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Research Article

Estimating the Quantity and Value of Water Needed to Achieve Self-Sufficiency and Food Security for Table Eggs in the Kingdom of Saudi Arabia

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Abstract

This research aimed to estimate the quantity and value of water needed to achieve selfsufficiency and food security for eggs during the period 1990-2021. In achieving its objectives, this study relied on secondary data and economic and statistical equations. This current paper resulted in a set of results, the most important of which are, the strategic stock of eggs reached about 114.39 thousand tons, sufficient for local consumption for 130.2 days, and then the food security factor for eggs is estimated at 0.357 at the end of the period 1990-2021. The total amount of water used to meet the local consumption needs for eggs amounted to 20.16 billion m3, with a value of 9.72 billion Riyals. The total amount of water used to achieve the current level of food security for eggs amounted to 402.5 million m3, with a value of 194.02 million Riyals during the period 1990-2021. Finally, this study recommends the need to maintain the percentage of self-sufficiency and the current level of food security for eggs until 2030, in line with the Saudi National Strategy for Agriculture for 2030, through the issuance of the necessary licenses by the Ministry of Environment, Water and Agriculture to establish new projects or expand the production capacity of existing projects, in addition to the Agricultural Development Fund providing the necessary financing needs for the establishment of these projects.

Keywords: Water; Self-Sufficiency; Food Security; Table Eggs; Saudi Arabia

Introduction

Eggs are one of the main sources of animal protein, as they contain many vitamins and minerals that are essential parts of any healthy diet. Eggs are used in many food and chemical industries, where they are used in the preparation of serums and the medical and food industries. Egg whites are used in the manufacture of medicines, glue, paint, textile dyeing, and leather tanning. Egg yolks are used in the manufacture of paints, hair paints, shampoos, and soaps, and the shell is used in the manufacture of fertilizers and the preparation of mixtures of mineral salts [3].

The government paid attention to food security projects, including laying hens projects, where the Agricultural Development Fund provided 286 loans, worth 930.86 million riyals, representing 8.57% of the total value of loans provided for food security projects amounting to 10867.94 million riyals since the establishment of the fund until the end of 2021 (Agricultural Development Fund, 2021). The Ministry of Environment, Water and Agriculture is issuing a statistical book, which includes the demand for water resources for agricultural, industrial and domestic purposes. The amount of water used for agricultural purposes increased from 11.27 billion m^3 in 1990 to 20.83 billion m^3 in 2015, then decreased to 8.5 billion m^3 in 2020 [6]. Since no government entity has published data on water consumption in the livestock and poultry production sector, this study was interested in answering the following question: What is the quantity and value of water used to meet both local consumption needs and egg food security during the period 1990-2021?

In egg production and water consumption, [15] evaluated the production efficiency of laying hens fed on diets containing four sources of protein (soybean gain, sunflower seed gain, watercress seed meal, and a mixture of these gains) before and after the addition of a biostimulant (Nutribioplus 0.5 g/kg) or an enzymatic preparation (Natozyme 0.5 g/kg). This study showed that sunflower seed meal and watercress seed gain can be used as safe feed ingredients for laying hens at levels ranging from 14%-15% or mixed in a 1:1 ratio if or without feed additives. Taking into account the economic aspect, the priority in choosing vegetable protein sources that replace part of the diet protein is the combination of sunflower

seed gain + watercress seed gain, followed by sunflower seed gain, and watercress seed gain.

A study [1] showed that the addition of sodium hypochlorite at a rate of (300 ppm) to the drinking water of laying hens, leads to a reduction in the consumption of both feed and water for laying hens at the age of (23-32) weeks. There is also an improvement in the efficiency of food conversion. A study [5] showed that birds' water consumption is affected by several factors, the most important of which are water quality, type of feed, temperature and humidity inside the house. It was also found that increasing the temperature inside the house by one degree Celsius above 23 degrees Celsius, leads to water consumption by 6%. Finally, a study [10] examined the effect of gum Arabic on the productive performance and quality of eggs and some blood components of domestic laying hens under hot weather conditions. This study showed that the addition of high level gum Arabic (1.5%) led to the improvement of most of the productive qualities, shell weight, thickness and some blood components of local laying hens (Maamoura breed) during the summer season in Egypt.

