INVESTIGATION OF RESPONSE TO SELECTION FOR MILK TRAITS IN DAIRY BUFFALO OF IRAN BASED ON THREE SALE SITUATIONS

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ABSTRACT

The aim of the present study was to estimate the index and individual responses to selection for milk, fat percentage and protein percentage for different breeding goals in three buffalo milk sale situations in *Khuzestan* State of Iran characterized by: 1) selling just milk, 2) selling milk and *Sarshir* cream and 3) selling milk and *Mozzarella*. The current payment policy is based exclusively on milk volume. Index responses to selection were calculated for three different breeding goals (BG): 1) milk yield (MY) exclusively; 2) milk yield and milk fat percentage (MY+FP), 3) milk yield and milk fat and protein percentage (MY+FP+PP), 4) fat percentage (FP) exclusively and 5) fat and protein percentage (FP+PP). Index responses for the milk sale situation were US$102.85 ($BG_1$), US$103.30 (BG_2), US$103.52 ($BG_3$), US$5.26 (BG_4) and US$5.94($BG_5$). For the *Sarshir* (local cream of the region) sale situation, index responses were US$143.99 ($BG_1$), US$143.97 (BG_2), US$144.12 (BG3), US$2.78 (BG_4) and US$2.80($BG_5$) and for *Mozzarella* sale situation, index responses were US$185.13 ($BG_1$), US$185.08 (BG_2), US$ 184.59 (BG_3) US$4.54 ($BG_4$) and US$9.22(BG_5). The results suggest that for the present circumstances, selection for milk components is not advantageous when milk is produced for sale only milk. However, when *Sarshir* cream or *Mozzarella* making is added to the production, the selection for components and milk volume is economically beneficial.

Keywords: buffalo, Iran, selection index, economic weight, *Sarshir* cream

INTRODUCTION

According to statistical data of Food and Agriculture Organization (FAO) in 2010, there is 650 thousand head of buffaloes in Iran that is ranked as 16th country among the 43 countries which breed buffaloes (FAO, 2010). There are buffalo in three different regions of Iran: 1) cold highlands, 2) *Mediterranean* humid temperate and 3) warm lowland. *Khuzestan* province in warm lowland region of Iran is one of the provinces that have buffalo. The suitable climatic conditions of *Khuzestan* for rearing buffalo (existence of important large rivers and ponds and also having a special weather conditions) causes to employment of more than 5 thousand rural families to buffalo rearing (Anonymous, 2008). Relative importance of buffalo products was the same in different areas of the province and in all regions buffalo are

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bred primarily for milk production, so that about 40 percent of *Khuzestan* dairy products produced from buffalo (Anonymous, 2008). There is not government payment policy for buffalo milk and all of its milk is sold to the private sector with free pricing system based on its volume. However, in some cities, most buffalo owners separate fat from milk with completely traditional method and sell it as *Sarshir* (a local cream) along with remaining milk (skim) to market. Buffalo milk has special features because of high fat percentage (6 to 7%), and its products are of high economic value. Therefore, increasing production capacity of buffalo and full use of its genetic potential can be effective in improving buffalo production efficiency and economic buffalo breeding, in addition to providing a significant portion of needed protein.

Generally, to achieve maximum genetic progress, it is necessary to define the target traits for selecting animals (Groen, 1988; Ponzoni, 1988; Bekman and Van Arendonk, 1993; Charfeddine, 2000) and selecting these traits should be such that maximize economic profit of the production system. In dairy animals, milk production and its components have higher economic importance than other traits that with changes in these traits, the greatest changes in profitability is obtained. Komlosi *et al*. (2010) in a study of 15 traits of milk production, growth and carcass characteristics of *Hungarian Holstein-Friesian* cows, reported milk production as the most economically important trait. Seno *et al*. (2006) also to provide a good selection program for buffaloes of *Sao Paulo* state in Brazil, studied the response of single trait and multi trait breeding purposes determined based on milk yield, fat and protein yield. The authors found that the high fat and protein percentages in buffalo milk provide high economic returns to *Brazilian* farmers that produce their own *Mozzarella* cheese.

