was 5 birds/ m^2.

Thirty layers were kept in battery cages. The battery system was consisted of triple deck cages, provided with automatic nipple watering system and front trough feeders. The ten lower cages were used; each cage of 48x35x40 cm was accommodating three layers. The Lighting programme was based on day light and additionally two hours of evening artificial light. Fresh water was accessible continuously and multivitamins and minerals added frequently.

3.4 Data Collection

The traits which were measured during the experiment included egg production and egg weight on daily basis. The average egg weight was calculated from the number of hen-day eggs and total weight at weekly interval. The egg weight was measured with a sensitive balance to the nearest 0.01g. The average daily feed consumption per bird was calculated from the total hen-day feed consumption.

The average egg shape index was calculated by measuring egg length and egg width of random samples of the two groups with a digital caliper to the nearest 0.02 mm. Egg shell thickness including shell membranes was measured with micrometer to the nearest 0.01mm. The average egg-shell thickness was determined from three sides, narrow side, wide side and medium side.

3.5 Statistical Analysis

The experimental design was the completely randomized design (CRD). Analysis of variance was used for detecting variations among different treatment means. Duncan Multiple Range Test (DMRT) was used to assess the significance among treatment means according to Gomez and Gomez (1984). SAS v0.9 software (Statistical Analysis System) was used to analyze data.

CHAPTER FOUR

RESULTS

The initial live body weight of the experimental layers ranged from 1.33 kg to 1.46 kg and 1.4 kg to 1.47kg for the layers housed in deep litter floor and layers kept in battery cages, respectively (table 4.1), while the final live body weight ranged from 1.38 kg to 1.42 kg for layers in deep litter floor and 1.36 kg to 1.42 for layers in cages (table 4.2).

For the whole production period of 8 weeks, the total egg produced from the layers kept in deep-litter and battery cages were 1118 and 921 respectively. Differences in egg production percentage were significant ($p \leq 0.05$) through the whole production period except the first and last weeks in deep litter and cages respectively (table 4.3).

The average egg weight of layers housed in deep litter system was greater than that of layers reared in cages during the experimental period; however significant differences ($p \leq 0.05$) occurred only in fourth week (table 4.4).

Table (4.5) shows insignificant differences in egg shape index for the two housing systems durning the whole period. There were no significant differences in egg shell thickness for the egg produced from two housing systems (table 4.6).

Table (4.7) shows the average weekly feed consumption, layers housed in deep litter system consumed significantly ($p \leq 0.05$) greater feed compared to layers kept in battery cages during the whole experimental period except the first week.

The weekly feed conversion ratios (kg /dozen) of the experimental Layers in two different housing systems are presented in Table (4.8). Layers in deep litter system showed better feed conversion ratios through the whole experimental period except the last week compared to layers reared in battery cages. Differences in feed conversion ratios were significant ($p \leq 0.05$) during the second, third, fourth and fifth week of experimental period.

Table 3.1. Experimental layer ration

3.1.1 Gross composition

Ingredient	Percentage (%)
Sorghum	57
Peanut/groundnut(cake)	20
Concentrate	05
Limestone	10
Wheat bran	07
Sodium Chloride	0.5
Premix	0.5
Total	100
3.1.2 Chemical composition	
Calculated analysis	
Crude protein (%)	18
Metabolism energy (Kcal/kg)	2870
Crude fiber (%)	4.6
Fats (%)	3.65
Calcium (%)	3.7
Phosphorus (%)	0.7

Source (Mekki, 2016).

Table 4.1 Initial live body weight (mean ± sd) Kg of experimental layer

	Replication			
Housing type	**R1**	**R2**	**R3**	**R4**
A	1.37±0.07 (8)	1.33±0.11 (8)	1.46±0.12 (8)	1.43±0.12 (8)
B	1.47±0.15 (8)	1.45±0.13 (8)	1.40±0.09 (7)	1.42±0.14 (7)

* Where: A= deep-litter housing and B= cages housing.

** Numbers between brackets are number of hens.

Table 4.2 Final live body weight (mean ±sd) Kg of the experimental layers.

