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RESEARCH ARTICLE

Economic Comparison of Sunflower, Canola, and Soybean Meals in Dairy Cow Diets and Their Impact on Milk Yield and Composition

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ABSTRACT

The goal of the current feeding trial was to compare the economic value of SBM (soybean meal), SFM (sunflower meal) and CM (canola meal) and their effect on milk yield, and milk composition of Holstein Friesian (HF) cows. Nine lactating HF cows were fed on three Iso-caloric and Iso-nitrogenous diets (A, B and C) containing SBM (3%), SFM (9%) and CM (6%) along with basal diet (Oat and wheat straw) respectively for 6 weeks. Mean daily dry matter intake (DMI) of basal diet and Daily total DMI (TDMI) was not different significantly (P>0.05), However DMI of the experimental diets was significantly (P<0.05) affected and daily DMI of experimental diets A, B and C was 5.93, 5.71 and 5.69 kg respectively. High MY (milk yield) (P<0.05) 17.74 kg/day, milk fat (3.87 %) and lactose (4.24 %) were observed for diet A as compare to diet B and C. Same level of TS (11.53, 11.43 % respectively) were observed for diet A and diet C. In *sacco* rumen degradability value (%) at different incubation period (3, 6, 12, 24, 48 hrs) were high for diet A and were significantly varied (P<0.05) in 6, 12 and 24 hrs among diets A and C. Economics evaluation revealed that cost of feeding (Rs/d) for experimental diets was significantly different (P<0.05) with highest cost of Rs. 204.80 for diet A and lowest was for diet C Rs. 166.65. GI (gross income) via selling milk was highest (P<0.05) for diet A (1419.2 Rs/d) than diets B and C. Net income (NI) of diet A (1214.4 Rs/d) was significantly (P<0.05) highest than diets B and C, 1012.3 and 1071.4 Rs/d respectively. These results concluded that SBM is more economical than SFM and CM at lower level of inclusion in dairy ration and there is a tendency of economical milk production in CM if included as a supplementary protein in the dairy cows ration.

1. Introduction

Milk industry is an emerging business in Pakistan (IFCN, 2014) with 52,632 million tons of milk production per annum but still milk production is low and cannot meet the demand of growing population [1]. Major cause of the lower production are insufficient nutrients supply as research studies in the past few decades revealed that available feed resources for livestock are poor qualitatively and quantitatively in terms of proteins, energy, minerals and vitamins supply [2]. For optimum production efficiency balanced supply of nutrients are needed to be provided in daily ration because production rely on the nutrients supply to the microflora of the rumen as rumen microflora are 75 percent AA (amino acids) [3], which can meet the 70-80 % of AA requirement of ruminants [4] and for this purpose energy and protein supplements are provided to enhance the milk production efficiency of lactating cows. Proteins supplements mostly included oil seed industry by products like cakes and meals [5]. Throughout the world SBM (Soybean meal), CM (Canola meal), SFM (Sunflower meal), PNM (Peanut meal) and FM (Fish meal) contribution in the animal feeds are 69, 13, 5, 2, 2 percent respectively [6]. Global production of SBM is estimated about 160 million ton [7] and the main exporter countries are Argentina, Brazil and USA which exports annually 37, 29 and 8 percent SBM respectively. Soybean is an important source of protein recognized as “gold standard” as other proteins sources are compared with it due to its high CP (crude protein) (42 %), high digestibility of rumen un-degradable protein in intestine (26 %) and best AA contents [8,9,10]. In developed countries SBM is mostly used in the dairy rations as it enhance feed intake (FI), dry matter intake (DMI), milk yield (MY) and improve milk composition especially proteins content [11,12,13,14]. Although soybeans contain high level of rumen degradability [10] some antinutrients like inhibitors of proteolytic enzymes like trypsin inhibitors (Kunitz inhibitors and the Bowman Birk inhibitors) can depress its digestibility [15]. Soybean meal has high cost and many research works have been carried for its replacement with other protein supplements like oilseed meals (cottonseed meal, sunflower meal, rapeseed meal, mustard meal and groundnut meal) [16,17,18,19], legume seed (peas, faba beans, lupins) [20], cassava hay [21], animal origin protein supplements (bone meal, fish meal, meat meal, poultry and slaughter house by-products) [22,23,24] and starch and distillery by-products, leaf meals (alfalfa) [25] in those countries which import SBM. Researchers conducted trials for the replacement of SBM with CM in dairy ration due to low levels of antinutrients (erucic acids and glucosinolate), low cost of feeding [26,27] good protein concentration [26,28] and its effect as a supplementary protein source for lactating cows may be efficient like SBM [29,30]. Another supplementary protein source used in dairy rations is SFM and considered good and major protein source fed to the livestock particularly in lactating cows ration, poultry, pigs and rabbits because it is a good source of vegetable protein, high in fiber and EE content. One good characteristic of SFM is that it does not have anti nutrients, although with high level of fiber and lignin which depress the digestibility moreover SFM is the good source of macro minerals (Ca and P) and vitamin B which positively affect milk composition that improved the market value of milk [31]. Manipulation of the proteins in dairy ration is the critical strategy that can provide economically feasible production to the dairy farmers [32]. Limited studies are available on comparison of the SBM, SFM and CM in dairy ration. Keeping in view the importance of the supplementation of protein in the dairy ration current study was conducted to compare the effect of soybean meal (SBM), canola meal (CM) and sunflower meal (SFM) in the dairy cow as a supplemental protein source. Objectives of this study were to investigate the comparative effect of soybean meal, sunflower meal and canola meal on milk yield, milk composition of dairy cows and to evaluate the economics of experimental ration.