The aim of this study was to estimate the total and component selection response for milk production traits (milk yield, fat and protein percentage) with different selection purposes in current milk sale situations in *Khuzestan* province of Iran.

MATERIALS AND METHODS

In this study, the current status of the sale of milk and fat (*Sarshir*) was used to calculate the economic values of milk yield (MY) and fat percentage (FP). Also, the proposed sale status of *Mozzarella* cheese was used to calculate economic value of protein percentage (PP) beside milk yield and fat percentage. Production, demographic, economic and management data of 30 buffalo herds with average of 30 head of buffalo cows were used to estimate the parameters required for the calculation of cost and revenue equations. Herds were selected from the main areas of buffalo breeding, so that covered different weather conditions and the production and sale of milk and dairy products, and also different managements. Management system of the herds in the study was traditional and in all herds, milking is performed twice a day by hand and in the presence of calves in order to expedite the removal of milk. Also, cows after the morning milking and feeding are taken to wetlands to bath for 2 to 3 hours.The aim of the present study was to estimate the index and individual responses to selection for milk, fat percentage and protein percentage for different breeding goals for three buffalo milk sale situations in *Khuzestan* state of Iran characterized by: 1) selling just milk, 2) selling milk and *Sarshir* and 3) selling milk and *Mozzarella*. The current payment policy is based exclusively on milk volume. Index responses to selection were calculated for three different breeding goals (BG): 1) milk yield (MY) exclusively; 2) milk yield and milk fat percentage (MY+FP), 3) milk yield and milk fat and protein percentage (MY+FP+PP), 4) fat percentage (FP) exclusively and 5) fat and protein percentage (FP+PP).

Revenues and costs for both present sales situations were considered for all herds: 1) sale of only milk and 2) separation of milk fat to produce *Sarshir*, and sale it and remaining milk along with selling buffalo milk and 3) production and sale of *Mozzarella* cheese substitute of milk and *Sarshir*. *Sarshir* or oily part of milk is produced from milk fat particles with different sizes which are spread on the surface of the milk by heating the milk. We produced *Sarshir* by 1 kilogram milk with different amount of fat percent. Based on this experiment the correlation between fat percentage of milk and the amount of *Sarshir* was obtained 0.72 and the amount of *Sarshir* increased 11 gram with increasing one percent of milk fat percentage. To calculate the amount of *Mozzarella* cheese produced (PKM) from one kg milk in the proposed sale of the study, the equation or *Mozzarella* index proposed by Altiero *et al*. (1989) was used:

$$PKM - MY \text{ x} \left(\frac{3.5\ (\%P)+1.23\ (\%F)-0.88}{100}\right),$$

Where, *MY* is the milk yield and *%F* and *%P* are the milk fat and protein percentage, respectively.

The significant sources of income for considered buffalo herds were sale of milk, *Sarshir* and remaining low-fat milk (skim), sale of animals (calves, heifers, culled cows and sires) and fertilizer. The annual costs for herds were: the cost of producing one kilogram of milk (food and non-food costs), the feed cost to produce one percent of additional fat, the feed cost to produce one percent of additional protein, variable costs include of the average cost of transporting, construction and maintenance, electricity, water, labor, health, and the average cost of feed for one buffalo herd, and also, the fixed cost of herd with an average size of 30 buffalo cows. During collecting data from the herds, measure the amount of feed used by each buffalo was not possible, feed intake and daily food requirements of maintenance, growth, reproduction and milk production of buffaloes were extracted using Borghese (2005).

Economic weights of milk traits were calculated in maximized profit breeding perspective, using following equation:

$$\boldsymbol{TP = TR\text{-}TC}$$

Where, TP is total annual herd profit per head of buffalo cow ($), TR is total annual herd revenues per head of buffalo cow ($) and TC total annual herd costs per head of buffalo cow ($).

The current payment policy is based on exclusively on milk volume. Milk and *Sarshir* prices were 0.73 US$/kg and 8.16 US$/kg, respectively. *Mozzarella* cheeses price were considered equal to *Sarshir* because it was proposed to substitute *Sarshir*. Exchange rate at the time of calculations for this paper: 1 US$ = 12260 Rials (March 2013).

