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EFFECT OF REARING METHODS ON THE GROWTH PERFORMANCE AND WELFARE STATUS OF CALVES

Muhammad Riaz[1], Muhammad Aneeq Azhar[1], Muhammad Sharif[1], Muhammad Yaqoob[1], Haroon Rashid[2]and Muhammad Aziz ur Rahman[1,*]

[1]Institute of Animal and Dairy Sciences, University of Agriculture, Faisalabad
[2]Institute of Physiology and Pharmacology, University of Agriculture, Faisalabad, Pakistan
[*]Corresponding author's e-mail: drazizurrahman@uaf.edu.pk; drriazvirk@yahoo.co.uk

The objective of the study was to evaluate the effect of calf rearing methods in Sahiwal cows on milk and feed intake, weight gain, body condition score, and locomotion score. We randomly selected the eight Sahiwal cows just before their calving and divided into two groups. After parturition, claves from both groups were reared under natural restricted suckling (RS) and artificial rearing system (AR) at Livestock Experimental Station, University of Agriculture, Faisalabad. Restricted suckling calves were allowed to suckle from cow's udder just before milking in the morning and evening (twice milking arrangement) up to weaning. In an artificial rearing system, calves were fed milk through bucket feeders @ 10% of their body weight up to weaning. Post-weaning data for two months were also conceded to complete the trial. The results for weight gain kg week^{-1} was significantly($P<0.05$) higher in RS group (3.35± 0.15) than AR group (2.88 ± 0.31) calves. The average daily weight gain in RS (465 g) group was higher ($P<0.05$) as compared to AR group (332 g) in the pre-weaning phase (90 days). The average weekly weight gain was also higher ($P<0.05$) in RS group (3.26 ± 0.24) as compared to AR group (2.33 ± 0.36) up to weaning. There was no significant difference in weight gain of calves in RS group (3.64 ± 0.16) as compared to AR (3.23 ± 0.15) group in post-weaning. The results of milk composition did not show any difference ($P>0.05$), but the effect of the suckling method had demonstrated a positive impact on the performance of calves. A higher ($P<0.05$) level of cortisol concentration was found in AR group as compared to RS group. Based on results, it is concluded that natural milk feeding had a positive effect in pre-weaning on the growth and stress of Sahiwal calves.

Keywords: rearing methods, performance, welfare status, cortisol, Sahiwal cows.

INTRODUCTION

The unorganized dairy farm operations in the country have been realized as unable to keep pace with emerging milk demands due to the poor potential of indigenous breeds, insufficient feed resources, and high early mortality in calves. The milk production cost in the peri-urban dairy system is relatively high due to a fully stall feeding system (Afzal and Naqvi, 2004; Zhang *et al*., 2020). A significant shift of production system has been observed toward commercial dairying from subsistence farming. It might be only due to ever-increasing demand for milk consumption in urban masses. The factors influencing the cost of milk production are feeding, dairy replacement stock or heifer production, labor wages, artificial insemination services, equipment, forages, concentrate and electricity cost (Flower and Weary, 2001). The successful rearing of dairy replacement stock is proved to be the 2nd highest cost in dairy production (Iqbal *et al.,* 2014).The 50% calf mortality occurs at an early age putting worries for future dairy cows (Ali *et al*., 2020). This high early age mortality affects the availability of quality future dairy animals due to meager milk supply for calves, poor health, and stunted growth, leading to delayed age of puberty (Khan *et al*., 2020). Presently two major calf rearing systems (with the dam or separate rearing) are in vogue at different levels of the dairy production system in Pakistan. The natural nursing of calves depends on the development of social bonds with the dam and it is necessary for the survival and welfare of newborn calf (Enriquez *et al*., 2011; Khan *et al*., 2020).

However, in recent years successful rearing of calves in the restricted suckling system is being compromised in market-oriented peri-urban dairying. The priority of selling more milk instead of feeding to calves is in practice (Iqbal *et al.,* 2014). In the market-oriented dairy farming, calves are mostly separated from their dams and reared separately (Khan *et al*., 2020). Early separation of claves is unnatural and a challenge for the dam along with calf's welfare and production as the detachment involves the loss of milk suckled and loss of care from the dam (Ventura *et al*., 2013). Previous research reported that that the nutritional component of the dam and calf bond is essential (Kamal *et al*., 2019). Restricted suckling (RS) is used to stimulate the milk letdown, and calf is leashed beside the cow in the restricted suckling system. After milking, the young calf is set free to suckle the dam for a specific amount of time (Orihuela, 1990; Derkho *et al*., 2019).

