Effects of housing systems on costs and profitability in dairy cattle farms in the Central Anatolia region of Turkey

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Abstract

In this study, the effects of different loose housing systems on the barn construction costs, animal welfare and health in dairy cattle farms were investigated. Total of 125 dairy farms were divided into three groups according to the housing systems. The first group cows (46 farms) were housed which has free-stalls with rubber or other bedding materials; the second group cows (58 farms) were housed which has free-stalls with concreted floor, and the third group cows (21 farms) were housed which has flat concreted floor without free-stalls and bedding materials. According to results, the cows that housed in the first housing systems produced 1.9 and 2.6 kg more milk per day than the the second and third housed cows. The average production cost of per kg of raw milk and milk sales price for the first, second and third group housing systems were calculated as 0.349, 0.497; 0.348, 0.490, and 0.390 and 0.457 US dollars respectively. Total active capitals and barn construction costs per cow for the first, second and third housing systems were calculated as 5547184, 4939; 4351222, 4511, and 2839452, 3856 US dollars respectively. While the gross production values, gross and net profit per cow were higher in the first group housing systems than the second and third group housing systems as 260, 635; 118, 752, and 109 and 726 US dollars, total production costs per cow were higher in the third the housing systems than the first and second housing systems as 91 and 242 US dollars, Results showed that barn investment costs in loose housing systems with free-stalls were higher than the other loose housing system without free-stalls, but higher quality and more milk production, higher milk sales prices, lower milk production costs and higher profitability. While the loose housing system without free-stalls was only more advantageous than other housing systems in terms of animal welfare and health. As a result, designers need to plan new types of dairy cattle barns that will reduce costs, increase profitability, and improve animal welfare and health.

Keywords: Dairy cow, barn design, building, cost, production, health, welfare,

1. Introduction

The concentration of the dairy industry still continues. Many modern housing systems involve keeping cattle indoors, in a restricted space, often at high density and separated from other animals, which raises concerns about the animals' welfare. Housing can impact animal welfare mainly by changing the risk that animals will suffer from health and injuries, or by

placing restrictions on their behaviour (RUSHEN, 2017). For owners of surviving and expanding farms, there is a significant economic outlay, especially for the construction of larger, more modern dairy farms. These changes, a result of adaptation to modern dairy technology, aim to enable dairy managers to work with lower investment per cow and improve the quality of life of dairy farm owners and employees.

To be successful, the manager must work to develop flexible business plans and facilities. All facilities should be designed to allow for future expansion and provide safe and comfortable conditions for both animals and workers. Different designs for housing and handling facilities are suitable for dairy farms considering fiancial costs, climatic conditions, topography, infrastructure, productivity of cattle, efficiency of operations, and availability of feed and pasture. It is important to know all rules and regulations regarding the location, design and type of housing. The importance of comparing investment options in terms of relevant financial costs has been emphasized by many researchers. One of the most critical decisions for final construction costs is the initial selection of foundation design. Designers of cattle barns should seek to provide an optimal environment, resulting in excellent animal welfare and health, to enable cows to maximize their milk production, to minimize injuries, to reduce building costs (HIVES, 1985; TRUEBA and MARCO, 1986; HARTMANN, 1995; PALMER, 1999; KARZES, 2000; KOBAYASHI *et al*., 2000; MARIÑO, 2001; PEREIRA *et al*., 2003).

Dairy cows may be housed in tie stalls and loose housing systems. The loose housing system consists of three types depending on the placement of the cattles in the barn. In the first type of loose housing system, cattle are housed in free-stall barns. In this system, rubber, straw, sawdust and sand are used as bedding materials on the stall floor. In the second type of loose housing system, cattle are housed in barns with stalls, but the floors of the stalls are concrete and no bedding materials are used. The free-stalls floor of both the first and second types loose housing systems are constructed approximately 20 cm above the feed and service alleys. In addition, in the third type of loose housing system, cattle are housed without free-stalls, the floor of the barn is flat concrete and no bedding materials are used. In this system, manure is removed at regular intervals using a large workforce. Loose housing systems with free-stalls can compromise welfare, cow comfort and cause a high risk of lameness and hock lesions, especially with inadequate positioning of stall hardware, limited space, hard lying surface or insufficient bedding. But, free-stalls that are well designed can reduce excessive standing, and minimize injuries (WEARY and TASZKUM, 2000; TUCKER *et al.*, 2004; TUCKER and WEARY, 2004; DIPPEL *et al.*, 2009).