Economic values (Table 1) were calculated for milk yield, fat percentage and protein percentage, taking into accounts the differences of the three sale situations. For the calculation of economic values, the prices of production components and product were obtained from questionary forms with going to each buffalo herd (Taheri Dezfuli *et al*., 2011).

Expected responses were calculated for five different breeding goals (BG) in each sale situation:

1) Milk Yield (MY) exclusively

2) Milk Yield (MY)+Fat Percentage (FP)
3) Milk Yield (MY)+Fat Percentage (FP)+Protein Percentage (PP)
4) Fat Percentage (FP)
5) Fat Percentage (FP)+Protein Percentage (PP)

Index responses to selection were calculated based on the selection index theory (Hazel, 1943). Solutions for weighting factors (b) were calculated as **b** = var (**X**)$^{-1}$ cov (**X**,**A**). **X** is a vector with the information sources, var (**X**) is a matrix with (co)variances between these sources and cov (**X**,**A**) is a vector of covariances between each information source and the true genotype. The index equations are then **Pb** = **Gv** or **b** = **P**$^{-1}$**Gv**. **P** is used to describe the matrix with variances and covariances between the information sources in **X**. It is a variance-covariance matrix between the means of phenotypic observations. **G** is the matrix with covariances between **X** and **A**. Finally, **v** is a vector with economic values of traits in the breeding goal. After calculating the b values, the index (σ^2_I) and breeding goal (σ^2_H) the standard deviation were obtained from: σ_I = sqrt(**b'Pb**) and σ_H = sqrt(**v'Cv**), where **C** = matrix of (co)variances for traits in the breeding goal. The correlation between the index and the breeding goal (r_{IH}) was given by σ_I/σ_H.

Index responses were then obtained from $R = i \times \sigma_I = i \times r_{IH} \times \sigma_H$, where i is the selection intensity, σ_I is the standard deviation of the index, r_{IH} is the correlation between the index and the breeding goal and σ_H is the standard deviation of the breeding goal.

Individual responses to selection were also calculated for the studied traits. The average of genetic and phenotypic parameters of traits used in response calculations are presented in Table 2 (Taheri *et al*., 2012; Da-you *et al*., 2008; Rosati and Van Vleck, 2002; Thevamanoharan *et al*., 2000; Seno *et al*., 2010; Castillo *et al*., 2001; Tonhati *et al*., 2000; Tonhati *et al*., 2004; Aspilcueta-Borquis

Table 1. Economic values (EV), expressed in US$ for milk (MY), fat (FP) and protein percentage (PP) for Milk, Milk and *Sarshir*, and Milk and *Mozzarella* sale situations.

Sale Situation	**EV_{MY}**	**EV_{FP}**	**EV_{PP}**
Milk	0.40	-15.92	-14.91
Milk and *Sarshir*	0.56	8.43	-12.60
Milk and *Mozzarella*	0.72	13.73	61.01

Table 2. Standard deviations (σ_p), heritabilities (bold), genetic (above diagonal), and phenotypic correlation coefficients (below diagonal) for milk yield (MY), fat (FP) and protein (PP) percentages.

Sale Situation	**σ_p**	**MY**	**FP**	**PP**
MY	635.4	**0.22**	-0.08	-0.12
FP	0.93	-0.19	**0.18**	0.31
PP	0.32	-0.20	0.48	**0.18**

et al., 2010). Progeny test was considered to select best buffalo bulls with an average progeny size of 50 daughters per sire. Selection intensity was assumed equal to one.

Relative selection efficiencies (RSE) were expressed as a percentage of the expected responses to selection obtained for BG_1 with each selection index, as follows:

$RSE_2 = (BG_2/BG_1) \times 100$, and
$RSE_3 = (BG_3/BG_1) \times 100$.
$RSE_4 = (BG_4/BG_1) \times 100$.
$RSE_5 = (BG_5/BG_1) \times 100$.

RESULTS AND DISCUSSION

The weighting factors for milk yield, fat percentage and protein percentage, standard deviations of indexes and of breeding goals, correlations between selection indexes and breeding goals, according to the breeding goals, are presented in Table 3, for the three sale situations.