Several positive effects were seen on cow and calf due to suckling both in Zebu crosses and pure Holstein's. The restricted suckling (RS) had shown increased milk production (Bar-Peled *et al.*, 1995). Hence the relative importance of dam's care licking in natural suckling compared to separate rearing impact on growth, behavior, and welfare of calves was desired to be investigated. Therefore, present study was planned to study the effect of mothering behavior on the growth and welfare performance in Sahiwal male calves to investigate better management guidelines for successful rearing of the future dairy replacement stock.

MATERIALS AND METHODS

Experiment protocol and experimental treatment:
Eight newly born male calves with mean weight 21kg from the Sahiwal dairy dams having similar parity and weight were maintained at Livestock Experiment Station (LES), University of Agriculture Faisalabad. All of the experimental calves were divided into two groups randomly in such a way that each had four calves. Dam feed was analyzed as described in literature (Su *et al.*, 2013; Li *et al.*, 2014; Wang *et al.,* 2016; Niu *et al.,* 2017; He *et al.,* 2018; Sharif *et al.,* 2018; Li *et al.,* 2019) for its chemical composition. Two groups of calves were randomly allotted to two experimental treatments, i.e., restricted suckling (RS) and Artificial rearing (AR). The calves in RS group were allowed to stimulate and suckle milk from their dams naturally. However, estimated quantity of milk as per bodyweight of the calf from one or two quarters was ensured. The AR group calves were fed milk through feeders @ 10% of the body. The duration of the weaning period was 90 days.

Data collection
The calves under RS group were weighed both pre-suckling and post-suckling. The calves in AR group were fed milk artificially @ 10% of the bodyweight of each calf (Iqbal *et al.,*2014) till weaning period of ninety days (90). After that weaning period daily ration as per routine (morning/noon/evening times) of LES were offered, and the intake was calculated as

F1 (Feed offered) – F2 (refusal) = FI (intake).

Ad-libitum assess to the fresh water was provided and the intake of water was measured by subtracting the refusal from the quantity offered as described in recent studies (Hussain *et al.,* 2018; Rehman *et al.,* 2019; Hussain *et al.,* 2020).

W1 (Water offered) – W2 (refusal) = WI (intake)

The animals were weighed at weekly intervals at 6.00 am before offering any feed. Weight gain or loss was calculated by subtracting the initial weight from the final weight as described in recent studies (Bajwa *et al.,* 2020; Muhmmad *et al.,* 2020).

Weight Gain = Final weight −Initial weight

Data for body condition scoring was done for the frequency and size of calves.

Maintenance of good skin condition and other welfare protocols were followed. The health status of calves was observed visually for any kind of disease injuries or pain stress induced by management practices as described in recent studies (Muhammad *et al.,* 2016; Aziz ur Rahman *et al.,* 2017; Aziz ur Rahman *et al.,* 2019; Chen *et al.,* 2020).

***Statistical Analysis*:**
The data were statistically analyzed using Completely Randomized Design Minitab's version 17, and the means were compared for significance level using Tuckey's test (Steel *et al*., 1997).