	Replication			
Housing type	**R1**	**R2**	**R3**	**R4**
A	1.38±0.12 (8)	1.41±0.09 (8)	1.42±0.17 (8)	1.41±0.16 (8)
B	1.42±0.15 (8)	1.42±0.12 (8)	1.36±0.12 (7)	1.38±0.11 (7)

* Where: A= deep-litter housing and B= cages housing.

** Numbers between brackets are number of hens.

Table 4.3 Weekly total egg production and production rate (%) of the experimental layers.

	Age (week)							
Housing type	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
A	130 (58.04)	143 (63.84[a])	135 (60.27[a])	148 (66.07[a])	136 (60.71[a])	134 (59.82[a])	158 (70.54[a])	134 (59.82)
B	123 (58.57)	110 (52.38[b])	118 (56.19[b])	117 (55.71[b])	102 (48.57[b])	109 (51.9[b])	117 (55.71[b])	125 (59.52)

* Where: A= deep-litter housing and B= cages housing.

** W1, W2, W2, W4, W5, W6, W7 and W8 are age of layers after starting the experiment by 1, 2, 3, 4, 5, 6, 7 and 8 weeks, respectively.

*** Numbers between brackets are egg production rate (%).

**** Numbers with different superscripts in the same column are significantly differ (Duncan multiple range test 5%).

Table 4.5 Egg shape index (%) of the experimental layers.

	Age(week)							
Housing type	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
A	73.67 (47.57)	72.59 (45.98)	71.21 (44.45)	72.91 (45.51)	75.14 (48.19)	72.77 (46.55)	73.02 (46.53)	76.59 (49.7)
B	72.67 (46.05)	72.01 (45.98)	73.19 (47.07)	75.33 (48.66)	74.24 (47.07)	75.79 (49.17)	72.97 (46.49)	73.18 (46.51)

* Where: A= deep-litter housing and B= cages housing.

** W1, W2, W2, W4, W5, W6, W7 and W8 are age of layers after starting the experiment by 1, 2, 3, 4, 5, 6, 7 and 8 weeks, respectively.

*** Numbers between brackets are the Arc-sine transformation according to (Rao, 1998).

CHAPTER FIVE

DISCUSSION

Uniformity of body weight in pullets and layers is of an important managerial concern (Ewa et. al., 2010). However, the study showed no significant differences in body weight gain durning the experimental period for layers housed in deep litter floor and layers kept in battery cages, the average body weight gain of battery cages layers (0.04) kg was slightly better over the average body weight gain of deep litter layers (-0.01) kg and that could be due extra energy and heat production and moving (Preisinger, 2000).

For the whole 8 weeks of production period, over all eggs produced were1118 and 921 for layers housed in deep-litter floor and layers kept in battery cages, respectively. Differences in egg production percentage were significant ($p \leq 0.05$) through the whole production period except the first week. However, the literature reveals that egg production from conventional cage layers is higher than in alternative systems such as aviary, floor management or free-range system (Tauson et al., 1999; Leyendecker et al., 2001; Djukić, 2012; Voslafiova, 2006). Other studies conducted in several European countries indicate that egg production in furnished cages is comparable to that in conventional cages (Abrahamson and Tauson, 1997); Meanwhile, Pohle and Cheng (2009) reported that layers maintained in furnished cages laid more eggs at 40 weeks compared to conventionally caged birds ($P \leq 0.05$) because of considerable improvements in welfare levels. The superiority of layers housed in deep litter floor could be due to increasing feed intake and welfare in deep-litter (Hall, 2001; McLean et al., 2002; Bessei, 2005).

Egg weight is a fairy high heritable characteristic which is unfortunately negatively correlated with egg production (Smith, 1990; Ojedapo, 2013); Layer production system has a considerable effect on egg weight and egg characteristics through its influence on feed consumption and body weight. Body weight and egg weight are two relevant productive traits in poultry (Sorensen et al., 1980).The overall average of the egg weight durning the experimental period were 60.25 g and 59.0 g for layers housed in deep litter floor and layers kept in battery cages, respectively. However, the egg weights of deep litter floor layers were heavier than egg weights of battery cages layers; significant differences were obtained only in the fourth week. Differences in egg weights could be attributed to slightly heavier body weight of layers housed in deep litter floor (Sorensen et al., 1980) and increasing feed intake (Bessei, 2005).

