Chapter 7
The Role of Poultry Production on Food Security in Saudi Arabia

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Abstract Poultry farm projects in Saudi Arabia have the potential to bring numerous advantages to entrepreneurs and households and local areas. The government of Saudi Arabia has placed improving the self-sufficiency ratio of poultry products as one of the priorities in both agriculture and food security strategies to enhance and achieve food security. This chapter gives an overview of the poultry sector, focusing on the significance of poultry companies and poultry products in Saudi Arabia's food security, as well as the efforts and support provided by government institutions to improve the poultry industry and address issues of poultry loss and waste.

Keywords Broilers · Egg layers · Food security · Healthy food · Poultry industry · Saudi Arabia

1 Introduction

This section will provide a brief history of the poultry industry in Saudi Arabia. The poultry industry began in the Kingdom of Saudi Arabia in 1976, initially with a limited production capacity in the Taif region. However, in 1982, the industry experienced a significant increase in production. This was made possible by the implementation of three projects in Riyadh, Qassim, and Jeddah, each with a production capacity of 30 thousand tons. In addition, the Al-Akhawain project, with a capacity of 8 thousand tons, was also established in Al-Kharj in 1994. As a result of continuous

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expansion, the production capacity reached 615.9 thousand tons in 2017 (Al-Duwais and Ghanem 2019) Saudi Arabia possesses a substantial capacity for producing poultry meat domestically. However, it falls short of meeting the domestic demand. According to the United States Department of Agriculture (USDA), the percentage surpasses 60%. In 2020, the production volume reached 900,000 metric tons and 910 thousand in 2021. As a result of these factors, the Government of Saudi Arabia is concentrating on implementing strategic measures to enhance local production and subsequently stimulate market growth (Mordor Intelligence 2023). The size of the Saudi Arabia Poultry Market is anticipated to increase from USD 17,328.07 million in 2023 to USD 21,193.97 million by 2028, with a compound annual growth rate (CAGR) of 4.11% during the forecast period (2023–2028) (Mordor Intelligence 2023). Despite its growth, the poultry industry in the Kingdom of Saudi Arabia faces various challenges according to local producers, including the possibility of unfair competition in the form of dumping from other countries, a rise in imports, high costs of storage and production, a lack of adequate storage facilities, difficulties in communication between producers and wholesalers, insufficient and inaccurate marketing information, and the absence of specialized marketing companies for broiler chickens (Al-Nashwan et al. 2008).

The poultry sector is considered one of the vital and important sectors in the Saudi economy. Poultry provides approximately 45% of the population's animal protein needs in the Kingdom (Al-Rajhi 2008). The poultry industry in Saudi Arabia is one of the largest food industries in the Kingdom, where millions of poultry are raised for the production of eggs and meat. Poultry, alongside fish, meat, and eggs, is one of the most important food sources rich in protein and other nutrients (Yaseen 2021). It represents an important resource for meeting the nutritional needs of Saudi society. The pharmaceutical industry related to poultry production also plays a significant role in providing job opportunities and improving the income level for many families in the Kingdom, employing trained and skilled workers. The Saudi government aims to support and develop the poultry industry to reach self-sufficiency in food production, achieve food security for citizens, and reduce reliance on agricultural and food imports. They also attempt to enhance the quality of pharmaceutical products, as well as develop production and marketing techniques to improve efficiency and competitiveness in local and global markets. The poultry industry in Saudi Arabia contributes to achieving food security, job creation, and income improvement for many families in the Kingdom. It is experiencing continuous growth due to government support and development initiatives. The industry offers diverse products, including various types of poultry for meat and eggs. Frozen, canned, and fresh poultry are available in the Saudi market. Saudi Arabia is planning to invest SAR 17 billion ($5 billion) in order to increase poultry production. The goal is to achieve a self-sufficiency rate of 80% in poultry meat by 2025, according to the Saudi Press Agency. The Ministry of Environment, Water and Agriculture, led by Abdulrahman Al-Fadley, aims to produce 1.3 million tons of broiler chickens annually. This initiative seeks to guarantee the country's food security, promote domestic products, and generate employment opportunities (Arab News 2022).

The poultry products sector offers numerous benefits for individuals, families, institutions, companies, and the nation as a whole. Poultry products have multiple advantages that impact all aspects of food security at various levels. These benefits include generating diverse sources of income, providing a wide variety of protein-rich and nutritious food, contributing to food security, supporting rural development through poultry production projects, improving farmers' livelihoods (especially for those who are economically disadvantaged), and diversifying agricultural products. Moreover, it plays a role in agriculture, food security, and health. Additionally, it serves as a source of income for the government and promotes economic integration with trading nations through intra-trade. Furthermore, production projects aid in achieving self-sufficiency in poultry meat and eggs, ultimately reducing the need for importing such products (Alraedah 2023).

Poultry products are an essential food commodity for achieving food security in Saudi Arabia. According to Alamri and Al-Duwais (2019), they have a positive impact on food security, the food gap, strategic stock, and the self-sufficiency ratio. Verdruye's analysis in 1967 showed that intensive poultry production was almost non-existent. Local production only met less than 50% of the nation's egg needs, and small flocks were the primary source. Over 24 million eggs were imported in 1964 alone. Imports also supplied half of the country's broiler meat needs, totaling 800–900 tons per year, while the remaining meat was domestically produced using imported chicks. Suggestions to the government included implementing a national strategy to grow the poultry industry, establishing a poultry extension service, and creating a poultry unit under the Ministry of Agriculture.