RESULTS

***Growth performance in calves*:** Data of intake and growth performance are presented in Table 1. The average daily weight gain in RS (478 ± 0.13 g day^{-1}) group was significantly higher (*P<0.05*) as compared to AR (411± 0.19 g day^{-1}) in 150 days. The data for average daily weight gain in RS (465 ± 0.21 g day^{-1}) group was significantly higher (*P<0.05*) as compared to AR (332± 0.33 g day^{-1}) in pre-weaning phase (90 days). The average weekly weight gain also showed significantly higher (*P<0.05*) values in RS group as compared to AR group up to weaning. Calves in the RS group showed significantly higher (*P<0.05*) milk efficiency (96 g L^{-1}) as compared to the AR group (78 g L^{-1}). The mean values for weekly weight gain (3.35± 0.15 kg week^{-1}) in RS calves for period of 150 days were (16.32%) higher (*P<0.05*) as compared (2.88 ± 0.31 kg week^{-1}) to AR. There was no significant difference in weight gain of calves in the RS (3.64 ± 0.16) group as compared to the AR (3.23 ± 0.15) group. The data of milk intake for RS group (4.83± 0.81 L.day^{-1}) and AR group (4.56 ± 0.58L day^{-1}) showed a non-significant *(P>0.05*) result. Milk intake in both groups also showed non-significant results during this trial during the first month of research calves. Artificial rearing and RS groups fed average 3.5 L day^{-1} during first month of experiment. Whereas, milk consumed by RS calves during the second month was average 4.7 L day^{-1} and 4.5 L day^{-1} in AR and RS calves, respectively. In last month before weaning AR calves consumed 5.7 L day^{-1} and RS calves 6.30 L day^{-1}, respectively.

Table 1. Effect of rearing methods on intake and performance in calves.

	Natural Rearing	Artificial Rearing
Pre-weaning Avg. wt gain (g day^{-1})	465±0.21^{a}	332±0.33^{b}
Overall daily wt. gain (g day^{-1})	478±0.13^{a}	411±0.19^{b}
Pre-weaning Avg. wt gain (kg week^{-1})	3.26±0.24^{a}	2.33±0.36^{b}
Post weaning Avg. wt gain (kg week^{-1})	3.64±0.16^{a}	3.23±0.15^{a}
Overall Avg. wt gain (kg week^{-1})	3.35±0.15^{a}	2.88±0.31^{b}
Avg. milk intake (L. day^{-1} calf^{-1})	4.83±0.81^{a}	4.56±0.58^{a}
Milk efficiency	0.10±0.09^{a}	0.07±0.07^{b}
Avg. intake DMI (kg day^{-1})	2.59±0.18^{a}	2.32±0.29^{a}
Avg. Water intake (L. day^{-1})	4.45±0.18^{a}	4.62±0.19^{a}

Welfare status: Data of body condition score and locomotion score are presented in Fig. 1. Body condition score was calculated as described in literature (Zhang *et al.*, 2015). Calves in RS group (2.95 ± 0.12) showed better (*P > 0.05*) results for body condition score (BCS) as compared to AR group (2.87± 0.08), respectively. Locomotion and well-being of calves were also scored (1-5). Mean values for RS calves were 4.25, and for AR calves were 4.05, respectively.

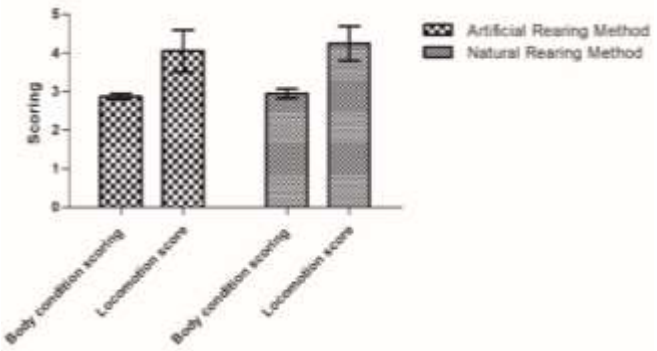

Figure 1. Effect of rearing methods on body condition scoring and locomotion score in calves

Data of cortisol concentration, rectal temperature, heart rate and respiration is presented in Fig. 2. Data was collected as described in recent studies with some modification (Xia *et al.*, 2018a; Xia *et al.*, 2018b; Xia *et al.*, 2018c; ; Chen *et al.*, 2019) The mean values of cortisol in the RS group were 140.86 ng ml^{-1} and in the AR group were 187.48 $ngml^{-1}$. Both treatments (RS vs AR) did not affect the rectal temperature of calves, respiration rate, and heart rate. Restricted suckling had(*P<0.05*) mean values for rectal body temp, respiration rate, and heart rate 102±0.12^{0}F,56.8, and 122, respectively. In contrast, in AR, the mean values for rectal body temp, respiration rate, and heart rate were102.02 ± 0.15^{0}F54.4 127, respectively.