The aim of this research was made to compare three different types of loose housing systems, which are the most preferred in Turkey, in terms of barn construction costs, capital structure, operating expenses and incomes, diseases, animal welfare and quality milk production.

2. Literature Review

Bewley *et al*. (2001) surveyed 244 dairy cattle farms. They reported that cost per stall for remodeled free-stall barns was less than new and remodeled or new only barns (534 vs. 980, and 1107 US dollars; respectively).

New buildings may require an investment outlay of 3075 to 5000 US dollars per animal, while the renovations require expenditures of 575 to 2885 US dollars per animal (BREHME and LAUFELD, 2001).

Investment cost for this operation was 14903 US dollars in 2000 year and present value of farm was calculated as 10865 US dollars. Total farmstead area is 0.47 ha. Barn construction and structure materials were suitable for renovation. However, some barn components and equipments consequently barn sizes must be renovated. In brief, one can be said that renovation is an attractive alternative for the modernization of dairy farms in developing countries. But, existing buildings must have appropriate characteristics for renovation and problems related to the facilities can be handled with renovation (YASLIOGLU *et al.*, 2008)

Galama (2011) stated that the construction costs for the types of loose housing system were 3011 Euro for free-stalls barns, 3138 Euro for compost type barns and 2580 Euro for composting type barns (excluding feeding, cooling and milking systems).

In order to have a more precise description of dairy farm structure and characteristics of dairy production systems, as well as to assess possibilities for improving production and farming conditions in which milk production is organized, a survey based research was directed at a select group of farms across the Serbia. 1180 questionnaires have been mailed to farmers whose farms are registered for either cattle or mixed production. Questionnaire was divided into 6 sections: general information of the farm, agricultural and structural information, zootechnical information, sanitary and veterinarian information, information about education and extension, and information on the perspectives of future farming. About 59% of analysed farms have size up to 20 ha, with average size of about 10 ha. On the other hand, about 55% farms raises up to 15 cows and heifers with average of 6 heads per farm,

while 3% of farms have more than 200 cows and heifers. Over 86% of surveyed farmers intend to expand existing farm production, mainly by increasing the number of animals, stricter selection and improvement of the conditions for feeding, housing, care and milking. About 75% of farmers have expressed a positive expectation from future membership of Serbia in EU, although these expectations are not clearly defined (BOGDANOVIĆ *et al*., 2012).

The present study aims to analyze the sustainability indexes and the financial return of a family-owned milk production. A checklist containing sustainability parameters (environmental, economic and social) was applied, as well as to verify aspects of milk quality that were later used to know the producers' remuneration by the cooperative. A case study was carried out on Santa Catarina west family property. Among the results, we highlight that the ownership of this case study obtained a minimum score of 0.85 points out of a total of 0.100 in 2017, and thus, being able to request the audit of the Sustainable Property Program of the affiliated cooperative to obtain the certificate. The certification provides for the ownership of incentive payments from the Program and also demonstrates the importance of environmental, economic and social controls for the planning of continued actions in the short, medium and long term, aiming at growth in a balanced and sustainable manner, improving environmental conditions in that the property is inserted (DALCERO *et al*., 2019).

Pereira *et al.* (2020) stated that the largest investment charge occurs in the workforce for herd management, which ensures the harmony of these cattle with the environment. It was observed that regardless of thecertification process, producers still need to make use of this workforce. Therefore, the differential expenses of production in this modality instead of the conventional creation occurs in the training of the employees, by the investments in adaptations and the quality seal that certifies the production.