2. Materials and methods

2.1. Site of experiment, formulation and chemical analysis of experimental diet

This trial was conducted at University Dairy Farm, The University of Agriculture, Peshawar to compare the economic value of SBM, SFM, and CM and its effect on milk yield and composition of Holstein Frisian (HF) cows. Experiment was completed in 6 weeks, first week was offered to each group as an adaptation period. Three iso-nitrogenic and iso-caloric concentrate diets A, B and C (table I) were formulated as per NRC recommendations [9] for dairy cows. Proximate analysis was carried out according to the method of Association of Official Analytical Chemist [33] for determination of dry matter (DM), crude protein (CP), crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), ether extract (EE) Ash at the laboratories of Department of Animal Nutrition, The University of Agriculture Peshawar and Center of Animal Nutrition, Directorate of Livestock Research and Development, Peshawar.

2.2 Selection, feeding and milking of experimental animals

This trial was conducted in the months of January and February 2016 at University Dairy Farm, The University of Agriculture, Peshawar to compare the economic value of SBM, SFM, and CM and its effect on milk yield and composition of Holstein Frisian (HF) cows. Experiment was completed in 6 weeks, first week was offered to each group as an adaptation period. Three iso-nitrogenic and iso-caloric concentrate diets A, B and C (table I) were formulated as per NRC recommendations [9] for dairy cows. Proximate analysis was carried out according to the method of Association of Official Analytical Chemist [33] for determination of dry matter (DM), crude protein (CP), crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), ether extract (EE) Ash at the laboratories of Department of Animal Nutrition, The University of Agriculture Peshawar and Center of Animal Nutrition, Directorate of Livestock Research and Development, Peshawar. Daily weighed quantity of feed was offered and feed intake was determined by obtaining the difference between the quantity of offered feed and the left over and the data of each group was recorded separately. Feed intake was measured as a dry matter intake (DMI), which was calculated as percent dry matter in feed offered multiply by feed consumed in kg/cow. Milk production per day for each experimental animal was calculated daily at the time of milking in a parlor by weighing the milk produced of each cow with the help of digital balance and the morning and evening data of each cow was recorded. Milk samples of each experimental cow were analyzed on weekly basis.100 ml representative sample of fresh milk was taken from each experimental animal in labeled bottles. Milk samples were analyzed for milk Fat, Solid Not Fat (SNF), total protein, lactose and total solids by Milko analyzer machine (Milk Analyzer, made in Bulgaria, serial 29722) at Center of Animal Nutrition, Directorate of Livestock Research and Development, Peshawar. Economics of experimental ration was calculated from the cost per day of feeding of experimental diet consumed by a cow and gross income via selling of milk per cow per day, then net income of groups (A, B and C) was compared for profitability.

Degradability of the experimental diets was determined by procedure of Cottrill and Evans [34]. Triplicate Nylon bags containing 5 gm sample for each diet (A, B and C) was incubated in the rumen of fistulated cow for different incubation period (3, 6, 12, 24 and 48 hrs) and at the termination of each incubation period bags for each diet were recovered from the rumen and were hand washed until the water flowing out from bags clear and the bags become free from any rumen content adhering to it. After washing each bag containing residues was oven dried for 48 hrs on 60 °C and after drying bags were shifted to dessicator for cooling and weighed for final weight after incubation and drying. In *sacco* percent protein degradability level was calculated by following formula and the disappearance of protein from bags was assumed degraded protein in the rumen as explained by Roomi et al. [35].