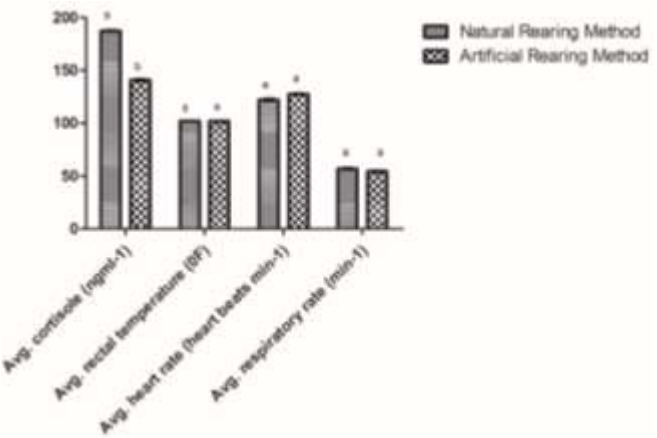

Figure 2. Effect of rearing methods on cortisol, rectal temperature and respiration in calves.

DISCUSSION

Results of the current study revealed that calves in RS had higher milk intake and better milk conversion efficiency for daily weight gain as compared to the AR. The development of social bonds of nursing calves with the dam resulted in beneficial effects and higher weight gain in RS group as compared to AR (Shahid *et al*., 2019). The mothering behavior of dams for calves might had stimulated better growth performance and wellbeing in the early days of calf's life. Therefore, a higher growth rate in RS in the current study might be attributed with the positive influence of mothering behavior. Positive influence for a higher daily weight gain for restricted suckling was also recorded by Fröberg *et al.* (2007). Similarly, Metz *et al.* (1987) also found higher weight gains by calves housed with their dams and allowed them to suckle milk directly for the first ten (10) days after birth. Another study (Metz *et al.*, 1987) indicated a 39.7% higher weight gain during the pre-weaning phase in RS group as compared to AR group. Roth *et al.* (2009) also supported the findings of the present study and revealed that dam suckled calves gained more weight gain in contrast to bucket fed calves. Grøndahl *et al.* (2007) reported that suckling calves having free access to the dams had shown higher gains as compared to bucket fed calves.

Findings of current study explored that weight gain was similar in calves of RS group AR group during the post-weaning phase (60 days) of growth even a negative impact of social bonding may have an impact on more cortisol production having additional stress caused due to weaning after the development of social bonding with the dam. Earlier studies also indicated that nursing with dam could provide good health and welfare advantages to calves (Krohn, 2001; Flower and Weary, 2003; Shahid *et al*., 2019). It can improve the gut microflora and recent studies reported that beneficial gut microflora have positive impact on growth(Qiu *et al.*, 2018; Qiu *et al.*, 2019a; Qiu *et al.*, 2019b; Qiu *et al.*, 2020). It was further mentioned that calves reared with their dams had better weight gain than the calves reared in artificial rearing system (Flower and Weary, 2001). It has been reported in the previous study that growth rate of calves in RS was due to higher growth-promoting hormones level in natural suckled calves (Lupoli *et al*., 2001). However, in the current study, the opposite happened. In the post-weaning phase, the growth rate was the same, which is similar to the findings of the previous study (Hepola, 2008), who found similar weight gain for restricted suckling and artificial rearing groups. More interestingly, it has been reported that calves up to 4th week had higher weight gain when fed with artificial teat instead of bucket fed. This increase was due to higher intake when fed with teat and better digestive system than bucket fed calves (Appleby *et al.*, 2001). Total sucking time day^{-1} and frequency of suckling day^{-1} may be decreased with increased age of calf

(Reinhardt and Rienhardt, 1981). It was also emphasized that the nutrition and weaning weight gain might influence the future milk capacity of the mammary glands of the replacement dairy cows (Sejrsen *et al*., 2000). Arginine is one of the limiting amino acid in poultry (Abdullah *et al.,* 2019) and dairy production. Emphasis on arginine requirement is also necessary to improve the udder health and calf-dam welfare.