3. Material and Methods

This research was conducted between 1 April - 31 August 2022 years in Central Anatolia region of Turkey. The Central Anatolia region is located between 39° 10′ 18″ north parallels and 33° 31′ 24″ east meridians, in Turkey. In this study, dairy farms with milking cow capacity of 50 heads and above, and three different barn types of the loose housing system were examined. Total of 125 dairy farms, where the Holstein Friesian dairy cattle breed was raised, were divided into three groups according to the housing systems. The first

group cows (46 farms) were housed in loose housing system which has free-stalls with rubber or other bedding materials, and 20 cm above the concreted feed alley; the second group cows (58 farms) were housed in loose housing system which has free-stalls with concreted floor and 20 cm above the concreted feed alley, and the third group cows (21 farms) were housed in loose housing system which has flat concreted floor without free-stalls and bedding materials. The cows were milked by automated milking system twice a daily. The cows were fed to *ad libitum* with TMR. A total mixed ration (TMR) was delivered daily from a central feeding station. For the statistical analysis, SPSS package program was used for for Windows (2015, version 23.00). Descriptive statistics were conducted for all variables. In the study, the values are presented as mean ± standard error. Data for three housing systems were compared with Oneway ANOVA and DUNCAN tests.

Differences were considered to be significant at 0.05 level.

The model used in the experiment is as follows;

$y_{ik} = \mu + m_i + e_{ik}$, where;

μ = Expected average (Population average)

m_i = Barn types (i= 1,2 and 3)

e_{ik} = Error term

Total gross return, gross gain, net gain, productivity and benefit-cost ratio were calculated in economic analysis of dairy farms by using Formulas 1, 2, 3, 4, 5 and 6. Net profit per cow was calculated by subtracting the total production cost from the gross revenue. Gross profit per cow was calculated by subtracting the variable cost of production from gross revenue. The benefit-cost ratio per cow was calculated by dividing the gross production value by the total milk production cost (ZANGENEH, 2010; SEFEEDPARI, 2012):

Total Gross Revenue = Milk yield per cow (kg) – Milk price per kg (USD) (1)

Gross Profit=Gross revenue per cow (USD)–Variable production cost per cow (USD) (2)

Net Profit = Total gross revenue per cow (USD) – Total cost per cow (USD) (3)

$$\text{Benefit} - \text{Cost Ratio} = \frac{\text{Total gross revenue per cow (USD)}}{\text{Total production cost per cow (USD)}} \quad (4)$$

$$\text{Productivity} = \frac{\text{Milk yield per cow (kg)}}{\text{Total production cost per cow (USD)}} \quad (5)$$

4. Results and Discussion

4.1. Production and capital structures of dairy farms according to housing systems

The minimum, maximum and average values, and standard deviations of some production and capital parameters of the dairy farms are shown in Table 1. According to Table 1, the average number of dairy cattle and milking cows in all farm groups are 567 and 163 heads; average lactation milk yield and land size are 7869 kg and 12.3 hectares, and the average animal, barn, land, total active and working capitals were calculated as 1448578, 759894, 1638649, 4437359 and 1697786 US dollars respectively (Table 1).

Table 1: Descriptive statistics of the capital and production status of dairy farms

Production and Capital Items	Minimum	Maximum	Average	Standart Deviation
Number of dairy cattle (head)	98	1300	567	97.9
Number of milking cows (head)	50	500	163	98.7
Lactation milk yield (kg)	6185	9615	7869	36.4
Land size (ha)	2.0	21	12.3	86.2
Animal capital (USD)	455384	2690000	1448578	110.2
Barn capital (USD)	217627	1324894	759894	92.4
Land capital (USD)	251004	2788845	1638649	61.3
Total active capital (USD)	2205471	6814149	4437359	112.5
Total working capital (USD)	519325	2911527	1697786	80.9

The average active and working capitals of 125 dairy farms which have three housing systems and the elements of capitals are shown in Table 2. The differences between the housing systems regarding all elements of active and working capitals were found to be statistically significant ($P < 0.05$). The total cattle and dairy cows numbers of the dairy farms were found to be higher while the land size was lower.than the results reported in Örs and Oğuz (2019).