2.3 Statistical analysis of the data

The data was recorded in MS excel sheet and after arranging for software statistically analyzed by using statistical analysis system (SAS version 2000) analysis of variance techniques appropriate for completely randomized design (CRD). Significant differences among the mean effects of experimental diets were determined by using least significant difference (LSD) test [36] for all the parameters.

Table 1. Formulation of experimental diets containing different meals.

Ingredients (%)	DIET-A	DIET-B	DIET-C
Soybean meal	3	0	0
Sunflower Meal	0	9	0
Canola Meal	0	0	6
Wheat Bran	34	34	34
Maize grain (Crushed)	11	11	11
Cotton Seed Cake	23	13	17
Mustard seed Cake	4	5	6
Molasses	11	11	11
Maize Gluten (30 %)	11	14	12
Salt	1	1	1
DCP	2	2	2
Total	100	100	100
Chemical Composition			
Crude Protein % in DM	16.57	16.56	16.76
TDN[1]% DM	70.84	69.67	70.53
NEL[2] (Mcal/Kg)	1.61	1.58	1.60

A .Soybean meal diet; B. Sunflower meal diet; C. Canola meal diet; 1. Total Digestible Nutrients; 2. Net Energy for Lactation [NEL (Mcal/kg) = 0.0245 × TDN (%) - 0.12………… NRC (2001)**].**

Table 2. Proximate chemical composition of different meals.

Nutrients	SBM[1]	SFM[2]	CM[3]
Dry Matter	90.20	90.67	89.13
Ash (% DM)	7.49	9.32	7.27
Organic matter (% DM)	82.71	81.35	81.86
Crude Protein (% DM)	47.97	27.50	41.40
Ether Extract (% DM)	2.0	2.3	3.05
Crude Fiber (% DM)	8.63	33.94	18.34
Neutral detergent fiber (% DM)	13.7	26.9	46.4
Acid detergent fiber (% DM)	8.3	18.8	33.2
Nitrogen Free Extract (% DM)	23.78	18.45	15.07

1.Soybean meal; 2. Sunflower meal; 3. Canola meal

Table 3. Proximate chemical composition of different experimental diets.

Nutrients	DIET-A	DIET-B	DIET-C
Dry Matter	85.00	84.84	84.74
Ash (% DM)	20.65	23.99	23.90
Crude Protein (% DM)	16.57	16.56	16.76
Ether Extract (% DM)	4.76	6.02	6.79
Crude Fiber (% DM)	13.34	16.15	14.37
Acid detergent fiber (% DM)	11.12	12.12	15.07
Neutral detergent fiber (% DM)	23.48	32.45	32.22
Nitrogen Free Extract (% DM)	29.68	21.96	22.92

A .Soybean meal base diet; B. Sunflower meal base diet; C. Canola meal base diet.

Table 4. Proximate chemical composition of other feed ingredients.

Nutrients	CSC[1]	MSC[2]	MG[3]	WB[4]	MG (30 %)[5]
Dry Matter	91.7	91.4	87.5	89.00	87.9
Ash (% DM)	6.9	11	1.7	4.3	1.4
Crude Protein (% DM)	23.07	30.04	9.00	11.03	30.00
Ether Extract (% DM)	8.3	9.7	4.8	4.2	7
Crude Fiber (% DM)	27.4	19.8	2.9	9.7	12.5
Nitrogen Free Extract (% DM)	26.03	20.86	69.1	59.77	37

1.Cotton seed cake; 2. Mustard seed cake; 3. Maize grain; 4. Wheat bran; 5. Maize gluten