Research Objectives

This research aimed to estimate the quantity and value of water needed to achieve self-sufficiency and food security for eggs in the Kingdom of Saudi Arabia during 1990-2021 by studying the following objectives

- Geographical distribution pattern of projects specialized in egg production in 2021.
- Evolution of egg food security indicators in the Kingdom of Saudi Arabia.
- Estimate the quantity and value of water used to achieve self-sufficiency and food security for eggs.

Research Methodology

This study relied on secondary data published in: (1) the statistical book issued by the Ministry of Environment, Water and Agriculture, (2) the website of the Food and Agriculture Organization (FAOSTAT), and (3) the annual reports issued by the Agricultural Development Fund. In achieving its objectives, this study relied on the following economic and statistical equations

- Gini-Hirschman's Coefficient in measuring the geographic concentration coefficient of egg projects and production. It was calculated by using the following equation Hirschman, 1964; [11]

$$G_i = \sqrt{\sum_{i=1}^{n} (\frac{X_i}{X})^2} \times 100$$

Where: G_i represents the geographical concentration coefficient, X_i represents the number and production of specialized projects in a region, and X represents the total number of projects and their production of eggs in the Kingdom of Saudi Arabia. The coefficient of geographical concentration is considered high if it exceeds 40.

- Indicators measuring the egg's percentages of self-sufficiency and food security are as follows (Ghanem, 1997):

$$SSR_{eg} = (DP_{eg} \div DC_{eg}) \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$PAPDC_{eg} = DP_{eg} \div DDC_{eg} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$PCIDC_{eg} = QIm_{eg} \div DDC_{eg} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$QSD_{eg} = [(SLAC_{pieg} - 365) \times DDC_{eg}] - QEX_{eg} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$CFS_{eg} = QSS_{eg} \div DC_{eg} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:

$\boldsymbol{SSR_{eg}}$: Self-Sufficiency Ratio.

$\boldsymbol{DP_{eg}}$: Domestic egg Production.

$\boldsymbol{DC_{eg}}$: Domestic Consumption of eggs.

$\boldsymbol{PAPDC_{eg}}$: Production Adequacy Period for Domestic Consumption of eggs.

$\boldsymbol{DDC_{eg}}$: Daily Domestic Consumption of eggs.

$\boldsymbol{PCIDC_{eg}}$: Period of Coverage Imports for Domestic Consumption of eggs.

$\boldsymbol{QIm_{eg}}$: Quantity Imported of eggs.

$\boldsymbol{QSD_{eg}}$: Quantity of Surplus and Deficit in eggs.

$\boldsymbol{SLAC_{pieg}}$: Sum of the length of production adequacy period and import coverage period for domestic consumption of eggs.

$\boldsymbol{QEX_{eg}}$: Quantity of eggs Exported.

$\boldsymbol{CFS_{eg}}$: Coefficient for Food Security of eggs.

$\boldsymbol{QSS_{eg}}$: Quantity of Strategic Stock.

The food security coefficient value ranges from zero to one. In the case of food insecurity, the food security coefficient value is zero. In the case of complete food security, the value of food security coefficient is one [7].

- Binomial distribution in estimating the contribution to egg food security at 95% confidence, using standard errors and confidence intervals as follows:
  - Standard probability error at 95% = $\pm 1.96 * \sqrt{\frac{P(1-P)}{N}}$
  - 95% confidence interval for probability = $P \pm 1.96 * \sqrt{\frac{P(1-P)}{N}}$

Whereas: P represents the probability of contributing to food security, $(1-P)$ represents the probability of not contributing, and N represents the length of the time series [16].

(d) Equations used to estimate the quantity and value of water used to achieve self-sufficiency and food security for eggs (Al-Nafissa., *et al.* 2021):

$$QWUASS_{eg} = (DP_{eg} \times AWN_{teg}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

$$QWUAFS_{eg} = QSS_{eg} \times AWN_{teg} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

$$VQWUSSF_{eg} = QWUSSF_{eg} \times DACEU_{gw} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Where:

$QWUASS_{eg}$: Quantity of Water Used to Achieve egg Self-Sufficiency.