Several studies have been conducted to conserve the native or local chicken flocks that originated in Saudi Arabia, called Baladi, and are adapted to their environment. These birds are characterized by their small size, different plumage colors, and different comb shapes (Al-Yousef 2007). They have a low production rate and small egg sizes, which are inherited traits that make them well-suited to the harsh environment. Baladi chickens are valuable genetic materials that need to be conserved and improved. Some research has been carried out to study the biological characteristics of these birds. Alsobayel (1986) compared two housing systems and their effect on the egg quality characteristics of local chickens reared under different systems. Attia et al. (1991) studied the effect of rearing system and age of the chicken on egg weight. Alsobayel (1992) reported the effect of dietary protein levels and age on fertility and hatchability. Several parameters were studied by Alsobayel et al. (1990) including the effect of storage, egg weight, and moisture loss on hatchability parameters of Baladi chicken eggs. Alsobayel and Atteia (1991) provided evidence of the influence of protein rearing regimens and age on egg quality characteristics.

The production of poultry in the Kingdom of Saudi Arabia dates back to the 1960s. Sheikh Abdul Rahman bin Abdul Qadir Fakih initiated the first commercial poultry project in the Kingdom in 1963. Currently, the Fakih project is one of the biggest customers of the international company, in the Middle East and North Africa.

Saudi Arabia has been very successful in poultry production, including a significant increase in the supply of both poultry meat and eggs. The Saudi Arabian former Ministry of Agriculture reported that the country's domestic poultry production

exceeded 493 million hens in 2009, with an egg production of 3473 million, as well as approximately 476,348 tons of chicken meat in specialized projects. Additionally, there were around 522 million meat chicks and 21.4 million egg chicks in the same year. This has resulted in Saudi Arabia being among the highest consumers of poultry in the world, with an annual consumption of 41.6 kg per capita of chicken, compared to the global average of only 12.5 kg (MOA 2009; Global Poultry Trends 2010).

Apart from the approximately 1500 mt of quail meat produced by Astra Farms in Tabuk, almost all poultry meat produced in Saudi Arabia is chicken meat. After consulting with the leading chicken meat producers in the country, the Saudi predictions for chicken meat production in 2019 and 2020 have been updated. According to these firms, around 800,000 mt of chicken meat were produced in 2019, which is an increase of 11% over the USDA's estimate of 720,000 mt. The overall output of chicken meat in Saudi Arabia is expected to exceed 930,000 mt in 2020, which is more than 27% higher than the USDA's official projection of 730,000 mt. The increase in chicken meat production can be attributed to the continued growth of the four major producers, namely Watania, Fakieh, Alyoum (Almarai), and Tanmiah poultry farms. Medium-sized chicken producers like Intaj and Aseer CO-OP, as well as smaller farms like Radwa and Golden Chicken, have also been contributing to filling the gap in meat production. Furthermore, expansion projects at existing farms and the establishment of new farms are expected to raise chicken meat output to 950,000 mt by the end of 2021, facilitating sustainable growth over the next few years (Mousa 2020).

In 2016, Selvanathan and colleagues conducted research on the consumption patterns of meat and fish in Saudi Arabia. The researchers examined data from 1985 to 2010 in order to investigate the demand for beef, chicken, lamb, and fish within an overall framework. Their findings revealed that the consumption rates of beef, chicken, and fish were on the rise, while lamb consumption was decreasing in Saudi Arabia. Additionally, they observed that the average relative price growth rates for beef, chicken, and fish were negative, while that for lamb was positive. Over time, the proportion of expenses allocated towards beef, chicken, and fish has increased, whereas the proportion allocated towards lamb has decreased. The income flexibility analysis showed that beef, lamb, and fish were considered luxuries, whereas chicken was a necessity in Saudi Arabia. Finally, the research revealed that the demand for all meat products and fish were price inelastic.

This chapter focuses on the historical importance of poultry products and farms in improving food security and bridging the gap between poultry product production and consumption. It also highlights the role of poultry in generating diverse income sources and providing nutritious protein. Additionally, it discusses the development and expansion plans of large and small poultry companies, as well as government initiatives to enhance the poultry sector's contribution. Lastly, the chapter addresses the significance of poultry products in ensuring food security and the need to minimize food loss and waste in the poultry industry.

2 Major Poultry Companies in Saudi Arabia

2.1 National Poultry Company (Al-Watania)

The National Poultry Company has become the biggest poultry facility in the Middle East and one of the largest in the poultry industry worldwide. The project is situated in Qassim city, located in the northern region of the Kingdom of Saudi Arabia. With over 5000 employees, Al-Watania Poultry holds a market share of over 40% in the Arab Gulf region, producing more than half a million chickens and one million eggs daily. Al-Watania Poultry takes pride in feeding their poultry a natural and nutritious diet while adhering to Islamic law for slaughter. The company produces around one million chickens and one and a half million eggs on a daily basis while also offering around 50 different chicken-based products. They have achieved recognition as the leading company in the Kingdom of Saudi Arabia for poultry, eggs, and related food products, and their items are present in every household in the country. This success is a result of their relentless pursuit and unwavering commitment to enhancing their products to the highest standards of quality, ensuring the provision of healthy and safe options (Al-Watania 2023).

