Cost benefit analysis of vaccination for sheep in Kuwait farms

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Abstract

Sheep mortality is a common agenda noticed in sheep farms globally. The mortality rate of newborn lambs in Kuwait ranges between 35 to 50 per cent (~43 per cent), leading to low profitability or loss to the farmer. Vaccination gives a better remedy to withstand the infections and stresses. Vaccines are available at various rates and hence the feasibility of the farmers to afford for vaccines and the subsequent profit to be earned need to be clarified for vaccinating their sheep confidently. With this objective, an investigation was conducted to cost analyze vaccinated sheep production that includes their feed, drinking water and housing values. A cost benefit analysis is an imperative activity that includes break down of total cost of each component and synthesizing to reach a value to compare with the profit gain from such activity. The total cost was calculated by vaccinating 5 groups of 30 ewes each along with the cost of feed, water and electricity for a period of 1 year to raise ewes. According to the results, a very slight difference in vaccine cost which is very nominal is recorded suggesting to vaccinate the ewes for the combined vaccine (*Pasteurella* + *Clostridia* + *Pest de Petites Ruminants (PPR)*) to protect for multiple diseases causing high mortality rate.

Keywords: Cost benefit analysis, farms; Kuwait; sheep; vaccination.

1. Introduction

Sheep farming is an important component of farming community of Kuwait for its multi-faceted utilities such as meat, milk, wool, skin and organic manure. Mortality and morbidity are the chief factors intervening in sheep production with considerable economic loss (Singaravadivelan *et al*., 2019). Steady increase in the mortality rate of new born lambs is a serious concern in sheep industry of Kuwait accounting for 35 to 50 per cent especially in the first three weeks of birth causing significant economic losses for the sheep producers (Un published data, Public Authority of Agricultural Affairs and Fish Resources (PAAFR)). Neonatal mortality of lambs is also affected by maternal nutrition (e.g., arginine provision) in ewes (Wu *et al*., 2022). Kuwait accounts for 588,618 heads of sheep and 11-12 per cent of red meat need of the country is met by sheep industry (Burezq & Khalil, 2021). Efforts to minimize lamb mortality could enhance the productivity of red meat by Kuwait Sheep industry. Mortality of lambs could be due to low level of immunity in the initial days of birth (United states Department of Agriculture, 2011). To maintain healthy ewes, vaccination is of utmost need to prevent diseases and develop immunity (Rathod *et al*. 2016). Vaccination aids to raise

Ig levels in the colostrum which ultimately transferred to the newborn lambs through colostrum that reduce the risk of mortality (Mohammed *et al*., 2009). Vaccines help the body to fight disease by giving it a "preview" of a pathogen that it might someday have to fight in earnest. Vaccines contain a *version* of a microbe, often an inactive form of a virus or bacterium, which triggers the immune system to make antibodies (Burezq *et al*., 2020). Virtually across the board, benefits of vaccines outweigh their costs, so farmers cannot afford and skip the process of vaccination. In view of the above facts, an investigation on cost benefit analysis of vaccination for Sheep in Kuwait farms was conducted.

2. Materials and Methods

A total of 150 ewes were selected and divided into 5 groups, representing five treatments. Ewes were made pregnant in the experiment by natural mating.

2.1 Breeding Program of Ewes Used in the Field Experiment

A straight breeding program of mating Naeemi rams with Naeemi ewes was done for breeding. The reproduction and mating procedures involved synchronizing the estrus induction of ewes (Gizaw, 1995) by inserting the vaginal sponge chronogest for ewes, to improve conception rates. The synchronized ewes with clear signs of estrus were allowed to mate with rams with proven libido. One ram was allowed to mate a flock of six to eight ewes by natural mating. Successful jumping and mating of ewes were marked. The marking procedure of ewes involved mounting a marking harness, which was strapped around the ram's shoulders and neck, and holding a crayon between the front legs. This arrangement was made so that when the rams mate ewes successfully, the crayon (colored chalk) would mark a color on the hip of the ewes. The marking of ewes was recorded with time/date to know the approximate date of lambing (Razzaque, 1995).

2.2 Diagnosis of Pregnancy

Diagnosis of pregnancy was carried out by ultrasound scanner after 42─50 days of breeding. Post successful mating of ewes, if any ewe found empty (not pregnant) will be rebred.