Table 2: Active and working capitals of dairy farms according to housing systems

Capital Items (USD)	Housing Systems					
	I		II		III	
	Total	%	Total	%	Total	%

Animal	1868805[a]	33.69	1422756[b]	32.70	599400[c]	21.11
Land	2016932[b]	36.36	1613546[a]	37.08	1474602[c]	51.93
Land improvement	67084[a]	1.21	60540[b]	1.39	58973[c]	2.08
Barn	1007556[a]	18.16	735293[b]	16.90	285344[c]	10.05
Buildings	178565[a]	3.22	156421[b]	3.59	129647[c]	4.57
Plant	109865[a]	1.98	101644[ab]	2.34	89473[b]	3.15
Tool and equipment	149857[a]	2.70	138730[b]	3.19	105785[c]	3.73
Materials and ammunition	56524[a]	1.02	45872[b]	1.05	36891[c]	1.30
Money	91996[a]	1.66	76420[b]	1.76	59337[c]	2.08
Total active capital	5547184[a]	100.0	4351222[b]	100.0	2839452[c]	100.0
Total working capital	2167182[a]	39.07	1683778[b]	38.70	801413[c]	28.22

[a,b,c] letters in different rows indicate statistical difference between barn types at 5% level.

According to Table 2, the animal, land, barn, active and working capitals of the first housing systems were higher than the second and third housing systems as 446049, 1269405; 403386, 542330; 272263, 722212; 1195962, 2707732, and 483404 and 1365769 US dollars respectively. While the ratios of animal and barn capitals in the the total active capital were the highest in the first housing system, land, land improvement, buildings, plant production, tools-equipment, materials and ammunition, and money capitals were the highest in the third housing system (Table 2). The results obtained in relation to total assets and working capital per cow were found to be similar to the results reported by Örs and Oğuz (2019).

4.2. Construction and design costs in different loose housing systems

Data on design and construction costs per cow of three housing systems are given in Table 3. When the housing systems were compared regarding barn construction costs, it was determined that the first housing system had higher cost than the second and third housing systems of dairy farms as 428 and 1083 US dollars (Table 3). The results obtained regarding barn construction costs were found to be close to Brehme and Laufeld (2001), and Galama (2011). When Table 3 is examined, the barn construction costs obtained in the current study were found to be higher than the reported in Galama (2011). Because, all tools and other equipments used on farms for feeding, cooling, calf housing and milking system were added to the barn construction costs in the current research.

Table 3: Design and construction costs of barn types per cow in housing systems

Cost Items (USD)	Housing Systems			Average
	I	II	III	
Barn carcass				
Preparative work	50	45	32	44.66

Substructure		1310	1248	971	1224.28
Superstructure		800	644	578	690.32
	Total	**2160**	**1937**	**1581**	**1959.26**
Other buildings and layout					
Sheds, stores, silos and feeding rack		674	649	603	650.47
Cubicles, rubber bed and water troughs		125	119	111	119.86
Animal cooling system and aeration		20	17	12	17.26
Water and electricity		25	21	19	22.14
	Total	**844**	**806**	**745**	**809.73**
Milking and cooling					
Milking system		425	389	364	398.05
Cooling tank		53	47	42	48.37
Milking parlours		55	46	41	48.47
	Total	**533**	**482**	**447**	**494.89**
Feeding					
Feeding wagon		576	513	469	528.79
Feed chopping and mixing machine		32	28	24	28.80
Manger lock system		19	16	13	16.60
	Total	**627**	**557**	**506**	**574.19**
Housing					
Calf pen and hutches		180	170	140	168.64
	Total	**180**	**170**	**140**	**168.64**
Manure storage					
Manure scraper, mixer, separator and carrier		105	100	91	100.32
Slurry silo (for 6 months)		450	421	314	413.70
Solid manure plate (for 6 months)		40	38	32	37.73
	Total	**595**	**559**	**437**	**551.75**
Total of barn construction cost per cow		**4939**[c]	**4511**[b]	**3856**[a]	**4558.46**

[a,b,c,], letters in the same row indicate statistical differences between barn types at 5% levels.