Al-Watania's vision stated, "To support the food security and national economy through providing the Arab and international markets with the best poultry products that are slaughtered according to Islamic Sharia and by using modern systems that protect the environment and achieve the highest safety standards and sustainable development through employing and developing the human elements that are characterized by efficiency, commitment and effective participation in the constant development" (Al-Watania 2023).

2.2 Fakieh Farms Company for Poultry

Al-Fakieh Poultry Farms, which is owned by Saudi real estate is one of the largest poultry producers in Saudi Arabia. As a part of the Fakieh Group, Al-Fakieh Farms holds a 40% market share. The company's expansion plan is aimed at increasing the production of broilers to 1 million per day. This will be achieved by constructing additional hatcheries, breeding farms, grow-out houses, and a feed mill, which will also create approximately 6000 new jobs. Al-Fakieh Farms was the first Saudi poultry company to establish and operate its own fast-food chain, exclusively serving broiler meat produced on its farms. The first Taza Barbecue Chicken restaurant was opened in 1989. Since then, the chain has grown to have over 100 outlets across the Kingdom, with branches in Kuwait, Jordan, Qatar, Egypt, Oman, Yemen, and the United Arab Emirates.

Fakih Poultry Farms Company is a large integrated project in the Middle East and worldwide. It was established in the early 1960s and continues to thrive today. The domestic production of poultry has been steadily increasing and currently stands at

67%. The company's aim, as a poultry producer, is to become self-sufficient and reach 100% production according to the Saudi government's vision for 2030 (WATTPoultry 2023). The company revealed its plans for expansion as part of its future vision. The goal is to double production in the coming years. These expansions align with the wider plans for poultry production in the Kingdom of Saudi Arabia. As the largest country in the Arab Gulf region in terms of both area and population, Saudi Arabia plays a significant role in poultry farming in the Middle East. The Saudi government is actively seeking innovative solutions to address regional challenges in poultry production and meet the increasing demand. Currently, the Kingdom produces over 1.3 billion birds and 5.4 billion eggs each year. Fakih Poultry Farms Company owns 32 broiler mother farms in Tabuk, Turbah, and Hotat Bani Tamim. These farms consist of 249 barns and have an estimated production capacity of 233 million broiler hatching eggs. Additionally, the company has four hatcheries with a capacity to produce 180 million broiler mother chicks annually. Furthermore, Fakih owns 52 broiler farms in the Najran, Radwan, and Asir regions. These farms consist of 436 barns and have an estimated production capacity of 110 million birds per year. In addition to poultry, the company also produces table eggs. To ensure the quality and safety of their feed, Fakih operates feed laboratories. These labs monitor the feed from the arrival of raw materials at the factory to the final product. The feed is examined to ensure it meets standard specifications before being sent to the farms. The feed is tailored to the specific needs of each farm. Fakih Poultry Farms Company has also established major diagnostic laboratories in Taif Governorate. Equipped with the latest equipment and technologies, these labs are responsible for diagnosing poultry diseases, monitoring the health of the birds during breeding and production, and examining the feed and water consumed by the poultry (Riyadh 2023). Today, it holds a prominent position among the enormous projects in the Middle East, and is one of the most extensive poultry projects globally. It offers consumers healthy and fresh products at an affordable price.

2.3 Almarai Company (Alyoum Chickens)

Almarai, a significant poultry company in Saudi Arabia, acquired the Hadco company in 2009. In 2010, the company changed its name to "Chicken Today" (Alyoum Chickens) and specialized in the production of chickens and eggs. Almarai invested 5 billion riyals in the Hail region of northern Saudi Arabia, where one of the world's largest poultry projects operates. This project has the capacity to produce over 200 million chickens and 300 million eggs annually. The "today's" poultry project aims to increase its production capacity, expand its markets, and venture into new regions. According to Al Mheiri et al. (2020), Al Marai is a company based in Saudi Arabia that specializes in the food industry and has its headquarters in Riyadh. The company's primary focus has been on producing high-quality products that meet improved standards. Almarai aims to provide consumers with nutritious and high-quality food that positively impacts their lives. The company envisions becoming the

preferred choice for food and beverage products in the market. Over time, Almarai has improved its financial status and increased its market value, resulting in a significant increase in the number of shareholders, reaching a total of 50,000. Almarai relies heavily on its inventories to fulfill its current obligations. However, the company faces financial risks due to competition in the market, which can only be overcome by increasing its market share. Although Almarai's overall performance is satisfactory, improvements are necessary to effectively compete with its rivals.

2.4 The Arab Company for Poultry Breeders (Ommat)

Ommat specializes in breeding parent stocks. It began the production of flocks in 1990 as the sole distributor of laying chicks in Saudi Arabia, the Gulf States, and Yemen. Its initial project was established on a land area of 500,000 m^2. Ommat, which is the company's commercial name, is among the top companies in the Gulf region, Yemen, Egypt, and Sudan for the production and marketing of poultry products.

3 Impact of Poultry Production on Food Security Pillars in Saudi Arabia

3.1 Importance of Poultry Farms

Food security is an extremely complex topic that includes various fields like agriculture, economics, sociology, culture, engineering, entrepreneurship, environment, politics, human physiology, and more. As stated by the FAO (2009), food security occurs exclusively, "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". This definition decomposed food security into four pillars, which are food availability, accessibility, utilization, and stability.