DP_{eg}: Domestic egg production.

AWN_{teg}: Average water requirement or Water footprint to produce one ton of egg.

$QWUAFS_{eg}$: Quantity of Water Used to Achieve egg Food Security.

QSS_{eg}: Quantity of Strategic Stock of eggs (surplus and deficit).

$VQWUSSF_{eg}$: Value of Quantity of Water Used in achieving Self-Sufficiency and Food security for eggs.

$QWUSSF_{eg}$: Quantity of Water used to achieve Self-Sufficiency and Food security for eggs.

$DACEU_{gw}$: Average Cost of Extracting the Unit of water from groundwater.

Research Results

First: The geographical distribution pattern of projects specialized in egg production

By studying the geographical distribution of egg production projects in the Kingdom of Saudi Arabia in 2021, it is clear from the data contained in table (1) and figure (1) that the specialized projects for egg production are distributed over nine regions in the Kingdom of Saudi Arabia, while there are no specialized projects for egg production in four regions: Al-Jowf, Jazan, Northern Borders and Al-Bahah. Specialized projects for egg production are concentrated in the Riyadh Province, where there are 40 projects, representing 44.94% of the total number of projects amounting to 89 projects in 2021. Projects operating in the Riyadh Province also contribute about 40.57% of the total egg production of 359.20 thousand tons in 2021. The Eastern Province ranks second in the number of projects, followed by Al-Qassim, Mecca and Aseer. By calculating the geographical concentration factor for the number of projects and egg production, it is clear that the value of the coefficient reached 50.3% and 47.5% respectively, which indicates that there is a geographical concentration of projects and egg production in several areas that make them monopolistic power in egg production and marketing.

Province	Number of Projects	%	Table egg production thousand tons	%
Riyadh	40	44.94	145.72	40.57
Eastern Province	11	12.36	41.54	11.56
Al-Qassim	9	10.11	43.00	11.97
Mecca	9	10.11	44.13	12.29
Aseer	9	10.11	42.76	11.90
Hail	5	5.62	16.82	4.68
Medina	3	3.37	14.01	3.90
Tabuk	2	2.25	9.42	2.62
Najran	1	1.12	1.79	0.50
Total	89	100.00	359.20	100.00
Geographic concentration coefficient	50.3%	-	47.5%	-

Table 1: Geographical distribution of specialized egg production projects in 2021.

Source: Ministry of Environment, Water and Agriculture (2021) Statistical book.

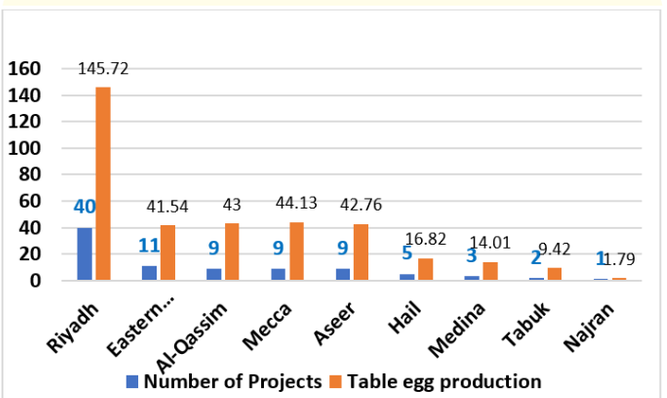

Figure 1: Number of specialized projects and their production of eggs per thousand tons in 2021.

Source: Data from Table 1.