Egg properties such as shape index affect the proportion of damaged eggs during handling and transport (Anderson, Tharrington, Curtis, & Jones, 2004). The results show insignificant differences in egg shape index durning the experimental period. Egg shape indices range were 71.21 % - 76.59% and 72.67% - 75.79% for egg laid by deep litter floor and battery cages layer, respectively. Evidence showed that housing system has no conclusive effect on egg shape index (Pohle and Cheng, 2009). Shell quality, particularly shell thickness is an important economic trait that primarily breeders of egg lying stock incorporate into their breeding programme to reduce shell breakage (Grunder et al., 1989). The results show insignificant differences in egg shell thickness between the two different house systems. The averages of shell thickness were 33.13 ± 3.57 and 33.25 ± 3.38 micron for eggs produced from deep litter floor layers and battery cages layers, respectively.

The results are inconsistence with the findings reported by Pohle and Cheng (2009), who stated that housing system of White Leghorn layers reared in batteries of conventional and furnished cages from 19 weeks of age had no effect on shell thickness. Similarly, Jiaying (2013) observed no difference in egg shell ash percentage and shell Ca concentrations between eggs laid by hens in deep litter and cages housing systems.

Differences in the feed consumption between layers housed in deep litter floor and battery cages were determined to be significant from the second week to the end of experiment. The hen's deep litter floor housing system had higher feed consumption than that kept in battery cages. The mean values of weekly feed consumption at the end of experiment were 740.6 and 707.6 g for layers housed in deep litter floor and layers kept in battery cages, respectively. Leeson and Summers (1987) and Harms et al. (1982) noted that there was a significant relationship between feed consumption and body weight and feed consumption and lying rate. As body weight and production rate increased, feed consumption of hens also increased. Highest feed consumption of layers housed in deep litter floor could be attributed to their relatively high production, slightly heavier weight and feed lost from feeders.

Layers lowest conversion rate are profitability and more economical and desirable for producers. Poultry birds are good converters of feed into usable protein in meat and egg (Abanikannda *et al*., 2007). Feed conversion ratio for the entire laying period, the best-feed conversion ratio was observed in layers reared in deep-litter and battery cage respectively. Highest best feed conversion was observed in deep-litter, battery cage at week fourth 1.91, and 2.12 kg respectively. Also report noted by (Gerzilov, 2012) the feed conversion ratio in layers kept in deep-litter was high versus other both poultry housing systems.

CONCLUSION

The results obtained from this study showed that deep litter system could provide a good managerial system then battery cages system in open-sided houses. However, some advantages of deep litter system have been detected so that some consumer prefer deep litter products because they think that deep litter products are profitable than battery cages.

RECOMMENDATION

The results of this study have demonstrated that there exist differences in productive performance and the housing system. Therefore it is important to select an appropriate housing system for a particular strain of layer in order to produces eggs in with the highest quantity and quality.

Further large scale studies could be necessary to obtain sufficient and accurate information of different housing systems and their effects on production performance and egg characteristics.

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APPENDICES

APPENDIX 1: TABLES

Table 4.4 Eggs weight (mean ±sd) g of layers durning experimental period.

	Age (week)							
Housing type	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
A	60.98±3.99	59.20±4.73	60.54±4.68	60.34 ^{a} ±4.19	59.39±4.45	61.58±4.19	62.31±4.53	61.36±3.70
B	60.57±4.80	59.30±5.07	59.18±4.61	57.02 ^{b} ±4.61	57.15±5.01	59.57±4.46	61.21±5.33	60.36±4.35

* Where: A= deep-litter housing and B= cages housing.

** W1, W2, W2, W4, W5, W6, W7 and W8 are age of layers after starting the experiment by 1, 2, 3, 4, 5, 6, 7 and 8 weeks, respectively.