According to Mottet and Tempio's (2017) study on global poultry production, the poultry industry is an important contributor to food security and nutrition. It provides humans with energy, protein, and essential micro-nutrients. Poultry has the advantage of having short production cycles and the ability to convert various agri-food by-products and wastes into meat and eggs that can be consumed by humans. It is also the fastest-growing agricultural sub-sector, particularly in developing countries. The demand for meat and eggs worldwide is increasing due to population growth, rising incomes, and urbanization, which is leading to the continuous expansion of the poultry industry. However, the industry is currently facing unprecedented challenges, especially for small-scale farmers and those who are economically disadvantaged, both in rural and urban areas. Poultry plays a crucial role in reducing poverty by providing income opportunities and market participation. During times of crisis,

selling birds can act as a form of household insurance. Unfortunately, the growth of the market mainly benefits large-scale operations, putting small-scale farmers at a disadvantage in accessing the market. Additionally, poultry can pose a threat to human health by carrying infectious diseases and contributing to antimicrobial resistance. Furthermore, the poultry industry has a significant environmental impact and consumes substantial natural resources. Although it efficiently converts natural resources into food, it requires large amounts of land, water, and nutrients for feed production. This contributes to climate change and leads to air and water pollution.

In the future, policymakers in the Middle East, including Saudi Arabia, will place increasing importance on food security. Fiaz et al. (2018) discussed the crucial role of extension agents in promoting innovative technologies and raising awareness among the farming community to meet the country's dietary needs. Alamri and Al-Duwais (2019) conducted a study on some key components of food security in Saudi Arabia, such as wheat, barley, and poultry, as well as forecasted demand from 2017 to 2025. The study focused on the demand for these strategic commodities in KSA, with results showing a positive impact on wheat and poultry, which play a vital role in ensuring food security.

In the Kingdom of Saudi Arabia, several charitable assistance programs were established to support the growing number of low-income communities caused by the rising cost of living (Saudi Food Bank 2020). A recent study was conducted to evaluate the state of food security in the western province of the Kingdom, with a focus on low-income women. The findings of Hanbazaza and Mumena (2022) revealed that half of the low-income women lacked food security, forcing them to find other means to address the food shortage. This challenge can have adverse effects on their mental and overall health, as well as their overall life satisfaction in comparison to the group that has access to enough food.

The government is motivated to prioritize poultry production for food security based on three criteria. Firstly, poultry production consumes less water compared to red meat production (Daghir et al. 2018). Secondly, due to its qualities, investments in the poultry industry provide animal protein in a timely manner and enhance food security in the short term. Poultry production exhibits higher food transformation efficiency and fattening rate compared to other animal sources. Thirdly, chicken production is relatively cost-effective, involves fast capital turnover, and requires minimal space (Agricultural Development Fund 2019).

With regard to food security, poultry production enhances food security by providing a crucial source of protein in the form of meat and eggs. Meat and eggs are two essential components of a healthy diet and are often in high demand, especially in developing countries where people may not have access to other protein sources like red meat (Alraedah 2023). Additionally, poultry farming helps to create jobs along the poultry supply chain, from production to consumption. The creation of jobs assists those involved in the sector by providing a better income and therefore better access to food. It also promotes the consumption of poultry products in rural areas. Hence, poultry is closely linked to the accessibility and availability of food. Effective management and good practices in poultry farming result in the production of high-quality poultry products and reduce poultry loss and waste. These reductions

not only contribute to sustainability but also decrease the environmental impact of the poultry sector. Furthermore, it is worth noting that poultry can be raised in diverse climatic conditions, providing a source of food and income for people residing in these areas. Compared to other livestock projects, the cost of poultry farming is relatively small. Moreover, poultry farming can help improve food security by enhancing access to food in rural areas. Poultry products, which are rich in protein and contain significant amounts of minerals and vitamins, play a crucial role in providing healthy food and are directly linked to the utilization aspect of food security. Poultry farms not only provide income at the individual or household level but also at the country level when poultry is exported to other countries, generating foreign currency or meeting local demand for poultry products and saving hard currency that would otherwise be spent on importing poultry products. Furthermore, poultry farming can be considered an anti-risk measure as it contributes to the diversification of agricultural production, which correlates with the stability pillar of food security. In conclusion, poultry production, whether as a backyard operation or on small or large farms, traditional or improved, has a direct connection to the pillars of food security.

3.2 The Importance of Chicken Meat for Human Health

Chicken meat is rich in desirable monounsaturated fats compared to the amount of less healthy saturated fats found in most cuts of red meat. Poultry meat is free from trans fats, which are known to cause coronary heart disease and are abundant in beef and lamb. A 2006 study conducted by the World Cancer Research Fund and Bingham found that consuming excessive amounts (over 500 g/week) of red meat, particularly processed meat, can be unhealthy. However, this study did not include chicken meat as a potentially harmful food.

Poultry meat is recognized for its low energy concentration and high nutrient density. It is an excellent source of high-quality protein, providing 20–22%. Additionally, it has lower amounts of iron and zinc compared to red meats. Poultry meat is also abundant in B vitamins including thiamin, riboflavin, niacin, and vitamin B6, while containing less vitamin B12 compared to other meats. Moreover, it has relatively lower amounts of vitamin E, pantothenic acid, folic acid, and biotin. Recent studies have shown that apart from vitamin D, the meat also contains 25-hydroxycholecalciferol metabolite, which is five times more active than calciferol (Ovesen et al. 2003; Barroeta 2007).