2.3 Vaccination Protocol Used in the Field Experiment.

Ewes were vaccinated on the side of the neck, using a syringe with 18 gauge needles. The injection area was cleaned with alcohol and the vaccines were administered under the skin.

The treatments of the experiment have been selected specifically to prevent 5 common diseases in Ewes, briefly described below.

T1- *Pasteurella*
T2- *Clostridia*
T3- *Foot and Mouth Disease (FMD)*
T4- *Pest de Petites Ruminants (PPR)*
T5- *Pasteurella + Clostridia + Pest de Petites Ruminants (PPR)*

Pasteurellosis is a devastating condition affecting sheep of all ages and the most common causes of mortality. *Clostridia* is not contagious but highly infectious and globally

pervasive. Bacterial spores are found in soil and enter the animal via the oral route. *Foot-and-mouth disease (FMD)* in adult sheep usually causes milder clinical signs and is often restrained to go undiagnosed. In contrast, FMD in lambs has been reported to cause high mortality during field outbreaks. *Peste des petits ruminants (PPR)* are a viral disease of both goats and sheep characterized by fever, sores in the mouth, diarrhea, pneumonia, and sometimes death. It is caused by a morbillivirus in the family of paramyxoviruses, which is related to rinderpest, measles and canine distemper. Ewes falling under different treatments were vaccinated with the respected vaccines as mentioned in Table 1. Ewes were vaccinated twice during pregnancy period, 1st vaccination was at the beginning of the pregnancy period, and 2nd booster dose was given four weeks prior to lambing.

Table 1. Experimental treatments with vaccination details

Treatments	No. of Vaccinated Ewes	Type of Vaccines
T-1	30	*Pasteurella*
T-2	30	*Clostridia*
T-3	30	*Foot and Mouth Disease (FMD)*
T-4	30	*Pest de Petites Ruminants (PPR)*
T-5	30	*Pasteurella + Clostridia + Pest de Petites Ruminants (PPR)*

Each group was submitted to a vaccination process twice during pregnancy to achieve maximum immunity according to Table 1. The ewes under treatments (1, 2, 4 and 5) were vaccinated with *Pasteurella, Clostridia, Pest de Petites Ruminants (PPR)* and *Pasteurella + Clostridia + Pest de Petites Ruminants (PPR)* were injected with 2ml twice a year, while ewes under treatment (3) vaccinated for *Foot and Mouth Disease* (*FMD*) was injected with 1 ml twice a year as its sanctioned dosage. In addition to vaccination, the ewes were submitted to a feeding process twice a day that includes special feeding ingredients which in turn assists in the immunity process. The amount of feed intake per day, was 0.800 kg and 1.250 kg for non-pregnant and pregnant ewes respectively. The final body weights of ewes were 58.75 ± 2.47 - 61.75 ± 6.01kg in an average. The pregnant ewes give birth to one lamb each; therefore, the litter size is one per ewe. The average milk consumption by lambs was 600 ml / day. The body weights of lambs at birth and the end of the study were 19.5 ± 1.41 and 44.73 ± 1.46 kg.

The total vaccination cost of group was calculated by considering cost per 200 ml and number of vaccination cycles per year. The feed cost was calculated by taking into account the feed portion and cost per kg. Some of the standard terms used in the cost analyses are material cost, which is the calculations of all the materials required for the experiment, that include the costs of vaccination, feed, drinking water and electricity, total cost which is the aggregated totals of all of the above cost groups for the required period of the experiment which is determined by costing all materials used, including the feed, drinking water, electricity and the vaccinations costs and unit cost, that is the final cost determined once all of the above groups are calculated.

3. Results and Discussion

3.1 Feed cost

The first material cost calculated was on feed material. The details of feed ingredients, their proportion and associated cost were enumerated in Table 2 and 3. The total cost of feed materials was calculated in portions and listed in Table 4. The diverse ingredients of feed materials are barley, wheat bran, corn, soybean meal, vitamins and minerals, limestone, salt, alfalfa hay and wheat straw. The average total portions were 1 kg and the corresponding cost was 1.094 KD. Accordingly, the cost per portion was 0.099 KD. The aggregated cost of feed of 30 ewes per year was listed in Table 3. The cost per portion for 30 ewes was 2.97 KD, where 2 portions per day was supplied accounting for 5.94 KD per day and consequently 2168.1 per year. All the five treatments marked the same value as the same feed was given for all treatments irrespective of their vaccination.