3. Results and Discussion

3.1 Dry Matter Intake (DMI)

Mean values of dry matter intake (DMI) from the basal diet and total dry matter intake (TDMI) of cows presented in table 5 were not significantly different (P>0.05) among the experimental groups. Mean values of the DMI of experimental diets were significantly different (P<0.05) for the diet A than diets B and C. Mean values of DMI of experimental diets revealed that DMI intake of diet A was high. Highest DMI of diet A than diet B and C may be due to the high NDF and EE content of diet B and C. Although all the three experimental diets were iso-caloric and iso-nitrogenous but level of the other nutrients (OM, EE, NDF and ADF) were different. DMI was adversely affected linearly by NDF and EE [37] because high NDF (cellulose, hemicelluloses and lignin)content of feed limited the gut fill and increased the digesta passage in the GIT and high EE content depressed the activity and growth of the fiber digesting bacteria [38]. High DMI for diet A was in line with the study of Moghadam et al., [39] who found in their experiment while comparing the XSBM (xylose treated soybean meal) and CGM (corn gluten meal) that DMI for cows receiving XSBM was higher. Ingredients' used in the diets formulation as diet A comprised high CSC and high DMI may be due to the high palatability of CSC and acting as a good source of appetizer [40]. Sunflower meal was extensively used in the dairy cows ration in the East Europe as a supplementary protein source because of lack of anti-nutrients, good palatability and no upper limits for inclusion in the diets when dehulled [41]. In the study conducted by Jabbar et al., [42] CSC was replaced by SFM in concentrate mixture fed to the cross bred heifers showed highest intake and palatability for SFM as compared to the CSC and considered one of the best source of Ca (calcium) P (phosphorus) and Vitamin-B complex [41]. However in the current study the lower DMI for diet B may be due to the high fiber (*lignin*) in SFM that reduced the energy, protein and AA (amino acid) supply to the rumen microbes and Titi [43] stated that exogenous fiber digesting enzymes (fibrolytic enzymes) may be used in the ration of SFM to break down the fiber portion of SFM for releasing of more energy and protein. The TDMI for all the experimental diets were in narrow ranges and similar results were found by Yildiz et al. [41]. They concluded in their study that the average TDMI was in narrow ranges without any significant difference for experimental diets supplemented with SBM, SFM, DDGS and RSM (canola type) having crude protein (CP) and energy level according to the animal requirements. Promkot et al. [44] concluded after conducting experimental trial on dairy cows while studying effect of different CP levels and CSM replacing for SBM in a cassava chips and rice straw based diets which were fed in a ratio of 40:60 (Concentrates: roughages, respectively) as TMR for *ad libitum* consumption by dairy cows that DMI is linearly increased with increasing the level of CP in the diet. However in other study field beans were used as a substitute of SBM in iso-caloric and iso-nitrogenous diets and no difference were found in DMI [45]. Yildiz et al. [41] observed that DMI tended to increase for diet containing SBM as a supplemental protein source. As stated by Jabbar et al., [46] that diets comprises same crude protein percentage and same energy did not influence the DMI and CPI however if they contained varied level of degradable proteins. In another study Mahr-un-Nisa et al. [47] conducted on productive parameters of ruminants affected by protein fractions in the diet and concluded that DMI is increased with increase in RDP in the diet which are deficient in RDP due to increase in rumen ammonia-N concentrations which enhance the microbial count and microbial function in the rumen. However in contrast Castillo et al. [48] stated that increasing the CP level or changing the CP degradability had also no effect on the TDMI. In contrast to our findings in a meta-analysis comparing the feeding value of CM and SBM in dairy cow diet high DMI was found for the CM than SBM [28]. Sporndly and Asberg, [49] examined the palatability of the common protein sources and that the consumption of the CM was 221 gm as compared to the SBM which was 96 gm in first three minutes. High palatability of CM may be due to the high sucrose content [26]. Increased DMI for CM as compared to SBM may due to the lower energy of the CM which stimulate the DMI but the effects of the concentrate metabolizable energy (ME) concentration are low and difficult to explain the difference in DMI for CM and SBM [28]. In current trial the lower DMI for CM may be due to the presence of anti-nutrients like glucosinolate as some regions of the world such as China and India still produce rapeseed and mustard with relatively high levels of glucosinolates which can reduce feed intake and DMI [26].