Poultry products help improve nutrition. The products of poultry projects in Saudi Arabia, such as eggs and chicken, are rich in nutrients like protein, iron, and vitamin B. This makes them an important component in achieving a balanced diet. Eggs are also a good source of choline, which is essential for brain function (Alraedah 2023). The nutritional value of poultry products for human health will be explained and thoroughly discussed in the subsequent sections below.

3.2.1 Source of the Protein

According to Kralik et al. (2017), chicken meat contains a high amount of amino acids which are essential for the development of human muscle protein. It is regarded as an easily accessible source of protein that is of high quality and also provides other important nutrients. To satisfy the increasing demand for high-quality protein from consumers, the poultry industry focuses on choosing fast-growing broilers that can attain a body mass of approximately 2.5 kg within six weeks of intensive feeding. Additionally, the composition of chicken meat can be altered by adjusting the chicken's diet, resulting in meat that is enriched with functional substances like n-3 PUFA, carnosine, selenium, and vitamin E. This makes chicken meat a valuable food item that not only possesses a high nutritional value but also contains beneficial components for human health (Kralik et al. 2017).

The fat content of cooked chicken varies depending on whether it is cooked with or without the skin, the portion of the bird, and the bird's diet and breed. Breast meat contains less than 3 g of fat per 100 g. On average, dark meat without the skin contains 5–7 g of fat per 100 g. Approximately half of the fat in chicken meat consists of desirable monounsaturated fats, while only one-third is less healthy saturated fats. In comparison, most cuts of red meat have higher proportions of saturated fats and vary in total fat content. Therefore, chicken meat is considered a healthy meat option. Unlike beef and lamb, chicken meat does not contain trans fats which contribute to coronary heart disease. In Canada, beef has been reported to have values of 2–5%, while lamb can have as high as 8% trans fats. The World Cancer Research Fund, along with other sources like Bingham (2006), has suggested that consuming large amounts (more than 500 g per week) of red meat, particularly processed meat, maybe unhealthy (FAO 2013).

3.2.2 Source of Vitamins and Minerals

Chicken is an important source of certain vitamins, such as vitamin D, that help in the absorption of calcium, ultimately leading to stronger bones. Additionally, vitamin A plays a role in improving eyesight, while B vitamins are necessary for generating energy and forming healthy red blood cells. Chicken also contains sodium and potassium, which contribute to balancing body fluids. Its phosphorus content helps regulate brain functions, maintain healthy bones and teeth, and enhance metabolism (Ahmad et al. 2018; Warren and Livingston 2021).

3.3 The Importance of Chicken Egg for Human Health

An egg is a food with low energy content that is economically beneficial and contains high-quality protein, as well as various important nutrients including folic acid, choline, iron, selenium, and vitamins A, B, D, E, and K. Eggs are also a rich source

Table 1 Types and functions of egg white proteins

Name	Action
Ovalbumin	The most significant proteins serve as a benchmark for comparison in biochemistry
Ovokinin	It has recently been discovered that it can dilate blood vessels, making it a potential treatment option for high blood pressure
Ovotransferrin	It has recently been discovered that it can dilate blood vessels, making it a potential treatment option for high blood pressure
Lysozyme	It is employed as an antimicrobial agent in various food items
Ovomucin	Prevent blood clotting caused by bacteria's β-subunit. It is toxic to cultured cancer cells that are glycosylated
Ovoinhibitor	Antitrypsin inhibits the activity of proteolytic enzymes in bacteria and mold
Cystatin	Medical applications include antimicrobial, antiviral, and insecticidal effects. They also include preventing cerebral hemorrhages and controlling the spread of cancer cells, though these applications are expensive
Avidin	It (referring to a specific protein) binds to biotin and has been widely used in molecular biology, biochemistry, and in ELISA assays

Source Abeyrathne et al. (2013, 2014)

of carotenoids, lutein, and zeaxanthin. They are a significant source of protein, with approximately 6–7 g of protein in one egg. The protein found in egg white is a standard for comparing with other food proteins (Réhault-Godbert et al. 2019). Egg white comprises important proteins such as ovalbumin (54%), ovotransferrin (12%), ovomucoid (11%), ovomucin (3.5%), and lysozyme (3.5%). These proteins are crucial and have importance in industrial applications if separated (Abeyrathne et al. 2013).

3.3.1 Types and Functions of Egg White Proteins

Abeyrathne et al. (2013, 2014) declared that egg white contains several functional proteins, as shown in Table 1.

3.3.2 Carbohydrates

The egg yolk comprises 1% carbohydrates. of that amount, 70% is composed of oligosaccharides, specifically mannose and glucosamine, which are bound to protein. The remaining 30% is in the form of free glucose carbohydrates. Yolk carbohydrates, such as Sialyloligosaccharides and Sialic acid (gangliosides), are crucial for the rapid growth of an infant's brain as they modify neural cell adhesion molecules (NCAM) (Wang 2009).

3.3.3 Egg Pigments

The egg yolk has the highest concentration of pigments, making up 0.02% of its dry weight. Chickens cannot produce carotenoids, which are responsible for the yolk's color, and therefore, they must obtain them from their diet. Yolk carotenoids can be divided into two groups: xanthophylls, which have a hydroxyl group in their molecules, and carotenoids that do not have this group (Kljak et al. 2021).

In study conducted by Dalle Zotte et al. (2021), the effects of various farming methods (cage, barn, organic) on egg quality traits were examined for marketing purposes. The results indicated that the physical characteristics and color of the eggs differed depending on the method employed, with organic eggs being the most notable. Specifically, organic eggs exhibited a distinct yolk color and nutritional composition.