Table 2. Cost of Feed Per Portion

Feed materials	Portion(kg)	Cost Per kg (KD)	Cost per Portion (KD)
	G70:30		**G70:30**
Barely	0.405	0.084	0.034
Wheat bran	0.100	0.080	0.008
Corn	0.100	0.090	0.009
Soya bean meal	0.065	0.175	0.011
Vitamin and minerals	0.010	0.320	0.003
Limestone	0.010	0.030	0.000
Salt	0.010	0.100	0.001
Alfalfa hay	0.150	0.150	0.023
Wheat straw	0.150	0.065	0.010
Totals/Average	**1.000**	**1.094**	**0.099**

Table 3. Aggregated Feed Cost of the Ewes per year

Treatments	Cost of Feed per Portion (KD)	No of Ewes	Total Cost of Portion Per Group KD	No of Portions Per day	Total per day (KD)	Total per year (KD)
T-1	0.099	30	2.97	2	5.94	2168.1
T-2	0.099	30	2.97	2	5.94	2168.1
T-3	0.099	30	2.97	2	5.94	2168.1
T-4	0.099	30	2.97	2	5.94	2168.1
T-5	0.099	30	2.97	2	5.94	2168.1

3.2 Vaccination Cost

The second material cost is for the vaccinations and the total vaccination cost of the experiment is enumerated in Table 4 and 5. For treatment 1 and 2, the ewes vaccinated with *Pasteurella* and *Clostridia* respectively reported 2.100 KD as total cost, which is the minimal cost used for vaccination. Ewes vaccinated with Treatment 4, which is *Pest de Petites Ruminants (PPR)*

recorded the next lowest total cost of 3.900 KD. The total cost of the ewes vaccinated with combined vaccine of *Pasteurella, Clostridia* and *Pest de Petites Ruminants (PPR)* recorded 8.100 KD. The highest total cost of 16.500 KD was observed in ewes vaccinated with *Foot and Mouth Disease (FMD)* though it was injected with 1 ml twice a year, while the other vaccines were injected at 1 ml, twice a year. The treatment wise vaccination cost in each group of 30 ewes is enumerated in Table 6.

3.3 Total vaccination and feeding cost

The total feed and vaccine cost was enumerated in Table 7. The total vaccination and feed cost of treatments 1 and 2 (*Pasteurella* and *Clostridia* Vaccine) were 2170.200 KD, whereas treatment 4 (*Pest de Petites Ruminants (PPR)*) was 2172.000 KD and the combined vaccine (*Pasteurella* + *Clostridia* + *Pest de Petites Ruminants (PPR)*) was 2176.200 KD, while FMD vaccination was the highest showing 2184.600 KD.

Table 4. Total Vaccination cost -I (Group 1-4)

Treatments	Vaccination	Cost Per 200 ml (KD)	(1ml) Unit Cost (KD)	Unit /ml	(2 ml) Unit Cost (KD)	No of Vaccination per Cycle	Cost of Vaccination per Cycle (KD)	Ewes Per Group	Cost Per Group (KD)
T-1	*Pasteurella*	3.500	0.0175	2	0.035	2	0.070	30	2.100
T-2	*Clostridia*	3.500	0.0175	2	0.035	2	0.070	30	2.100
T-3	*Foot and Mouth Disease (FMD)*	55.000	0.275	1	0.275	2	0.550	30	16.500
T-4	*Pest de Petites Ruminants (PPR)*	6.500	0.0325	2	0.065	2	0.130	30	3.900

Table 5. Total Vaccination cost -II (Group 5)

Treatments	Vaccination	Cost Per 200 ml (KD)	(1ml) Unit Cost (KD)	Unit /ml	(2 ml) Unit Cost (KD)	No of Vaccination per Cycle	Cost of Vaccination per Cycle (KD)	Ewes Per Group	Cost Per Group (KD)
T-5	*Pasteurella*	3.500	0.0175	2	0.035	2	0.070	30	2.100
	Clostridia	3.500	0.0175	2	0.035	2	0.070	30	2.100
	Pest de Petites Ruminants (PPR)	6.500	0.0325	2	0.065	2	0.130	30	3.900
	Total	**13.500**	**0.0675**	**6**	**0.135**	**6**	**0.270**	**30**	**8.100**