4.3. Economic analysis of milk production in different housing systems

The results of economic analysis for dairy farms that preferred three housing systems were shown in Table 4. The differences between the housing systems of the dairy farms for all parameters were found to be statistically significant ($P < 0.05$). The average production cost of per kg of raw milk and milk sales price for the first, second and third group housing systems were calculated as 0.349, 0.497; 0.348, 0.490, and 0.390 and 0.457 US dollars respectively. Milk sales price and milk production cost per kg were similar to Örs and Oğuz (2019). The average lactation milk yield in all housing systems was 7869 kg, and the cows housed in the first system produced 411 and 654 kg more milk than the cows housed in the second and third systems. The lactation milk yields of the cows in all housing systems were higher than the results reported by Örs and Oğuz (2019).

The average of gross production value was 3985 US dollars per cow in all housing systems, and the cows housed in the first system higher than the second and third housing systems as 260 and 635 US dollars. The results emphasized that gross production values per cow increased in the loose housing type with free-stalls and beds, and without beds. The

results of present study were higher than the reported by Yilmaz *et al*. (2016) and Örs and Oğuz (2019). Yilmaz *et al*. (2016) reported that the gross value was as 1401.32 US dollars.

The total milk production cost per cow (variable + fixed costs) in the third housing systems were 91 and 242 US dollars higher than the first and second housing systems. The average total production cost per cow in all housing systems was 2892 US dollars. The results of present study revealed that the total production cost per cow was higher in dairy farms that had preferred the first housing system, due to the initial investment expenses, the use of modern tools and equipments, and higher operating costs. The results on total milk production cost, gross profit and net profit per cow were higher than the reported by Yilmaz *et al.* (2016). Yilmaz *et al.* (2016) expressed that these values were as 1621.52, 332.65 and -220.24 US dollars. Although Yilmaz *et al*. (2016) reported that the net profit per cow negatively, this value was expressed positively with 558 US dollars in the first housing type. But, is similar to the results in Örs and Oğuz (2019). While the average gross and net profit in all housing systems were calculated as 851 and 815 US dollars, the first housing system higher than the second and third housing systems as 118, 752, 109 and 726 US dollars, respectively. The results were similar to the Örs and Oğuz (2019).

The average benefit-cost ratio, productivity, capital turnover ratio per cow in all housing types were determined as 1.34, 3.16 and 29.87%, respectively. For these parameters, the first housing system was more advantageous than the second and third housing systems. The third housing system were higher than the first and second housing systems for the total active and working capital amounts per cow as 11179, 11676, and 207 and 500 US dollars respectively (Table 4).

Table 4: Economic analysis of milk production per cow in differenet housing systems

Economic Parameters	Housing Systems			Average
	I	II	III	
Number of cattle (head)	740^{c}	553^{b}	226^{a}	567
Number of milking cow (head)	204^{c}	163^{b}	74^{a}	163
Sale price per kg milk (including incentives, USD)	0.497^{ab}	0.490^{a}	0.457^{b}	0.472
Cost of per kg milk (USD)	0.349^{ab}	0.348^{a}	0.390^{b}	0.369
Average daily milk production per cow (kg)	28.4^{b}	26.5^{ab}	25.8^{a}	26.9
Average lactation milk yield per cow (kg)	8424^{c}	8013^{b}	7770^{a}	7869
Gross production values per cow (USD)*	4186^{c}	3926^{b}	3551^{a}	3985
Total production cost per cow (USD)	2939^{ab}	2788^{b}	3030^{a}	2892
Gross profit per cow (USD)*	1444^{ab}	1326^{a}	692^{b}	851
Net profit per cow (USD)*	1247^{ab}	1138^{a}	521^{b}	813
Benefit to cost ratio	1.42^{ab}	1.41^{a}	1.17^{b}	1.34