Second: Evolution of Egg Food Security Indicators during the Period 1990-2021

By studying the evolution of egg food security indicators in the Kingdom of Saudi Arabia during the period 1990-2021, it is clear from the data contained in tables (2 and 3) the following

- Domestic egg production increased from 113 thousand tons in 1990 to 359.2 thousand tons in 2021, this means domestic egg production increased at an annual growth rate of 3.9% during the period 1990-2021. Domestic consumption of eggs

Year	Domestic production in thousand tons	Imports in thousand tons	Exports in thousand tons	Domestic consumption in thousand tons	Self-sufficiency %
1990	113	2.50	10.75	104.75	107.9
1991	113	3.62	12.64	103.98	108.7
1992	120	4.28	12.85	111.43	107.7
1993	123	3.74	11.48	115.26	106.7
1994	127	3.03	8.75	121.27	104.7
1995	132	2.45	12.17	122.28	107.9
1996	125	3.70	14.55	114.15	109.5
1997	131	3.20	13.23	120.97	108.3
1998	136	3.48	13.48	126.00	107.9
1999	136	3.90	10.27	129.63	104.9
2000	129	4.56	7.67	125.90	102.5
2001	138	4.60	6.90	135.69	101.7
2002	138	6.35	6.28	138.07	99.9
2003	137	9.17	7.89	138.28	99.1
2004	145	5.48	10.55	139.93	103.6
2005	169	3.66	12.67	160.00	105.6
2006	174	3.23	26.61	150.62	115.5
2007	188	3.28	28.16	163.12	115.3
2008	170	4.82	11.47	163.35	104.1
2009	191	3.29	29.65	164.64	116.0
2010	219	1.97	41.22	180.05	121.8
2011	218	2.66	41.59	179.07	121.7
2012	220	2.89	35.61	187.47	117.5
2013	237	5.96	44.82	198.14	119.6
2014	255	1.04	43.14	213.10	119.8
2015	275	1.89	20.02	256.87	107.1
2016	280	1.09	10.67	270.43	103.5
2017	283	4.01	8.59	278.42	101.6
2018	345	16.98	0.88	361.10	95.5
2019	349	10.00	1.37	357.64	97.6
2020	351	15.9	1.8	302.6	116.0
2021	359.2			320.7	112.0

Table 2: Evolution of production, consumption, exports, imports and the percentage of self-sufficiency of eggs during the period 1990-2021.

Sources: (1) FAO, 1990-2020, (2) Ministry of Environment, Water and Agriculture, Statistical Books, 1990-2021.

increased from 104.75 thousand tons in 1990 to 320.7 thousand tons in 2021, and then domestic consumption of eggs increased at an annual growth rate of 3.8% during the period 1990-2021. Self-sufficiency ranged from a low of 95.5% in 2018 to a high of 121.8% in 2010 (Figure 2).

- The adequacy period for domestic egg consumption ranged from a minimum of 348.7 days in 2018 to a maximum of 444.4 days in 2011. The coverage period of imports for domestic consumption of eggs ranged from a minimum of 1.5 days in 2016 to a maximum of 24.2 days in 2003.
- By estimating the total surplus and deficit of eggs destined for domestic consumption, the strategic stock of eggs is estimated at 114.39 thousand tons, sufficient for domestic consumption for 130.1 days, about 4.34 months. In light of both the strategic stock and domestic consumption of eggs of 320.7 thou-

Year	Daily domestic consumption thousand tons	Production adequacy period day	Import coverage period day	Total of the two periods	The amount of surplus and deficit in thousand tons	
					Surplus	Deficit
1990	0.287	393.7	8.7	402.5	0.000	0.00
1991	0.285	396.7	12.7	409.4	0.000	0.00
1992	0.305	393.1	14.0	407.1	0.000	0.00
1993	0.316	389.5	11.8	401.4	0.000	0.00
1994	0.332	382.2	9.1	391.4	0.010	0.00
1995	0.335	394.0	7.3	401.3	0.000	0.00
1996	0.313	399.7	11.8	411.5	0.000	0.00
1997	0.331	395.3	9.7	404.9	0.000	0.00
1998	0.345	394.0	10.1	404.0	0.000	0.00
1999	0.355	382.9	11.0	393.9	0.000	0.00
2000	0.345	374.0	13.2	387.2	0.000	0.01
2001	0.372	371.2	12.4	383.6	0.010	0.00
2002	0.378	364.8	16.8	381.6	0.000	0.00
2003	0.379	361.6	24.2	385.8	0.000	0.00
2004	0.383	378.2	14.3	392.5	0.000	0.00
2005	0.438	385.5	8.3	393.9	0.000	0.01
2006	0.413	421.7	7.8	429.5	0.000	0.00
2007	0.447	420.7	7.3	428.0	0.000	0.00
2008	0.448	379.9	10.8	390.6	0.000	0.00
2009	0.451	423.4	7.3	430.7	0.000	0.00
2010	0.493	444.0	4.0	448.0	0.000	0.30
2011	0.491	444.4	5.4	449.8	0.000	0.00
2012	0.514	428.3	5.6	434.0	0.000	0.19
2013	0.543	436.6	11.0	447.6	0.000	0.00
2014	0.584	436.8	1.8	438.5	0.000	0.20
2015	0.704	390.8	2.7	393.4	0.000	0.00
2016	0.741	377.9	1.5	379.4	0.000	0.01
2017	0.763	371.0	5.3	376.3	0.000	0.00
2018	0.989	348.7	17.2	365.9	0.000	0.00
2019	0.980	356.2	10.2	366.4	0.000	0.01
2020	0.829	423.4	19.2	442.6	62.500	0.00
2021	0.879	408.8	18.1	426.9	52.600	0.00
Total	-	-	-	-	115.120	0.73
	Strategic stock in thousand tons				114.39	
	Food Security Coefficient				0.357	