3.3.4 Egg Fats

The yolk of an egg is mixed with bile salts to assist in the process of digestion, including for infants. The ratio of unsaturated fats to saturated fats is 1:2, which is highly beneficial. The primary unsaturated fat, known as oleic acid, does not have any negative impact on blood cholesterol levels. Poultry meat serves as a significant source of crucial polyunsaturated fatty acids (known as PUFAs), particularly omega-3 fatty acids. In comparison to other types of animal meats, chicken meat contains a higher quantity of important fatty acids. To fulfill the recommended daily intake (RDI) of niacin, adults can consume 100 g of chicken meat per day, while infants can do so with 50 g. By incorporating flaxseed, which is a supplement rich in n-3 PUFAs, into chicken, the amount of n-3 PUFAs in thigh meat can be increased from 86 to 283 mg/100 g, and in minced carcass from 93 to 400 mg/100 g (Bingham 2006; Barroug et al. 2021).

3.4 The Designer Eggs

Designer eggs are eggs that have been modified from the standard egg by the addition of vitamins, minerals, and omega fatty acids. This discovery was initially made by Miles in 1998. Omega-3 fatty acids, which are a type of polyunsaturated fatty acid, contain a double bond that is three atoms away from the terminal methyl group in their chemical structure (Sireesha and Prasanna 2019). Consuming omega-3 polyunsaturated fatty acids (PUFAs) can provide several health benefits. These benefits include reducing plasma triglycerides, blood pressure, platelet aggregation, thrombosis, and atherosclerosis. These findings were initially reported by an anonymous source in 2002. Brown-seeded flax (*Linum usitatissimum* L.) is an outstanding source of omega-3 unsaturated fatty acids, especially suitable for poultry feed (Cassiopaea

Forum 2009). Common varieties of flaxseed have high concentrations of polyunsaturated fatty acids, particularly alpha-linolenic acid. In 2010, Najib and Al-Yousef conducted an experiment to examine the effects of different levels of flax seeds on laying performance and fatty acid content in egg yolks. They fed 200 pullets, placing 5 birds per cage, with 0, 5, 10, 15, or 20% weight of flax seeds—either roasted or unroasted. Each treatment was repeated 5 times. The results demonstrated that feeding 10% roasted flax seeds led to higher levels of docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA), and alpha-linolenic acid (C18:3n3) in egg yolks. In contrast, feeding 5% or 15% unroasted flax seeds resulted in the highest levels of linoleic acid (C18:2n6) in the eggs. Including 15% unroasted flax seeds led to a relatively lower egg production rate but promoted an excellent omega-3 fatty acid profile in the eggs. In conclusion, adding 10% flaxseed to the feed is highly beneficial for egg production, while incorporating 15% unroasted flax seeds may be more advantageous for the omega-3 fatty acid content in the eggs (Najib and Al-Yousef 2010).

3.5 Healthy Eggs

In recent years, there has been a significant interest in consuming chicken eggs to obtain essential nutrients (Miles 1998). This is especially important for improving the nutrition of individuals with low income in developing countries since eggs are relatively inexpensive (FAO 2013). The process involves increasing the levels of certain nutrients, like folic acid, B12, and vitamin E, in the diets of hens. These nutrients are then passed on to the eggs. Two trace minerals that can also be increased in eggs are iodine and selenium. Iodine is necessary for the production of two hormones (T4 and T3) in the thyroid gland, while selenium is a powerful antioxidant that has recently gained attention (Surai and Dvorska 2001). Despite the controversy surrounding the belief that chicken eggs are unhealthy for humans due to their high cholesterol content (187 g) and saturated fat content (1.6 g), eggs actually contain significant amounts of important nutrients. These include folate, riboflavin, selenium, choline, vitamin B12, fat-soluble vitamins A, K, E, and D, as well as lecithin. Furthermore, eggs are an excellent source of high-quality protein (6 g) and pigments such as Lutein and Zeaxanthin, which are antioxidants that protect eye health. Additionally, eggs are the primary source of choline, which, along with Lutein, plays a crucial role in the development of the brain and nervous system in fetuses and newborns. Eggs also contain natural vitamin D, an important nutrient for bone health and immune support. Finally, it's important to note that hens provide all the necessary nutritional components for the embryo to develop into a mature chick. Based on this information, it is clear that consuming eggs is particularly important for children and healthy adults. Recently, the Supreme Advisory Committee for Nutrition in the United States of America retracted its previous warning that foods containing cholesterol posed a threat to society (Farrell 2013).

4 Food Loss and Waste of Poultry Products in Saudi Arabia

One-third of food produced each year, which is suitable for consumption, is lost or wasted annually. In order to decrease food loss and waste, the Food and Agriculture Organization (FAO), along with other organizations, agencies, and associations, has been making significant efforts. They aim to raise awareness through educational campaigns and implement laws that will help reduce food loss and waste. Additionally, the formation of numerous food banks or charities has taken place, which are dedicated to reusing surplus food and distributing it to those in need. This initiative aims to prevent food loss and waste and preserve the environment. The FAO has also reported that the production costs of waste reach USD 750 billion annually. Food waste contributes to the problems of famine and food insecurity, which affected between 720 and 811 million people worldwide in 2020, an increase of 118 million compared to 2019 (FAO et al. 2021).