3.2 Milk yield

Daily average milk yield (kg/day) of the experimental groups is presented in the table 5. Milk yield of cows fed on experimental diets A, B and C was significantly different ($P<0.05$) for diet A than diets B and C. The result of the study revealed that SBM supplementation in the feed has high milk yield however the groups fed on diet B (SFM) and diet C (CM) showed no statistically difference in milk yield. Results of MY for this study are supported by the experiment conducted by Yildiz et al. [41]. They observed highest MY for cows receiving diet comprising SBM as a supplemental protein source while comparing different dietary protein sources (SBM, SFM, DDGS and RSM, Canola type) as a supplemental protein in the diet of dairy cows. Highest MY for diet A as compare to diets B and C may be due to the highest level of feed unit for milk (FUM) in SBM as compare to SFM and CM. Todorov et al. [50] stated that SBM contained higher level of FUM (1.13-1.15 FUM/Kg) followed by CM (0.9-1.05 FUM/Kg) and lowest for SFM (0.70-0.98 FUM/Kg), high level of RDP (rumen degradable protein) with balanced AA (amino acids) profile and the greatest cell wall digestibility than other oil seed meals (INRA, 1988) and comprised a good source of intestinal digestible lysine [51]. Experimental diet had significantly affected the overall MY in lactating cows when the dietary allowances matched the requirements of animal [42] which supported the highest MY for diet A (contained SBM) because the DAA (digestible amino acids) profile of SBM more closely matched the AA requirements of animals than any other meal [52]. Our results were also supported by other experiments conducted by Magometovich [53] and concluded that cows fed on SFM based diet had lower MY as compared to SBM based diet however in contrast Drackley and Schingoethe, [54] stated that SFM is an appropriate and a sole supplementary protein source and equal MY was observed when partially or fully dehulled SFM was used for the replacement of SBM in dairy ration. Different constitution of the diets affected the MY due to change in the fermentation pattern and fermentation metabolites especially volatile fatty acids (VFA) (acetic acid, propionic acid and butyric acid) produced in the rumen as high proportion of propionic acid in the VFA is positively related to milk yield and propionic acid production predominates on a high concentrate intake [55]. Rumen VFA content and proportion of different VFA are affected by concentrate, level of starch and roughages proportion in the daily ration [56]. Proportion of VFA in the rumen is different with different ration and the total VFA produced in the rumen and their proportion are important factor for MY and milk composition [43]. The production and proportion of different VFA are affected by changing the microflora (bacteria, protozoa and fungi) of the rumen especially bacterial type and populationas reduction in the number of ruminococci an acetate producing bacteria and results in proliferation of succinate producing gram negative bacteria and succinate is converted by selenomonas ruminantium to propionate [55]. In contrast to our study in a review and meta-analysis of evaluation of Canola meal as a protein supplement for dairy cows Huhtanen et al. [28] concluded that the daily MY responses were high for CM than SBM. Newkirk, [26] stated that CM has the best AA (amino acids) balance and highest MPS (milk protein score) from all other plant protein sources which increased MY but the lower production of the MY of cows receiving CM diet in the present study as compare to SBM diet may be due to lower intake of diet C than diet A which lead to the lowered propionate production in the rumen. Brito et al. [57] observed high MY with CM due to the AA profile in the bypass protein of CM matching the MP (microbial protein) which lead to increased MY. After reviewing previous experimental studies Yildiz and Todorvo [52] found equal or high MY for RSM while compared with SBM and Brito et al. [57] also observed equal MY when feeding RSM as a substitute of SBM. In experiment of Agapov [58] cows receiving RSM has high MY than cows fed on SFM diet. Variation in the MY for different experimental diets in the current study may be due to the different constitution of the diets and CSC supplementation in the diets overlapped the individual effect of the meals (SFM, CM and SBM) due to lower level of inclusion of the meals in the diets. Our results are supported by Toolsee [59] who concluded that MY was increased up to 11-30 % in lactating cows with increasing the CSC supplementation in the dairy ration because of high DMI and high energy intake as CSC act as an appetizer source with good palatability [40].