Table 3: Evolution of Food Security Indicators for Table Eggs during the Period 1990-2021.

Source: Data from table 2.

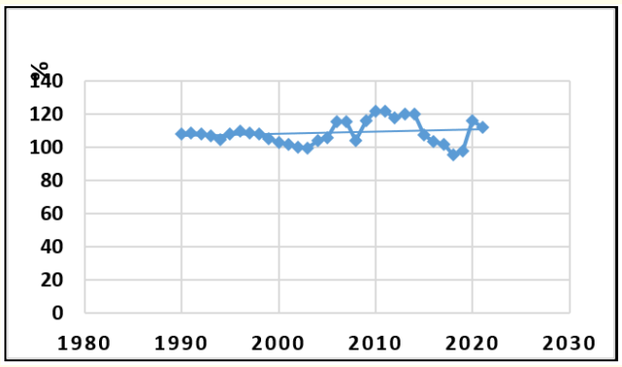

Figure 2: Evolution of the self-sufficiency rate of eggs during the period 1990-2021.
Source: Data from Table 2.

sand tons in 2021, the egg food security factor is estimated at 0.357 at the end of the period1990-2021.

- By studying the relative importance of the contribution of local production and imports to achieving the level of food security of eggs of 0.357 at the end of the period 1990-2021, it is clear from the data in table (4) that the contribution of local production to achieving the level of food security of eggs ranged between a minimum of 32.86% and a maximum of 36.74% at a confidence score of 95%. The maximum contribution of imports to the current level of food security for eggs was about 2.84% at a confidence score of 95%.

Third: Estimating the quantity and value of water used to achieve self-sufficiency and food security for eggs

Statement	Local production	Imports
Contribution probability in food security level	0.348	0.009
Probability of not contributing to the level of food security	0.009	0.348
Standard error of contributing probability to the level of food security	0.010	0.010
Standard error at a confidence score of 95%	0.0194	0.0194
Probability of contributing to the level of food security at a confidence score of 95%	0.348 ± 0.0194	0.009 ± 0.0194
Percentage of contribution to the level of food security at a confidence score of 95%: Upper Limit	%36.74	%2.84
Lower Limit	%32.86	%**1.04-**

Table 4: Relative importance of the contribution of domestic production and imports to achieving the current level of food security of eggs during the period 1990-2021.

Source: Collected and calculated from data in table (3).

The amount of water used to achieve self-sufficiency and relative food security of eggs was estimated by multiplying the local production of poultry meat by the average water requirement or water footprint of a ton of eggs which reached 3519 m^3/ton (Table 5).

Sources	Water requirements of eggs
Chapagain and Hoekstra (2003)	4657
Zimmer and Renault (2003)	2700
Oki., *et al.* (2003)	3200
Average	3519

Table 5: Average water requirements (water footprint) for egg production in cubic meters/ton.

Source: Mekonnen M. M. and Hoekstra A. Y. (2011).