Pruductivity per cow (%)	5.31[c]	4.97[b]	1.80[a]	3.16
Rate of working capital in active capital (%)	39.07[ab]	38.70[a]	28.22[b]	37.08
Capital turnover ratio per cow (100%)	36.41[a]	38.00[ab]	32.79[b]	29.87
Average active capital per milking cow (USD)	27192[ab]	26695[a]	38371[b]	28839
Average working capital per milking cow (USD)	10623[ab]	10330[a]	10830[b]	10522

[a,b,c,], letters in the same row indicate statistical differences between barn types at 5% levels.
*Only the income from raw milk sales was taken as revenue.

Detailed information about variable and fixed costs are given in Table 5. The third housing system was higher than the first and second housing systems as 117 and 259 US dollars for the total variable costs, and, the first housing system was higher than the second and third housing systems as 9 and 26 dollars higher than the second and third housing systems for the fixed costs. The fact that the total variable cost was higher in the third housing system was due to feed, veterinary service and medicine, and temporary labor costs. Artificial insemination, electricity, water and fuel costs were lower in the third shelter system than in other shelter systems. Average the rates of variable and fixed costs of milk production were calculated as 93.68% and 6.32%, respectively, and these rates were higher than the rates reported by Yilmaz *et al.* (2016) and Örs and Oğuz (2019). Yilmaz *et al*. (2016) stated that the variable and fixed cost values were 65.91% and 34.09% (Table 5).

Table 5. Detailed results of variable and fixed costs per cow in different housing systems

Cost Items	**Housing Systems**						**Average**	**%**
(USD)	**I**	**%**	**II**	**%**	**III**	**%**		
A. Variable Costs								
Temporary labor	18[a]	0.7	21[ab]	0.8	35[b]	1.2	24	0.9
Animal feed	2385[b]	87.0	2163[ab]	83.2	2459[a]	86.0	2357	85.5
Veterinary services and medicine	213[a]	7.8	281[b]	10.8	293[c]	10.2	262	9.5
Articifal insemination	30[b]	1.0	41[ab]	1.6	22[a]	0.8	33	1.2
Electricity, water and fuel	96[a]	3.5	94[b]	3.6	50[c]	1.8	81	2.9
Total Variable Cost	**2742[a]**	**100.0**	**2600[b]**	**100.0**	**2859[c]**	**100.0**	**2757**	**100.0**
B. Fixed Cost								
Animal depreciation	21[a]	10.7	39[b]	20.8	47[c]	27.5	36	19.7
Building and machine depreciation	18[a]	9.1	12[b]	6.4	8[c]	4.7	13	6.7
Building and machine maintenance	31[a]	15.7	23[b]	12.2	19[c]	11.1	25	13.0
Permanent labor	39[a]	19.8	31[b]	16.5	17[c]	9.9	29	15.4
Human and animal insurance	42	21.3	42	22.3	42	24.6	42	22.7
Taxes, interest and administrative	46[b]	23.4	41[ab]	21.8	38[a]	22.2	42	22.5

Total Cost	**Fixed**	**197[a]**	**100.0**	**188[b]**	**100.0**	**171[c]**	**100.0**	**186**	**100.0**

[a,b,c], letters in the same row indicate statistical differences between barn types at 5% levels.

4.4. Health, quality milk production, and body lesions and injuries in the housing types

Somatic cell count (SCC), quality milk production rate, incidences of mastitis, lameness, other body lesions and injuires, udder injuires, and proportions of clean udders and legs were shown in Table 7. According to Table 7, the differences observed between housing systems in terms of all these parameters were found to be statistically significant ($P < 0.05$).