3.3 Milk composition

The data recorded for the milk percent components is presented in the table 5 showed significant difference ($P<0.05$) in fat and lactose percentages. Milk protein and solid not fat (SNF) percentages were not significantly different ($P>0.05$) for diets A, B and C while average milk total solids (TS) percentage was significantly different ($P<0.05$) for diet A and C than diet B. There was no significant difference present in diet A and C. Highest milk fat percentage was observed for diet A, followed by diet C and lower for diet B which might be due to the high MY of cows receiving SBM as compare to the SFM and can be linked with the study conducted by Yildiz, [60] while comparing different protein sources (SBM, SFM, RSM and DDGS) they observed that there was a tendency of low milk fat in cows receiving SFM diet due to lower MY as yield of milk fat is positively correlated with MY and Fat percentage of milk is more sensitive to feed manipulation [61]. Reducing the negative energy balance and moving the cow towards positive energy balance can be achieved by maximizing the feed intake with proper roughage to concentrate ratios which lead to gain in body weight, restoring the body condition and milk of normal fat and protein percentage is produced (Schroeder, 2012). High milk fat for diet A might also be due to the low level of EE (fat) that stimulate the *cellulolytic* bacteria in the rumen which are essential for fiber fermentation as high dietary EE reduces the activity and number of *cellulolytic* bacteria [62] decreasing the fiber fermentation that resulted lower fat content in milk. High Milk fat percentage for diet A was also supported by the study conducted by Miller and Wise [2004], they evidenced that milk fat content significantly affected by increasing CSC level in the diet and high level of CSC in the ration resulted high milk fat content. The result of the study revealed that supplementation of CM in the diets of dairy cows showed high protein percentage levels than SFM and SBM supplementation. Milk protein is positively related to the improvement of the utilization of metabolizable protein which is dependent by either changing or balancing the EAA (*lysine*, *methionine*, and *leucine*) content in the diet of dairy cows [64]**.** Although SBM is a better source of supplying DEAA (digestible essential amino acids) as compare to the other protein source and resulted to enhanced the proteins level in the milk [65]. However CM produced high milk protein which is in lined with the meta-analysis of Huhtanen et al. [28] they evaluated the effect of SBM and CM on milk composition and their findings revealed that milk protein production was high for CM than SBM. Milk protein concentration on diet with CM (treated or untreated) was high than SBM diet in experiment conducted with an iso-nitrogenous diets [66] without any affect on DMI [67]. Amongst the supplementary protein sources SFM stands as a best source of supplying nearly about 85 % of EAA (Essential Amino Acid) but there is 85 % limiting lysine content in SFM which is required for milk protein synthesis in mammary tissues and experimental trials comparing the SBM and SFM showed similar milk protein synthesis which may be due to the other nutritional factor (carbohydrate, energy concentration, time needed to pass through rumen and feeding effect of feeds in the ration, etc) which compensate the deficiency of the AA [52]. Milk percent lactose content is affected by concentrate intake as high concentrate intake produces high propionic acid ($CH_3.CH_2.COOH$) production [56] because activity of the *amylolytic* bacteria that hydrolyses starches and utilized sugars was enhanced on increased consumption of concentrates that provide amino acids needed in high ratio by *amylolytic* bacteria as compare to *cellulolytic* bacteria [68]. Intermittent feeding (twice daily) of concentrate at milking time high propionic acid proportion is produced in the rumen [69]. After absorption from the rumen propionic acid is removed from the portal blood and converted to glucose via gluconeogenic pathway by liver [70]. High milk lactose content of the cows receiving diet A (SBM supplemented) might be due to high MY and high DMI of experimental diet as compare to diet B concentrate provided balanced proportion of nutrients which effected the milk components and this is in agreement with Looper [61] who stated that feed provides nutrients that directly or indirectly affect milk components (milk solids) and increased feed intake resulted high MY and milk components (lactose, fat and proteins) increase correlatively with MY. Kittivachra et al. [71] investigated that about 45 to 60 % of blood glucose is formed from propionic acid in the ruminants and the main precursor for the milk lactose is the blood glucose and reduction in the blood glucose level resulted in decreasing the milk lactose content and water secretion in milk that lowered MY as milk production is directly correlated with glucose uptake from blood. Milk lactose (%) was intermediate on diet C (CM supplemented) although MY for SBM is highest than SFM and CM but same level of lactose in milk on diet A and C [41] might be due to the production of the same level of propionic acid by SBM and CM in the rumen evidenced by Sanchez et al. [72]. Lower lactose content of milk for cows fed on diet B (SFM supplemented) is supported by the observation of Yildiz et al. [41] they evidenced in their study while comparing the different supplemental protein sources in dairy cow ration that cows fed on SFM produced lower milk that led to lower lactose content in milk. Nutritional changes, changing in the type and method of feeding can affect the SNF percentage in the milk and primarily influenced by the protein content of milk. Feeding extra energy (Above the NRC recommendations) and increasing the concentrate feeding to lactating cows may increase the SNF in milk. Similarly increasing roughages intake usually reduced the SNF % in milk because of reduction in energy intake and DMI. Dry roughages (Hay) of good quality increased and poor quality hay depressed the milk SNF percentage [73]. Similar SNF content (%) for our study might be due to the same roughages and TDMI our result is in lined with study of Yildiz et al. [41] they concluded that there is no effect of SBM, SFM and RSM on milk composition. Milk TS is affected by MY and increases with increase in milk yield. High milk TS for diet A was due to high MY and lower TS content (%) for diet B was due to lower MY which is supported by [74]. Total solids are the sum of the milk fat, proteins, lactose and Ash content. In our study cows receiving CM diet showed equal TS to the cows receiving SBM diet which might be due to the slightly high milk protein content on CM diet and equal milk fat and lactose content. Milk fat and proteins are influenced by dietary changes and milk Ash (minerals) and other solids do not respond to dietary alteration [65].