The data in table (6) shows an increase in the amount of water used to meet the local consumption needs of eggs from 368.6 million m^3 in 1990 to 1128.5 million m^3 in 2021, with a total of 20.16 billion m^3 during the period 1990-2021. In light of the average cost of groundwater extraction which hit 0.482 riyals/m^3 at a discount rate of 10% (Nashwan., *et al.* 2016), the value of water used to meet the domestic consumption needs of eggs increased from 177.67 million Riyals in 1990 to 543.96 million Riyals in 2021, with a total of 9.72 billion Riyals during the period 1990-2021.

The amount of water used to achieve the current level of food security of eggs was also estimated by multiplying the amount of surplus and deficit by the average water requirement or water footprint of a ton of eggs. It is also clear from the data in table (6) that the total amount of water used in the surplus directed to the development of the strategic stock of eggs is 405.1 million m^3, with a value of 195.26 million Riyals. The total amount of water used in the amount of deficit or withdrawal from the strategic stock amounted to 2.6 million m^3, with a value of 1.24 million Riyals during the period 1990-2021.

It is known that the strategic stock is the sum of both surplus and deficit, so the amount of water used to achieve the current level of food security for eggs amounted to 402.5 million m^3, with a value of 194.02 million Riyals. The amount of water used to achieve the current level of food security for eggs is only 2.0% of that used to meet domestic consumption needs of 20.16 billion m^3 during the period 1990-2021 (Table 6) (Figure 3).

Discussion and Recommendations

Due to the state's interest in food security projects, the Agricultural Development Fund provided loans for laying hens projects amounting to 930.86 million riyals, representing 8.57% of the total

Year	Meet local consumption needs		Relative food security			
		Surplus		Deficit		
	Quantity in million m^3	Value in Million Riyals	Quantity in million m^3	Value in Million Riyals	Quantity in million m^3	Value in Million Riyals
1990	368.6	177.67	0.0	0.00	0.0	0.00
1991	365.9	176.37	0.0	0.00	0.0	0.00
1992	392.1	189.00	0.0	0.00	0.0	0.00
1993	405.6	195.50	0.0	0.00	0.0	0.00
1994	426.7	205.69	0.0	0.02	0.0	0.00
1995	430.3	207.41	0.0	0.00	0.0	0.00
1996	401.7	193.62	0.0	0.00	0.0	0.00
1997	425.7	205.18	0.0	0.00	0.0	0.00
1998	443.4	213.72	0.0	0.00	0.0	0.00
1999	456.2	219.87	0.0	0.00	0.0	0.00
2000	443.0	213.55	0.0	0.00	0.0	0.02
2001	477.5	230.15	0.0	0.02	0.0	0.00
2002	485.9	234.19	0.0	0.00	0.0	0.00
2003	482.1	232.37	0.0	0.00	0.0	0.00
2004	492.4	237.34	0.0	0.00	0.0	0.00
2005	563.0	271.39	0.0	0.00	0.0	0.02
2006	530.0	255.48	0.0	0.00	0.0	0.00
2007	574.0	276.68	0.0	0.00	0.0	0.00
2008	574.8	277.07	0.0	0.00	0.0	0.00
2009	579.4	279.26	0.0	0.00	0.0	0.00
2010	633.6	305.39	0.0	0.00	1.1	0.51
2011	630.1	303.73	0.0	0.00	0.0	0.00
2012	659.7	317.98	0.0	0.00	0.7	0.32
2013	697.3	336.08	0.0	0.00	0.0	0.00
2014	749.9	361.45	0.0	0.00	0.7	0.34
2015	903.9	435.69	0.0	0.00	0.0	0.00
2016	951.6	458.69	0.0	0.00	0.0	0.02
2017	979.8	472.24	0.0	0.00	0.0	0.00
2018	1214.1	585.17	0.0	0.00	0.0	0.00
2019	1228.1	591.96	0.0	0.00	0.0	0.02
2020	1064.8	513.26	219.9	106.01	0.0	0.00
2021	1128.5	543.96	185.1	89.22	0.0	0.00
Total	20160.0	9717.10	405.1	195.26	2.6	1.24

Table 6: Quantity and value of water used to meet local consumption needs and current food security for eggs during the period 1990-2021.