Table 7: The results of different health and cleanliness of dairy cows

Incidences	Housing Systems			
	I	II	III	Average
Somatic cell count (x 1,000 cells mL-1)	204.2[a]	245.7[b]	346.3[c]	268.7
Quality milk production rate (%)	93.11[c]	90.89[b]	74.66[a]	86.71
Mastitis incidence (%)	22.50[a]	27.50[b]	38.75[c]	27.05
Lameness incidence (%)	26.15[b]	29.75[c]	17.23[a]	28.14
Other body lesions and injuries incidence (%)	28.50[b]	31.82[c]	18.75[a]	27.8
Udder injuries incidence (%)	11.25[a]	15.00[b]	35.23[c]	21.3
The proportion of clean udders (%)	49.74	46.86	14.72	43.15
The proportion of clean legs (%)	44.52	36.28	12.51	38.29

[a,b,c], letters in the same row indicate statistical differences between barn types at 5% levels.

The somatic cells count in the first housing system were higher than the first and second housing systems as 142100 and 100600. The most mastitis diseases were observed in third group housing system, and the rates of mastitis in this group were higher than the first and second housing systems as 16.25% and 11.25%.The highest quality milk production rate was realized in the first housing system, and the quality milk production rate in all housing systems was calculated as 86.7%. The results for the somatic cell count and mastitis incidence (%) were similar to Bery (1998), Klaas et al. (2010) and Emanuelson et al. (2022). Klaas et al. (2010), stated that mastitis disease and the number of somatic cells in milk increased in loose housing with soil floor without free-stall systems.

The rates of lameness in the second housing group cows were higher than the first and third group cows as 3.6% and 12.52%. The other body lesions such as forelimbs, skin, head, neck, back and abdomen were the highest in the free-stalls with concreted floor barn type. The proportions of other body lesions in the free-stalls with concreted floor system were higher than the first and third group cows as 3.32% and 13.07%. The results were similar to Weary and Taszkun (2000), Livesey *et al.* (2002), Klaas *et al.* (2004), Tucker and Weary (2004),

Barberg *et al.* (2006), Dippel *et al.* (2009), Fregonesi *et al.* (2009) and Klass *et al.* (2010). Barberg *et al.* (2006) found a low prevalence of cows with hair loss (24 %) and swollen hocks (1 %) in 12 herds in loose housing without free-stall compost system. The most udder injuires were observed in third group cows. The rates of udder injuires in this group were higher than the first and second housing systems as 23.98% and 20.23%.

The most clean udders and legs were observed in first housing system. The first housing systems were higher than the second and third housing systems for the rates of clean udders and legs injuires as 2.88, 8.24%, and 35.02 and 32.01%, respectively. The results regarding clean udders and legs were similar to the reported literature results. The proportion of cows with clean udders was comparable to Schreiner *et al.* (2003), 58 %, and Klaas *et al.* (2004), 52.6 %, both studies from cows in free-stall housing systems.

5. Conclusions and Recommendations

The results of this study, in which three different types of loose housing systems were evaluated, number of cattle and milking cows, raw milk sales price, quality milk production rate, clean udder and leg ratios, the amounts of active and working capitals, barn investment cost, lactation milk yield, gross production values, gross and net profits and fixed costs per cow were found to be higher in the first housing system (Loose housing system with free-stalls and rubber or other bed materials) than other housing systems, per kg raw milk production cost was lower than other housing systems. In addition, the lowest raw milk production cost per kg was realized in the first housing system. Somatic cell count, which is measure of milk quality, mastitis incidence rate, udder injuries, and total variable and production costs were found to be highest in the third housing system (loose housing system which has flat concreted floor without free-stalls and bedding materials). Due to metal bars of free-stalls, lameness, and body lesions and injuries were mostly detected in the first and second housing (Loose housing system with free-stalls and concreted floor) systems. As a result, designers need to plan new types of dairy cattle barns that will reduce costs, increase profitability, and improve animal welfare and health. In the new plans to be developed, the free-stalls areas to be designed for each animal should be larger, and open areas outside the closed areas should be added to the plans. In addition, barn types such as bedded pack should be further improved by working on them.

6. References

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