Table 5. Effect of experimental diets on Mean ± SE Dry Matter Intake, Milk Yield and Milk Composition of Holstein Friesian cows

Parameter	Diets A	Diets B	Diets C
Dry Matter Intake (DMI) Kg/d			
DMI of basal diet	9.42^{a}±0.310	9.47^{a}±0.337	9.37^{a}±0.096
DMI of experimental diet	5.93^{a}± 0.051	5.71^{b}± 0.074	5.69^{b}± 0.010
TDMI	15.35^{a}± 0.275	15.18^{a}± 0.373	15.06^{a}± 0.093
Milk Yield (MY) Kg/d			
Milk Yield	17.74^{a}±0.530	14.97^{b}±0.541	15.47^{b}±1.097
Milk Composition %			
Milk Fat	3.87^{a}±0.012	3.53^{c}±0.025	3.77^{b}±0.012
Milk Protein	2.78^{a}±0.030	2.79^{a}±0.034	2.80^{a}±0.036
Lactose	4.24^{a}±0.061	3.94^{b}±0.119	4.17^{ab}±0.046
SNF	7.58^{a}±0.084	7.62^{a}±0.093	7.70^{a}±0.088
Total Solids	11.53^{a}±0.078	10.92^{b}±0.139	11.43^{a}±0.073

3.4 Economics of the experimental diets

Economics of the experimental diets A, B and C was analyzed in term of cost of experimental diets consumed per day per cow, gross income (GI) from selling milk and net income (NI) from milk in rupees (Rs.) and mean values are presented in the table 6. Average cost, GI and NI values were significantly different (P<0.05) for diets A, B and C. Actual prices of the components (SBM, SFM, CM, CSC, MSC, CGF, Molases, Maize, salt, and DCP) used in formulation of diets were taken from the local market to determine the cost of the experimental diets. Highest feed cost was observed for diet A and minimum was observed for diet C excluding the roughages cost which was produced on the farm and offered in an equal amount to all the three experimental groups [75]. Highest cost for diet A (SBM based) was due to the high price/kg of the diet A which was in line with the study of Yildiz et al. [41] who concluded that SBM inclusion increase the feeding cost. Highest gross income was observed from the cows receiving diet A was supported by the experiment of Chen et al. [76] who compared ESBM (extruded soybean meal) with GCS (ground canola seed) and WCS (whole cotton seed) and observed highest MY for cows fed on SBM and also supported by the study of Yildiz et al. [41]**.** Highest NI for diet A was due to the highest MY that resulted highest GI [32]. The cost of diet A was highest and it is not economical in our condition so as per economical interpretation the cost for diet C was the lowest and the NI was not significantly different than diet A (P>0.05) which concluded that under Pakistan condition CM inclusion and inclusion of SBM in low level in the dairy ration were economical, as cost per day for SBM was highest and SFM decreased the average daily MY. Current result is supported by the Yildiz [41] who concluded that under experimental condition CM was more economical as compare to SBM. In other study [41] MY from cows fed on SBM diet had 15 to 23% higher price than those which were fed on RSM (canola type) and SFM. The cheapest milk in the present study was from CM followed by SFM. Due to importance of SBM in dairy ration and its highest cost mainly in those countries where it is imported, many experimental trials were conducted to compare SBM with other oilseed meals and supplemental protein sources (Animal protein and NPN sources) which reduced the need and used of SBM in dairy cows ration [18]**.** The cost of milk production (Rs/liter) varies with MY per day, price of the feed ingredients and the efficiency of the utilization of the nutrients by lactating cow and higher the MY lower will be the cost [77] and for the improvement of animal production efficiency feeding strategy is needed to be evaluated for the potential of the strategy in practice and farmers are enthusiastic to adopt strategy when it has financially positive effects [18].

Table 6. Effect of experimental diets on profitability (Mean±SE) of the experiment.

PARAMTER (Economics)	DIETS		
	A	B	C
Cost of experimental diet (Rs/d)	204.80^{a}±1.789	185.85^{b}±2.411	166.65^{c}±0.319
Gross income (Rs/d)	1419.2^{a}±42.434	1198.2^{b}±43.347	1238.0^{b}±61.605
Net income (Rs/d)	1214.4^{a}±43.621	1012.3^{b}±45.507	1071.4^{ab}±62.292

A. Soybean meal based diet, B.Sunflower meal based diet, C.Canola meal based diet. Means within a row with different superscripts are significantly (P<0.05) different.