Source: Collected and calculated from the data contained in tables (3, 5).

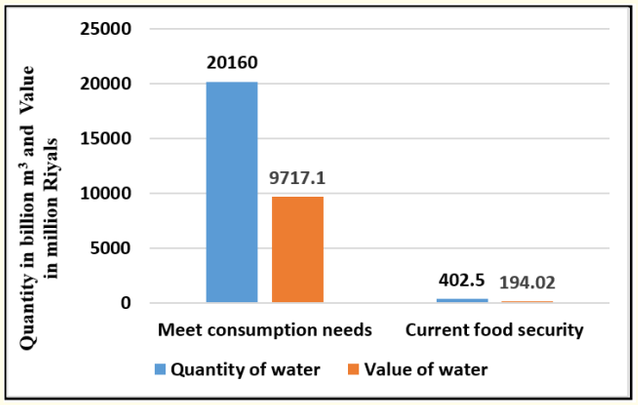

Figure 3: Total quantity and value of water used to meet current consumption needs and food security during the period 1990-2021.
Source: Data from table 6.

value of loans provided for food security projects since the establishment of the fund until the end of 2021. By studying the pattern of the geographical distribution of egg projects and production, it was found that these projects are concentrated in certain areas, making them monopolistic power in egg production and marketing. There are also no specialized projects for egg production in several areas: Al-Jowf, Al-Bahah, Jazan, and the Northern Borders. There is no doubt that the geographical concentration of egg production projects leads to a disparity in retail prices of eggs between consumer regions. This is confirmed by the fact that the average retail prices of eggs in the Al-Bahah region, the northern borders, Al-Jowf, and Jazan are higher than those estimated in the Hail region, at a rate of 27.8%, 20.4%, 17.3%, and 15.4% respectively in 2021 (Ministry of Environment, Water and Agriculture, 2021).

By calculating the amount of surplus and deficit in eggs allocated for human consumption, it was found that the strategic stock of eggs is estimated at 114.39 thousand tons, sufficient for domestic consumption for 130.1 days, or 4.34 months. With domestic egg consumption of 320.7 thousand tons in 2021, the egg food security factor is estimated at 0.357 at the end of the period 1990-2021. These findings are in line with the recommendations of Saudi National Agriculture Strategy, which included the need to maintain current self-sufficiency rate for eggs until 2030.

Since no governmental entity has published data related to water consumption in livestock and poultry production sector, this study was concerned with estimating the quantity and value of water used to meet both local consumption needs and egg food security during the period 1990-2021. The study showed that the total quantity of water used to meet local consumption needs for eggs amounted to 20.16 billion m^3, with a value of 9.72 billion Riyals during the period 1990-2021. The total quantity of water used to achieve the current level of food security for eggs amounted to 402.5 million m^3, with a value of 194.02 million Riyals. From the above, it is clear that the quantity of water used to achieve the current level of food security for eggs does not exceed 2.0% of that used to meet local consumption needs during the period 1990-2021.

In order to maintain the self-sufficiency rate and the current level of food security for eggs until 2030, in line with the Saudi National Agriculture Strategy for 2030, the study recommends that the Ministry of Environment, Water and Agriculture should continue to issue the necessary licenses to establish new projects or expand the production capacity of existing projects, in addition to the Agricultural Development Fund providing the necessary financing needs for establishment of these projects.

Conclusion

In conclusion, this research article provides valuable insights into the geographical distribution pattern of specialized egg production projects in Saudi Arabia and the evolution of egg food security indicators during the period 1990-2021. The study reveals that specialized projects for egg production are concentrated in certain areas, making them monopolistic power in egg production and marketing. However, there are no specialized projects for egg production in some regions, leading to a disparity in retail prices of eggs between consumer regions. The study also highlights the importance of maintaining the current self-sufficiency rate for eggs until 2030, as recommended by the Saudi National Agriculture Strategy. Additionally, the study estimates the quantity and value of water used to achieve self-sufficiency and food security for eggs, which can be useful for policymakers in making informed decisions regarding water management in the livestock and poultry production sector.

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