Saudi Arabia is considered one of the worst countries in the world when it comes to food waste. On average, each person in the Kingdom wastes between 200 and 500 kg of food, which amounts to roughly one-third of all the food that is wasted. This has significant economic implications and poses a threat to global food security. To address this issue, one of the main objectives of the Saudi Vision 2030 is to implement strategies for food security. In a recent study conducted by Alshabanat et al. (2021), different models were used to estimate the level of food loss and waste in Saudi Arabia. The findings revealed that food loss and waste (FLW) accounted for 33.1% overall, with food loss making up 14.2% and food waste making up 18.9%. Furthermore, their analysis projected that food loss and waste would decrease by 50% between 2020 and 2030.

Saudi Arabia is considered one of the worst countries in the world when it comes to food waste. On average, each person in the Kingdom wastes between 200 and 250 kg of food, which amounts to roughly one-third of all the food that is wasted. This has significant economic implications and poses a threat to global food security. To address this issue, one of the main objectives of the Saudi Vision 2030 is to implement strategies for food security. In a recent study conducted by Alshabanat et al. (2021), different models were used to estimate the level of food loss and waste in Saudi Arabia. The findings revealed that food loss and waste (FLW) accounted for 33.1% overall, with food loss making up 14.2% and food waste making up 18.9%. Furthermore, their analysis projected that food loss and waste would decrease by 50% between 2020 and 2030.

One-third of food produced annually, which is suitable for consumption, is lost or wasted each year. In order to reduce this issue, FAO, various organizations, agencies, and associations have been making increased efforts. This includes raising awareness through educational campaigns and implementing laws to decrease food loss and waste. Additionally, the formation of food banks and charities has helped in reusing surplus food and distributing it to those in need, thereby preventing food loss and waste and protecting the environment. In terms of poultry, the amount of loss and waste accounts for 29% of the available poultry for consumption.

Based on the Saudi Arabia Baseline for food loss and waste, the findings show that in poultry production, approximately one-third (29%) is lost or wasted. This can be further broken down into 13% food loss and 16% food waste. The overall loss and waste of poultry totals to 444 thousand metric tons, equivalent to a value of 2799 million SAR. When examining the poultry supply chain, roughly half of the total loss and waste occurs during the consumption stage (46%). This is followed by a 26% loss during distribution, 14% during handling and storage, 9.5% during production, and 4.5% during packing. These figures were obtained from the Baseline Study.

Results from the field survey indicate that health factors, such as the spread of viruses and bird diseases, as well as noncompliance with required product specifications, are the main causes of loss in the poultry sector. Inefficient workforce practices and failure to adhere to appropriate cooling conditions also result in the disposal of significant quantities of poultry meat (SAGO 2019a, b).

5 Production of Major and Medium Poultry Projects in Saudi Arabia

In Saudi Arabia it is expected that the production of chicken meat raised locally will reach 950,000 tons in the year 2022. This rise can be attributed to the expansion project of the National Poultry Farm (Al-Watania) in Al-Qassim, which is estimated to be finished by 2022. This expansion will introduce an additional 850,000 to one million chickens into the market. The Al-Youm Chicken Company, a division of the Almarai Group, has recently disclosed a noteworthy expansion plan totaling $1.8 million.

It has been observed that most of the increase in production is because of large companies operating in the country. However, medium-sized companies like The Agricultural Development Company, Intaj, and Aseer, as well as small companies like Radwa and Golden Chicken, have also contributed to this increase. It is important to note that the main source of poultry meat production in the country is broiler chicken. Quail represents a small percentage of 1500 tons a year from Astra farms in Tabuk, located in the northern region of the country. The expansion in production is believed to be a result of government support and decreased mortality rates. The decrease in mortality rates among poultry has had a significant impact on the increase in production. Poultry companies, especially larger ones, have strictly followed biosecurity measures to reduce the risk of disease. As a result, the average mortality rate has decreased from 25% to less than 6% in recent years. Some projects that implement these measures well have demonstrated a mortality rate of 2.5% or less. This has helped increase production while significantly reducing overall costs.

According to Mousa (2020) currently, chicken meat production in Saudi Arabia is mostly controlled by about ten vertically integrated companies. Three major companies, namely Al Watania, Fakieh, and Alyoum, along with seven medium-to-small-sized farms, have control over up to 95% of the production. Poultry farms can be found in twelve different provinces in Saudi Arabia, but only six provinces contribute to 88% of chicken meat production. In the year 2020, the Al-Qassim province, where Al Watania Poultry Farm is located, accounted for approximately one-third of the total chicken meat production in Saudi Arabia. Makkah and Riyadh each contributed 15%, followed by Aseer and Hail, which contributed 13% each. Over time, there has been an increase in the percentage of chicken meat produced in the Hail province due to the expansion of Almarai's Alyoum Poultry Farm.