The milk intake remained in accordance to the 10% of body weight. Otherwise, they might be able to suckle more milk as per result revealed earlier by (Jasper and Weary, 2002) that dairy calves are clearly able to consume much more milk during suckling than they are typically provided through buckets. The calves fed *ad libitum* consumed on an average of 8.8 $Lday^{-1}$, compared to 4.7 L day^{-1} for the bucket fed calves. Fröberg *et al.* (2007) also reported similar milk intake in both groups and the current study is an agreement with previous study. Appleby *et al.* (2001) also suggested that calves in a partial suckling system drink as much milk as that fed *ad libitum* from a teat. The calves fed *ad-libitum* consumed an average of 8.8 kg day^{-1}, compared to 4.7 kg day^{-1} for the conventionally fed calves (Appleby *et al*., 2001). Similar levels of milk intake trends were found in RS group of the present trial as compared to AR group. Calves that were provided with more milk consumed less calf starter and hay, respectively (Hammell *et al*., 1988; Khalili *et al*., 1992). A constant amount of concentrate was fed to both groups according @ 400gm $caIf^{-1}$ during the first three months and after that 1 $kgday^{-1}caIf^{-1}$. It was also further observed that RS calves were found more active than AR calves. FIower and Weary (2001) also revealed that calves weaned Later start rumination at the 2nd week of age and ate more solid food as compared to other calves. Concentrate intake was higher in milk-fed calves in contrast to mother fed calves (Jasper and Weary, 2002; HepoIa, 2003; Borderas *et al*., 2007) and rumen development was also influenced by concentrate intake (Roth *et al*., 2009).

The weekly data of BCS showed a non-significant effect on BCS in both of the groups (RS vs AR). During restricted suckling when calves suck milk directly from dam's udder, dams tended to lick calf's body. This physical stimulation increases the blood circulation which helps in improving the metabolism and alleviating the oxidative stress. The liking behavior of cow had a beneficial effect on body condition to improve the scoring of calves, which was absent in artificial rearing. (Fröberg *et al*., 2007) described the coat scoring of calves during the trial and reported that the body coat of RS calves (92) was better as compared to AR calves (65). It was further revealed that mothering behavior improved body condition scoring of calves as endorsed by earlier researchers that suckling the dam reduced bouts of diarrhea for three weeks, improved digestive function, prevented the abnormal behavior of cross-sucking, as the motivation was satisfied on the dam (Flower and Weary, 2003), and also improved immunity by exposure to existing pathogens in the herd (Wagenaar and Langhout, 2007). All these factors increased the body condition score due to improved health in RS group. Improved health was observed as chances of diarrhea in calves decreased by suckling (Preston and Vaccaro, 1989). Moreover, lowered mortality rate was also observed in traditional management (Preston, 1984). It might be attributed to better antibodies transferred from mother to calf through colostrum and suckling milk (Ryle and Orskov, 1990); and reduced chances of milk contamination in restricted suckling (Fulkerson *et al*., 1978). The separation was proved to be a stressful factor to calves, which could damage their health and body condition scoring in AR group (Stěhulová *et al.*, 2008). It could be revealed that calves allowed to be remained with the dam until weaning simultaneously improved body condition scoring, reduced risk of disease or diarrhea through improved colostrum intake and licking by the dam.

Locomotion of calves was scored as 1-5. The result of locomotion during the trial indicated that RS calves scored better than AR calves, but values showed non-significant difference. The better score in RS group might be due to better physiological functions in response to dam persuading behavior. This activity was absent in AR group. It was revealed that mothering behavior improved the health and wellbeing as endorsed by earlier researchers that suckling the dam reduces bouts of diarrhea for 3 weeks, improves digestive function, prevents the abnormal behavior of cross-sucking, as the motivation is satisfied on the dam (Flower and Weary, 2003), and improves immunity by exposure to existing pathogens in the herd (Wagenaar and Langhout, 2007).The dam might had also enhanced calf absorption of colostrum Immunoglobulin's (Ig's), essential for passive immunity in the first 14 days of life. The dam also persuades the calf to stand and suckle sooner (Flower and Weary, 2003). In the first 24 hours, 30% of calves naturally do not suckle and so need guidance to the teat or supplementary colostrum to ensure adequate intake (Flower and Weary, 2003).It was observed that the calves typically licked by the dam for several hours post-partum showed better health and wellbeing. That might have stimulated the calf activity and had physiological benefits for stimulating breathing, blood circulation, urination, defecation, and drying (Rushen *et al.*, 2007).