Table 6. Treatment wise Vaccination Cost for 30 Ewes

Treatments	Vaccines for diseases	Sub Total (KD)
1.	*Pasteurella*	2.100
2.	*Clostridia*	2.100
3.	*Foot and Mouth Disease (FMD)*	16.500
4.	*Pest de Petites Ruminants (PPR)*	3.900
5.	*Pasteurella + Clostridia + Pest de Petites Ruminants (PPR)*	8.100

Table 7. Total Vaccination and Feed Unit Costs (30 Ewes in each group per year)

Treatments	Vaccination	Total of Vaccination per Group (KD)	Total of Feed Cost per Group/year (KD)	Total (KD)
1	*Pasteurella*	2.100	2168.100	2170.200
2	*Clostridia*	2.100	2168.100	2170.200
3	*Foot and Mouth Disease (FMD)*	16.500	2168.100	2184.600
4	*Pest de Petites Ruminants (PPR)*	3.900	2168.100	2172.000
5	*Pasteurella + Clostridia + Pest de Petites Ruminants (PPR)*	8.100	2168.100	2176.200

4. Miscellaneous cost

4.1 Electricity cost

Assuming each group of ewes (30 each) was kept separately in each pen, electricity consumption and cost was calculated for a period of one year (Table 8).

Table 8. Electricity costs for Ewes Per Year

Treatments	No of Ewes	Electricity consumption kw/year	Cost of electricity KD/kw	Cost of electricity per year KD
1	30	1666.67	0.015	25.000
2	30	1666.67	0.015	25.000
3	30	1666.67	0.015	25.000
4	30	1666.67	0.015	25.000
5	30	1666.67	0.015	25.000

4.2 Drinking Water Cost

Cost of drinking water was calculated for two seasons i.e., spring (6 months) and summer (6 months). During spring each ewe drunk 2.1 liters of water daily, whereas in summer each ewe drunk 4.6 liters. Based on the cost of water as 0.00105 KD, calculations were done and presented in tables 9 and 10.

Table 9. Cost of Water for 5 Ewes Groups (each group 30 ewes) in Spring (6 months)

Treatments	No of Ewes	Daily water consumption (L) in Spring per Ewe	Total daily water consumption per group of 30 Ewes (L)	Total water consumption per group of 30 Ewes for six months (L)	Cost of water per liter (KD)	Total cost of water for Spring (6 months) (KD)
1	30	2.100	63.000	11,498	0.00105	12.073
2	30	2.100	63.000	11,498	0.00105	12.073
3	30	2.100	63.000	11,498	0.00105	12.073
4	30	2.100	63.000	11,498	0.00105	12.073
5	30	2.100	63.000	11,498	0.00105	12.073

Table 10. Cost of Water for 5 Ewes Groups (each group 30 ewes) in Summer (6 months)

Treatments	No of Ewes	Daily water consumption (L) in Spring per Ewe	Total daily water consumption per group of 30 Ewes (L)	Total water consumption per group of 30 Ewes for six months (L)	Cost of water per liter (KD)	Total cost of water for Summer (6 months) (KD)
1	30	4.600	138.000	25,185	0.00105	26.444
2	30	4.600	138.000	25,185	0.00105	26.444
3	30	4.600	138.000	25,185	0.00105	26.444
4	30	4.600	138.000	25,185	0.00105	26.444
5	30	4.600	138.000	25,185	0.00105	26.444

whereas, Table 11 presents aggregate cost of total materials (vaccination, feed, water, electricity) and unit cost per Ewe.

Table 11. Aggregated Cost for Each Ewe Group (30) Per Year and Per Ewe (last column)

Treatments	No of Ewes	Cost of vaccination (KD)	Cost of feed (KD)	Cost of Electricity (KD)	Cost of Water (KD) Spring	Cost of Water (KD) Summer	Total cost (KD)	Cost per Ewe per year (KD)
1	30	2.100	2168.100	25.000	12.073	26.444	2233.717	74.50
2	30	2.100	2168.100	25.000	12.073	26.444	2233.717	74.50
3	30	16.500	2168.100	25.000	12.073	26.444	2248.117	74.94
4	30	3.900	2168.100	25.000	12.073	26.444	2235.517	74.52
5	30	8.100	2168.100	25.000	12.073	26.444	2239.717	74.66

4.3 Cost Analyses to Raise the Lambs for 21 Months

The ewes under each vaccination treatment were vaccinated after pregnancy to enhance the immunity system against potential diseases. No mortality rate was noticed after the birth of the lambs in all 5 groups of ewes vaccinated. The lambs took colostrum and milk from their ewes for the first three months. After the preliminary three-month period the lambs were given 2 portions of feed daily for a period of 1 year and 9 months (21 months), before they were expected to be sold. It is only after three months they start drinking water. Based on these facts, cost valuation is made as shown in Table 12.