In general, the weighting factors of traits showed magnitude and signals that were in agreement with the breeding goals and economic values of traits in the breeding goals. In the research of Seno *et al*., (2005), taking into account the differences of the two production systems (milk and *Mozzarella* systems), economic values were calculated for MY, FY and PY as 0.26, -0.27 and -0.30 for milk production system and 1.12, 6.90 and 20.14 in *Mozzarella* production system, respectively. Also, Pieters *et al*., (1997) calculated economic values of milk traits for three different *Italian* payment systems. The first system is based on a payment system for regions, where milk is produced for direct consumption or fresh dairy products, second system is based on using milk for the production of *Parmesan* cheese, where protein is of high value and payment system suggested by Badino dealing for the 1985 price and production circumstances for an optimal cheese production (Rozzi, 1989). The results showed that *Parmesan* payment system resulted in the highest marginal value of milk with average composition in situations without herd output limitation.

The selection indexes, calculated for the three studied sale situations and different breeding goals are presented in Table 4. XM, XF and XP refer to the average performance of sires' daughters for milk yield and milk fat and protein percentage, expressed as deviations from the average performance of all females. XF and XP were standardized for the b value obtained for milk yield.

The index and individual responses to selection, calculated for each breeding goal in the three sale situations (Milk, Milk and *Sarshir*, Milk and *Mozzarella*), are presented in Table 5.

In the case of milk sale situation, when breeding goal was only milk, the individual response for milk yield was 257.12 kg. For breeding goal 2 and 3, when we select with two and three-trait indexes, the individual response for milk yield approximately decreased (256.96 and 256.91 kg, respectively), but decreasing amount is negligible. About breeding goal BG_2 and BG_3, individual responses for fat and protein percentage were negative. In the fourth and fifth breeding goals, as the results show due to the negative economic weights for both fat and protein percent, selection based on the attributes of the characters and for these traits, reduced fat and protein percentage (-0.3 and -0.06 %).

Regarding the milk sale situation, the greatest economic response to the index was observed for BG3 (US$103.52), when three studied traits were in the breeding goal, while the lowest index response was observed for BG1 (US$102.85) when selection was only on the milk yield. This was expected, taking into account the current milk payment policy with no differential payment for milk components in this region and negative correlations between fat and protein percentage and milk yield. However, the expected index response for breeding goal BG3 (US$103.52) was the same as BG2 (US$103.30) and both of them were close to BG1 (US$102.85) and the differences were low.

The relative efficiencies of selection were 100.43 and 100.63% for BG2 and BG3, respectively, indicating that the selection exclusively on each selection index (BG1, BG2, and BG3) would be efficient. But this parameter was calculated as 5.11 and 5.77% for BG4 and BG5, respectively, indicating that selection exclusively on fat percent of fat and protein percent would not be efficient in this case. Totally, these results suggest that under the current payment policy, it is not desirable to select on fat and protein percentage, given that the revenues are based exclusively on milk sale. So, selection for milk is the easiest index and more suitable for milk sale situation.

In the case of milk and *Sarshir* sale situation, when breeding goal was only milk, the individual response for milk was approximately the same for three first breeding goals (257.10, 257.20, 257.30 kg). The economic responses were also the same for these three breeding goals. For BG_2, with increasing the number of traits in the index, the individual result for milk did not change basically, but with adding fat and protein percentage in this index, the individual response for fat percentage was improved (from -0.03 to -0.01%). In breeding goal 3, the three-trait indexes (257.30 kg) were superior to selection on milk and fat percentage for milk response. But there were not observed any advantage between two and three-trait indexes for fat percentage response (-0.01 and -0.01%).