Separation was proved to be a stressful factor to calves, which could damage their health and well-being as calves heart rates increased rapidly at separation (Stěhulová *et al.*, 2008). Serum cortisol level was used as a stress indicator in the experimental calves in RS and AR groups. The average cortisol value was higher ($P<0.05$) in AR calves as compared to RS calves. The mean values of cortisol in RS group were 140.86 ng ml^{-1} and in AR group were 187.48 $ngml^{-1}$, respectively. The results of cortisol concentration the research trial was supported by Hernández *et al.* (2006) who reported that artificially reared calves (AR) had a significantly higher level of serum cortisol

concentration than in those suckling from their mothers (RS). Acevedo *et al.*(2005) reported that calves in the RS treatment displayed lower levels of serum cortisol concentration 24 h after the beginning of the treatment in comparison with those in the AR treatment, suggesting that suckling or social contact may reduce anxiety.

These findings were in agreement with Price *et al.*(2003) who showed that the well-being of newly weaned calves was improved if allowed some social contact with their dams at weaning. It might have been a wellbeing indicator of calves with dam and explained the welfare condition of calves (RS) due to suckling of dams with the effect of mothering behavior of dams. The stress level was also reduced in natural suckled calves during isolation test (Duve *et al*., 2012). Dams tended to lick calf's body during suckling might have been a cause of pleasing hormone to reduce stress in calves. Oxytocin had an anti-stress effect on calves, such as maintain blood pressure level and decreased cortisol levels (Lupoli *et al.*, 2001). Previous studies also explained that higher oxytocin levels due to suckling in calves lead to lower cortisol levels in the later part of life (Uddin *et al*., 2020). The behavioral affection of cows was missed in AR calves. The daily 60-min suckling periods probably affect how the animals react to the stress, resulting in lower cortisol levels. Roth *et al.*(2009) further explained in their findings that oxytocin level in restricted suckled calves was higher than bucket fed calves, although calves had contact with dam or not. Allowing calves to remain with the dam until natural weaning simultaneously improved health reduced the risk of diarrhea through improved colostrums intake. Licking by the dam might have improved psychological wellbeing by avoiding the distress of separation and allowing positive bonding experiences with the dam. Calves associated with their mothers for two months had also shown more social behavior and less abnormal oral behavior i.e., cross sucking than the calves separated at day old (Wagner *et al.*, 2013).

The results for the physiological parameters are non-significantly different. Both treatments (RS vs AR) did not affect the rectal temperature of calves, respiration rate, and heart rate. Restricted suckling and artificial rearing both groups had similar ($P>0.05$) mean values for rectal body temp 102^0F, respiration rate (56.8), and heart rate 122 in RS. In contrast, in AR the mean values for respiration rate were 54.4, and heart rate 127 in AR calves. Acevedo *et al.* (2005) also reported non-significant difference in body temperature between suckling and non-suckling treatments. The non-significant variation in physiological norms indicated no distress upon the experimental calves as the heart rate had been used to monitor animal anxiety and physical activity (Lefcourt *et al.*, 1999). The little higher values for the respiration rate in RS might be due to more social behavior and physical activity. The results are in line with Lefcourt *et al.* (1999) who reported that the significant increase found in the respiration rate of RS calves could be due to from licking activity observed but not measured in calves during suckling at pasture. Stěhulová *et al.*(2008) reported that calves exhibited an increase in heart rate after separation, probably indicated an immediate stress reaction due to separation from the dam. Steinhardt and Thielscher (1999) also reported lower heart rates in calves that could hear the voice of their mothers, i.e., RS group as compared to AR group. Acevedo *et al.*(2005) reported that calves in the RS treatment showed a higher respiration rate (44.4±1.73 respirations min^{-1}) than those in AR (37.8± 2.5 respirations min^{-1}), 24 h after the beginning of the treatment.

***Conclusion*:** The findings of the research revealed that the effect of mothering behavior was more critical in the pre-weaning phase with restricted suckling on growth performance and the welfare of calves as compared to artificial rearing (bucket feeding). It was found that a positive effect on growth performance persisted for the first couple of months (weaning), after that (post-weaning) more stress and non-significant difference in weight gain was observed. Long term studies for post-weaning weight gain are desired to study adaption and positive carry-over effect in RS group.

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