3.5. Rumen degradable protein (RDP) percentage in the experimental diets

The mean values of percent rumen degradable protein of the experimental diets A, B and C incubated in the rumen of fistulated animal at different incubation period (3, 6, 12, 24, and 48 hrs) are presented in the table 7. The average percent degradable protein for diets A and C were significantly different (P<0.05) at 6, 12 and 24 hrs incubation periods. Diet A reached the high value of percent degradability in all incubation period except 3 and 48 hrs of incubation at which no significant (P>0.05) difference was observed for diets A, B and C. however diet B percent degradability were not different significantly (P>0.05) in all incubation periods and remained intermediate among the diet A and C. High rumen degradation for diet A in all incubations may be due to the lower level of EE in the diet as higher EE of the diet depressed the microbial activity which decreased the rumen fermentation process and current result is in line with the study of Adnan et al. [78] who concluded that the EE of the diet has a protecting effect on protein degradability. Another possible reason of the high degradability values (%) for diet A can be linked with the activity of the protozoa as contributor to ruminal protein degradation and their degradation activity is more pronounced on the insoluble dietary proteins like SBM (NRC 2001). Marghazani *et al.* [77] reported high protein degradability for CSC (90.36 %) at 0.02 passage rate in the rumen while analyzing the degradability characteristics of vegetable protein source and highest degradability level for diet A can be linked with high inclusion of CS. Low level of protein degradability for diet C may also be linked with slightly greater level of MSC (mustard seed cake) which contained higher concentration of anti-nutritional factor (ANF) like Tannin which is inversely related to the degradability of protein the rumen [79]. The lower degradability of diet C can also be connected with the Presence of high level of indigestible NDF in the CM [67] and fiber content of the feed also give different result for rumen degradability [77].

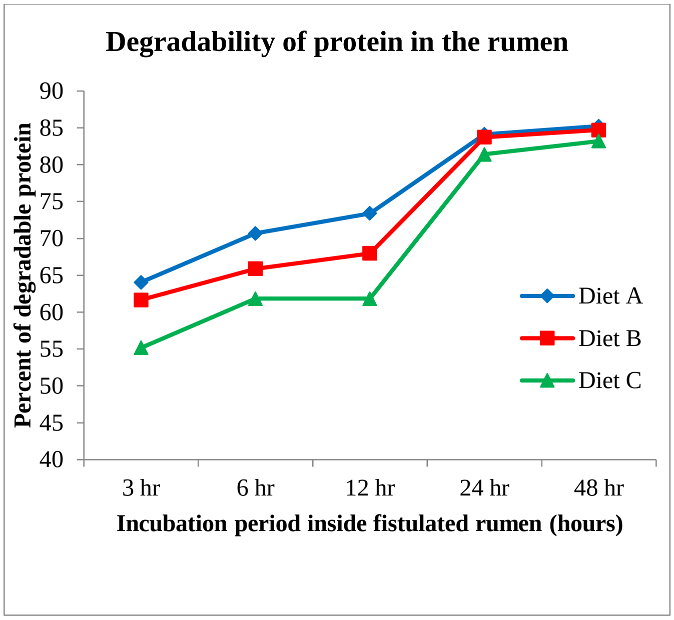
Table 7. Rumen degradable protein (RDP) Mean levels (%) of experimental diets at different rumen incubation period.

Diets	Incubation period					
	3 hr	6 hr	12 hr	24 hr	48 hr	± SE
Diet A RDP (%)	64.06^{a}	70.70^{a}	73.41^{a}	84.12^{a}	85.23^{a}	±2.265
Diet B RDP (%)	61.67^{a}	65.90^{ab}	67.98^{ab}	83.73^{ab}	84.71^{a}	±0.993
Diet C RDP (%)	55.17^{a}	61.83^{b}	63.59^{b}	81.41^{b}	83.21^{a}	±1.324
± SE	±2.910	±1.229	±1.699	±0.584	±1.161	---

A. Soybean meal based diet, B.Sunflower meal based diet, C.Canola meal based diet. Means on the same column followed by different letters (small letter) are significantly (P<0.05) different.

4. Conclusions

The current study revealed that amongst the experimental diets A, B and C containing SBM, SFM and CM respectively daily milk yield, milk fat, lactose and TS (total solids) content were highest for SBM as compare to the cows fed on SFM and CM based diets. Milk protein and SNF contents did not respond to the diets however milk protein and SNF were numerically high for the cows fed on CM. Economical evaluation showed that inclusion at low level of SBM as supplemental protein was more economical in term of high net income and there was a tendency of economical milk production in CM if included as a supplementary protein in the dairy cows ration because of lower feeding cost and intermediate net income.



Conflicts of interest
There are no conflicts of interest.

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