The expected index responses, in the milk and *Sarshir* sale situation, were US$143.99 (BG1), US$143.97 (BG2) and US$144.12 (BG3). Despite the positive economic weigh for fat percentage, the individual responses to selection for FP were negative and similar for BG2 and BG3. It seems that negative correlation between fat percentage and milk yield and also greater response for milk yield cause to decrease fat percent. In the fourth and fifth breeding goals, as the results show, selection based on and for fat percent, increased fat percentage as 0.3%, but the response for protein percentage is negative. It was expected because in this case the protein percentage is not important. The relative efficiency of selection for BG2 and BG3 was 100% (99.98 and 100.09%, respectively). This parameter was calculated as 1.93 and 1.94% for BG4 and BG5, respectively, indicating that selection exclusively on fat percent of fat and protein percent would not be efficient. So, comparing these results suggest that with selling of *Sarshir* besides the milk, selection on milk and fat percentage can be desirable as easiest selection index.

In the case of milk and *Mozzarella* sale situation the individual response for milk was also approximately the same for all three breeding goals with increasing the number of traits in index (257.12, 257.30, 257.00 kg) with insignificant differences. The economic responses were also the same for indexes of MY and MY & FP, in this sale situation. For BG_2 with two-trait index, with adding fat and protein percentage in the index, the individual response for fat percentage was improved (from -0.03 to -0.01%). The economic response also had slight increasing for this breeding goal. In breeding goal 3, selection on milk and fat percentage or milk, fat and protein percentage

(-0.004 and -0.005%) were superior to selection index on only milk. For protein percentage also there were not observed any advantage between two and three traits (-0.01 and -0.01%). In this case, the economic response increased for BG3 with adding traits in selection index.

In the milk and *Mozzarella* sale situations, the expected index responses were US$185.13 (BG1), US$185.08 (BG2) and US$184.59 (BG3). The individual responses to selection for FP and PP were negative but less than those in milk and *Sarshir* sale situation. In this case, the relative efficiency of selection for BG2 and BG3 was 100%, too (99.97 and 99.70%, respectively). This parameter was calculated as 2.45 and 4.98% for BG4 and BG5, respectively. The greatest selection response in these two breeding goals was obtained in milk and *Mozzarella* sale situation.

In spite of the economic importance of milk components (fat and protein percentage) in the production of *Mozzarella* cheese, in this situation the results showed that the greatest response was observed when the breeding goal included just the milk yield. But, in the production of *Sarshir*, the results showed that the responses were approximately the same for three breeding goals. Comparing the individual responses to selection for FP and PP obtained for the milk and *Mozzarella* and milk and *Sarshir* sale situations, in milk sale situation if selection were based on these two traits (BG2 and BG_3), negative responses were obtained because of negative economic values. In two other situations, these individual responses also were obtained negative because of their negative correlation with milk yield but its magnitude has decreased from milk sale situation.

The differences in both index and individual responses for milk production traits between the two sale situation (milk and, milk and *Sarshir*) show the importance of implementing appropriate selection indexes for buffalo dairy herds taking into account the local production and market circumstances, with special reference to regions where the *Sarshir* represents the main product of the buffalo dairy activity. Also, the incorporation of the *Mozzarella*-making process on the farm level (as proposed sale situation) resulted in positive economic values for FP and PP, and consequently improved individual responses for these traits. Also, at the individual responses obtained for BG_3, it is observed that the individual responses for FP and PP were around 40 and 50%, respectively, superior to those of BG_2. The results also suggest that the additional payment for fat and protein percentage could benefit not only milk producers, but also the industry.

Seno *et al*., (2006) in study of the index and individual responses to selection for milk (MY), fat (FY) and protein (PY) yields for different breeding goals for two commercial buffalo milk production systems in *São Paulo* State (1. all milk produced is sold to the industry and 2. all milk produced is used in the *Mozzarella* cheese-making process at the farm), suggest that when milk is produced for sale to the industry, selection for milk components is not advantageous and when *Mozzarella* making is added to the system, the selection for components and milk volume is the most economically beneficial.

CONCLUSION

The results obtained in the present study suggest that for the milk sale situation, selection for milk components is not advantageous. However, when the sale situation shifted to milk and *Sarshir* or the manufacturing of *Mozzarella* cheese is

Table 3. Weighting factors (b) for milk Yield (MY), fat (FP) and protein (PP) percentage, standard deviations of indexes (σ_I) and of breeding goals (σ_H), correlations between selection indexes and breeding goals (r_{IH}), according to the breeding goal (BG), for the three sale situations.