6 Efforts to Improve Poultry Sector in Saudi Arabia

The Ministry of Environment, Water, and Agriculture has reported good news regarding poultry production in the Kingdom of Saudi Arabia. In 2021, the production of poultry amounted to 910,000 tons, and it is expected to increase significantly in the coming years due to the expansion of the National Company's chicken projects in Qassim. This company is the largest poultry producer in the Kingdom and one of the largest in the world. A major factor contributing to the increase in production is the significant decrease in broiler chicken mortality from 25% ten years ago to less than 6% today. In 2020, the domestic production of Saudi Arabia reached 60% of self-sufficiency, and plans are underway to increase this level to more than 85% by 2030 in collaboration with the private sector. The Saudi government aims to facilitate producers' access to land for broiler chicken farms, provide loans to purchase equipment, and improve the feed support system to achieve this goal. Furthermore, the import of chicken meat to Saudi Arabia decreased from 617,930 tons in 2020 to 520,000 tons in 2021, a decrease of 16%. The Saudi Food and Drug Authority prevented imports from 11 major poultry export companies in Brazil, leading to this decrease. However, it is expected that the percentage of imports will increase by 4% in 2022 to reach 540,000 tons, as the largest Brazilian company in the field of broiler chicken production has gathered large resources to increase its exports to the Kingdom.

According to the Ministry of Environment, Water and Agriculture (MEWA) (2022) the government of the Kingdom of Saudi Arabia, specifically MEZWA and the Agricultural Development Fund (ADF) provides unmatched financial support for the development and expansion of the poultry sector. They offer financing for up to 70% of the capital required for modern technology projects in the poultry sector, as well as granting government lands for these projects. The goal of these initiatives is to increase the self-sufficiency rate of poultry meat to over 65% in the near future. The poultry sector has received more than 665 million riyals of support through agricultural subsidies, according to the last official announcement by the Ministry in January 2021. These subsidies aim to strengthen the food security system and

encourage new investments in the Saudi poultry industry. The MEWA is targeting an annual production of 1.3 million tons of broiler chickens to ensure national food security, increase local content, and generate employment opportunities. Saudi Minister of Environment, Water and Agriculture, stated that this effort follows a significant increase in self-sufficiency in poultry meat from 45% in 2016 to 68% in 2022. The MEWA has established six goals for the poultry sector, including increasing the number of licenses and expanding investment operations to meet growing demand and achieve self-sufficiency. These goals also involve boosting the macro economy and attracting new investors, creating job opportunities for local individuals, empowering women in support services within the sector, and achieving rural development (MEWA 2022).

The Ministry of Environment, Water, and Agriculture (MEWA 2022) has announced a plan to expand the broiler chicken sector and support services in collaboration with relevant authorities. The objective is to increase the self-sufficiency rate of poultry meat to 80% by 2025, which is the first step in achieving food security. This plan will attract new investments worth SAR 17 billion ($4.5 billion) to the poultry production sector in the Kingdom, resulting in a target production capacity of approximately 1.3 million tons of broiler chicken per year. The plan aims to achieve food security and create job opportunities. MEWA has confirmed that over SAR 56 million will be provided in the eighth support cycle for the poultry sector as part of the agricultural subsidy program, which aims to assist this vital sector. The program has totaled more than SAR 430 million and is one of the wise leadership's initiatives to maintain local food security, with the poultry sector being one of its critical contributors. The poultry sector includes broiler chicken products, table eggs, broiler chicks, parent stocks, and laying hens. The support program aims to enhance food security in the Kingdom by supporting local product to meet the increasing demand. It is important to note that the self-sufficiency percentage in poultry meat has risen from 45% in 2016 to 68% in 2022 (Bulletins 2019; Mousa 2020; MEWA 2022).

According to the USDA Foreign Agricultural Service (2021) and Mousa (2020) Chicken meat production is expected to continue to increase as the Kingdom aims to achieve 80% self-sufficiency by 2025. Currently, the percentage is already over 60%. Saudi chicken meat production in 2020 is estimated to be 930,000 mt and is projected to rise to 950,000 mt in 2021. It is anticipated that Saudi chicken meat imports will reach 550,000 mt in 2020 and are expected to reach 625,000 mt in 2021. Brazil is the main supplier of poultry imports to Saudi Arabia, and Saudi Arabia is the second-largest export market for Brazilian chicken meat. The Saudi ban on electric immobilization continues to prevent the United States from exporting chicken meat to Saudi Arabia.

The Agricultural Development Fund is a credit institution run by the government that specializes in financing various agricultural activities across all regions of the Kingdom. Its purpose is to support and improve the agricultural sector by utilizing modern scientific and technical methods to increase productivity. The fund provides credit services to help achieve the strategic agricultural and water goals

of the Kingdom. It has recently launched a new strategy that aligns with the policies of the Ministry of Environment, Water, and Agriculture to contribute to the implementation of the Agricultural Strategy (Fiaz et al. 2018).

7 Conclusion and Prospects

The poultry industry is considered one of the important industries that Saudi Arabia has paid great attention to. This is because it plays a significant role in achieving food security for Saudi society and directly impacts the lives and health of citizens. The poultry sector contributes to providing food that is rich in protein and also serves as a source of income for various segments involved in the supply chain of poultry products. This includes production, processing, cold storage, handling, transportation, and consumption, as well as supporting sectors involved in poultry production, such as feed manufacturing, veterinary medicines, and the manufacturing of poultry farms. The Ministry of Environment, Water and Agriculture, in collaboration with the Agricultural Development Fund and large companies specialized in poultry products, has developed multiple expansion plans to increase the production of poultry meat and eggs. This is done in order to achieve target self-sufficiency by 2030 and to meet the Saudi demand for these products. In order to succeed in this sector and achieve the objectives of the agricultural strategy and the Saudi food security strategy, it is necessary to have the combined efforts of the private sector, large poultry product companies, and owners of medium and small farms to attain these targeted levels of self-sufficiency for the Kingdom in poultry products.

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