Table 12. Aggregated cost for each group (30) of lambs for 21 months

Treatments	No of lambs	Cost of feed (KD) 639 days (21 months)	Cost of Water (KD) 639 days (21months)	*Total raising cost (KD)	Raising cost per lamb per year (KD)	Total selling price per 30 lambs @ 160 KD/lamb	Total profit (KD)
T1	30	3794.2	67.40	3861.6	128.72	4,800	938.4
T2	30	3794.2	67.40	3861.6	128.72	4,800	938.4
T3	30	3794.2	67.40	3861.6	128.72	4,800	938.4
T4	30	3794.2	67.40	3861.6	128.72	4,800	938.4
T5	30	3794.2	67.40	3861.6	128.72	4,800	938.4
Total profit from 5 treatments							3,753

*Since the lambs were living with Ewes, therefore, electricity cost is omitted.

5. Mortality Rate of Lambs after Birth and Cost Analyses

A mortality rate between 35 and 50 percent (~ 43%) is very common without vaccinating the ewes (Hinch & Brien, 2014). Accordingly, the cost of raising the lambs born to non-vaccinated ewes was calculated. The lambs usually die within 4 weeks after birth. Comparison of tables 12 and 13 clearly shows that there was a gain of 3753 KD profit due to vaccination (Table 12) and a loss of 5707.75 KD on overall 5 groups with an average of 43% mortality rate.

Table 13. Aggregated Cost of Lambs for 21 Months and Profit

Treatments	No of lambs born	No of lambs survived @ 43% mortality rate	Cost of feed (KD) 639 days (21 months)	Cost of Water (KD) 639 days (21 months)	Total cost (KD)	Cost per lamb per year (KD)	Total cost to raise 17 lambs (KD)	Total selling price per 17 lambs @ 160 KD/lamb	Total loss (KD)
T1	30	17.0	2150.05	38.19	2188.24	227.15	3861.55	2720.0	1141.55
T2	30	17.0	2150.05	38.19	2188.24	227.15	3861.55	2720.0	1141.55
T3	30	17.0	2150.05	38.19	2188.24	227.15	3861.55	2720.0	1141.55
T4	30	17.0	2150.05	38.19	2188.24	227.15	3861.55	2720.0	1141.55
T5	30	17.0	2150.05	38.19	2188.24	227.15	3861.55	2720.0	1141.55
Total							19,308	13,600	**5707.75**

6. Conclusion

The cost benefit analysis of vaccinating sheep in Kuwait and raising for 21-month period until taken to market showed that vaccination has great promise to control the mortality rate in ewes to gain maximum profits. Though the profit gained was more or less similar for all vaccinations, it was higher for FMD vaccination. The combined vaccination is suggested as it combines the effect of three vaccines together in almost similar cost per year for other sole vaccines. With

regards to the new born lambs from the vaccinated and non-vaccinated ewes to calculate the cost of raising the lambs from both vaccinated and non-vaccinated groups with the assumption of an average of 43% mortality rate to non-vaccinated group of ewes. It is concluded that the farmer will spend 227.15 KD per lamb (due to 43% mortality) to raise before he will sell at the rate of 160 KD, so there is net loss of 67 KD to the farmer per lamb and a total loss of 5707.75 KD from a group of 30 ewes. It is clearly illustrated that vaccination has great promise to control the mortality rate in ewes to gain maximum profits, as none of the lamb from all five groups (total of 150) were dead after the birth. The cost of raising 30 ewes for a year showed a slight difference due to difference in vaccine cost which is very nominal suggesting to vaccinate the ewes for the combined vaccine (*Pasteurella + Clostridia + Pest de Petites Ruminants (PPR)*) to protect for multiple diseases causing high mortality rate.

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