*** Numbers with different superscripts in the same column are significantly differ (Duncan multiple range test 5%).

Table 4.6 Egg shell thickness (mean ±sd) µ of experimental layers.

Age (week)								
Housing type	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
A	34.25±3.70	33.50±4.49	31.61±2.05	32.84±6.19	32.50±1.19	34.08±2.09	34.66±5.93	34.92±3.95
B	31.92±2.92	32.59±5.64	31.28±2.28	34.08±3.24	32.50±5.01	34.99±4.03	34.25±2.35	37.00±2.16

* Where: A= deep-litter housing and B= cages housing.

** W1, W2, W2, W4, W5, W6, W7 and W8 are age of layers after starting the experiment by 1, 2, 3, 4, 5, 6, 7 and 8 weeks, respectively.

Table 4.7 Feed consumption per bird/day (Gram /Day) of experimental layers.

	Age(week)							
Housing type	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
A	93	101^{a}	104^{a}	105^{a}	95^{a}	111^{a}	121^{a}	116^{a}
B	95	94^{b}	100^{b}	98^{b}	89^{b}	105^{b}	117^{b}	113^{b}

* Where: A= deep-litter housing and B= cages housing.

** W1, W2, W2, W4, W5, W6, W7 and W8 are age of layers after starting the experiment by 1, 2, 3, 4, 5, 6, 7 and 8 weeks, respectively.

*** Numbers with different superscripts in the same column are significantly differ (Duncan multiple range test 5%).

Table 4.8 Feed conversions (Kg/dozen) of experimental layers.

	Age(week)							
Housing type	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**
A	1.92±0.02	1.9 ^{a} ±0.09	1.91 ^{a} ±0.02	1.83 ^{a} ±0.04	1.83 ^{a} ±0.04	2.23±0.06	2.05±0.01	2.33±0.04
B	1.95±0.06	2.15 ^{b} ±0.04	2.14 ^{b} ±0.02	2.12 ^{b} ±0.02	2.19 ^{b} ±0.05	2.42±0.03	2.51±0.02	2.28±0.04

* Where: A= deep-litter housing and B= cages housing.

** W1, W2, W2, W4, W5, W6, W7 and W8 are age of layers after starting the experiment by 1, 2, 3, 4, 5, 6, 7 and 8 weeks, respectively.

*** Numbers with different superscripts in the same column are significantly differ (Duncan multiple range test 5%).

**** Numbers between brackets are number of hens.

APPENDIX II: CURRICULUM VITAE

Curriculum Vitae

North Kordofan State Elobied

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Sex: male

Data of birth: 1.1.1985

Nationality: Sudanese

PERSONAL DETAILS

Name: ISMAILYOUNES IBRAHIM ADAM

JOBS

Job Applied for position: Kholoj for Animal Production Institute El-obied-Sudan
Professional Background: Kholoj for Animal Production Investment CO.ltd, Assistant Teaching**,** Also I worked in tissue culture lab, Animal production lab, Farm of unit Researches' Department of Animal Production

Work Experience

One year in Kholoj Animal Investment Co.ltd One year Assistant in Animal Production Department Five month in tissue culture lab

One year in Animal production lab Eight month in Farm of unit Researches' Department of Animal Production

EDUCATION

Education and Training: 1992-2003 Primary school and basic school of Rashid 2003-2007 high school of Gebish and ELgeel 2007-2012 University of Kordofan Faculty of Natural Resources and Environmental studies Department of Animal production Graduation in 2012 with Full Time 1st Class 2015-2017 Master Degree of Natural Resources Management in Dry Land (Animal Production-Poultry) 2017 Which Offered from African Union Universities (RUFORM) Implemented in Kordofan University 2015. 2015 data collection in Animal gene mapping training 2016Poultry Management in Dry Land training

SKILLS

Personal Skill: Compute and teaching
Mather language: Arabic writing, reading talking proficient
Other language: English Dynamic ,hard working and team working

RECOMMENDATION

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