Sale Situation	BG	B			σ_I	σ_H	r_{IH}
		MY	FP	PP			
Milk	1	0.5954	-	-	102.85	119.22	0.86270
	2	0.5968	-7.306	-	103.30	119.89	0.86164
	3	0.5979	-9.939	3.905	103.52	120.18	0.86138
	4	-	-22.35	-	5.26	6.28	0.83787
	5	-	-22.41	-17.43	5.94	7.17	0.82773
Milk & *Sarshir*	1	0.8336	-	-	143.99	166.91	0.86270
	2	0.8373	33.05	-	143.97	166.67	0.86377
	3	0.8385	30	10.06	144.12	166.88	0.86366
	4	-	11.84	-	2.78	3.33	0.83787
	5	-	12.47	-20.19	2.80	3.23	0.86399
Milk & *Mozzarella*	1	1.072	-	-	185.13	214.59	0.86270
	2	1.077	46.56	-	185.08	214.23	0.86392
	3	1.079	40.5	123.3	184.59	213.46	0.86475
	4	-	19.28	-	4.54	5.42	0.83787
	5	-	17.9	84.14	9.22	11.21	0.82258

Table 4. Selection indexes standardized for the b value obtained for milk yield (MY), for the three sale situations (Milk, Milk and *Sarshir* cream and Milk & *Mozzarella*) and different breeding goals.

Sale Situation	BG	Index	b value(MY)
Milk	1	$1 (X_{my})$	0.5944
	2	$1 (X_{my}) - 12.24 (X_{fp})$	0.5968
	3	$1 (X_{my}) - 16.62 (X_{fp}) + 6.53 (X_{pp})$	0.5979
	4	$- 22.35 (X_{fp})$	-
	5	$- 22.41 (X_{fp}) - 17.43 (X_{pp})$	-
Milk and *Sarshir*	1	$1 (X_{my})$	0.8330
	2	$1 (X_{my}) + 39.47 (X_{fp})$	0.8373
	3	$1 (X_{my}) + 35.78 (X_{fp}) + 12 (X_{pp})$	0.8385
	4	$11.48 (X_{fp})$	-
	5	$12.47 (X_{fp}) – 20.19 (X_{pp})$	-
Milk and *Mozzarella*	1	$1 (X_{my})$	1.072
	2	$1 (X_{my}) + 43.23 (X_{fp})$	1.077
	3	$1 (X_{my}) + 37.53 (X_{fp}) + 114.27 (X_{pp})$	1.079
	4	$19.28 (X_{fp})$	-
	5	$17.9 (X_{fp}) + 84.14 (X_{pp})$	-

Table 5. Individual* and expected index responses to selection for Milk, Milk and *Sarshir*, and Milk and *Mozzarella* sale situations.

Sale Situation	BG	Individual Response			Index Response ($)
		MY (kg)	FP (%)	PP (%)	
Milk	1	257.10	-	-	102.85
	2	256.90	-0.03	-	103.30
	3	256.90	-0.03	-0.01	103.52
	4	-	-0.3	-	5.26
	5	-	-0.3	-0.06	5.94
Milk and *Sarshir*	1	257.10	-	-	143.99
	2	257.20	-0.01	-	143.97
	3	257.30	-0.01	-0.01	144.12
	4	-	0.3	-	2.78
	5	-	0.3	-0.03	2.80
Milk and *Mozzarella*	1	257.12	-	-	185.13
	2	257.30	-0.01	-	185.08
	3	257.00	-0.005	-0.01	184.59
	4	-	0.3	-	4.54
	5	-	0.23	0.10	9.22

*For milk yield (MY), fat percentage (FP) and protein percentage (PP).

adopted, selection for components and milk volume is the most beneficial from decreasing fat and protein percentage. The differences in index responses for milk production traits between the three sale situations (Milk, Milk and *Sarshir*, Milk and *Mozzarella*) suggest that it is necessary to take into account the local production and market circumstances, when designing breeding programs for buffalo milk production situations in Iran.

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