Buletin Peternakan 45 (1): 66-74, February 2021

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

Bulletin of Animal Science

ISSN-0126-4400/E-ISSN-2407-876X Accredited: 36a/E/KPT/2016
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v45i1.60880

Supply Chain Performance and Quality Measurement of Dairy Cow Concentrate in Cooperative toward Sustainable Productivity: a Case Study

Norma Nuraina[1]*, Atikah Nur Hamidah[1], Despal[2] and Epi Taufik[3]

[1]Graduate Student of Department of Animal Production and Technology, Faculty of Animal Science, IPB University, Bogor, 16680, Indonesia
[2]Department of Animal Nutrition and Feed Technology, Faculty of Animal Science, IPB University, Bogor, 16680, Indonesia
[3]Department of Animal Production and Technology, Faculty of Animal Science, IPB University, Bogor, 16680, Indonesia

Article history
Submitted: 27 October 2020
Accepted: 24 February 2021

* Corresponding author:
Telp. +62 852 1378 0166
E-mail: norma_na@apps.ipb.ac.id

ABSTRACT

This research aims to measure supply chain performance of dairy concentrate in cooperative with the SCOR-AHP approach and develop improvement based on the performance result, and to analyze the quality suitability as a basis to develop a comprehensive quality standard and its quality control mechanism. This research was conducted at a dairy farmer cooperative located in West Java. The analysis used to measure the performance was supply chain operation reference-analysis hierarchy process (SCOR-AHP). For measuring the product quality, ten post-production concentrate samples, 27 samples after the distribution process, and 25 samples for homogeneity test from five mixer machines were taken. Concentrate quality parameters were moisture, ash, crude fat, crude protein, crude fiber, total digestible nutrients (TDN), and salt content. Post-production samples data were compared with Indonesian National Standard (SNI) using one-tailed one-sample t-test, samples data from the field were tested using two samples independent t-tests compared to post-production samples data, and homogeneity test was seen from the coefficient of variation value of the salt content. The results show that the supply chain performance value of dairy cow concentrate at the cooperative is excellent. The nutrient content complies with SNI, but the homogeneity of the mixture is classified as poor category. The nutrient content of samples taken from the field shows differences with post-production samples except for TDN. The excessive total cost can be utilized to enhance performance in generating a better quality product. The cooperative should enhance homogeneity by concerning the mixing process and maintain the quality consistency by reformulating, stabilizing the quality of feedstuff, and calculating stock properly to avoid longer storage.

Keywords: Concentrate feed, Cooperative, Nutrient content, Quality, SCOR-AHP

Introduction

In many countries, dairy farming development depends on cooperative existence. Campina in The Netherlands (Bijman, 2018), Frontera in New Zealand, KPBS (Koperasi Peternakan Bandung Selatan), and KPSBU (Koperasi Peternak Sapi Bandung Utara) in Indonesia are some examples of the dairy cooperative. Cooperatives are the organization for building a community of small-scale farmers and playing strategic roles by helping farmers to improve milk production, collecting milk, and then selling milk to final consumers (Faysse *et al.*, 2012; Ricard, 2015; Rahmah, 2020). Milk production can be affected by limited feed quantity and quality (Moran and Morey, 2015). Forage cannot fulfill the daily needs of dairy cows because the supply is relatively limited and depends on the season in some countries. Milk could be supplied higher in the rainy season and lower in the dry season, besides high competition for land use between agriculture and non-agriculture causes limited land for planting forage (Njarui *et al.*, 2010; Zahera *et al.*, 2015). Therefore other types of feed should be available to help farmers in providing cows' needs. Concentrate is another feed that contains high protein and can increase milk production (Pimentel *et al.*, 2013).

Providing concentrate is not easy because the concentrate is composed of agricultural by-products from several regions and is distributed to farmers through various parties with varied quality (Baran *et al.*, 2008; Feyissa *et al.*, 2014). Meanwhile, feedstuff orders couldn't be made in a small quantity, whereas Indonesian farmers are dominated by small-scale farmers. The problem caused a shift in the function of providing

concentrate to cooperative. This evidence can be found in West Bandung Regency (KPSBU), for instance (Resti *et al.*, 2017). Yearly, KPSBU produced about 25,000 Ton (KPSBU, 2018). This phenomenon makes cooperative has a function as feed manufacturer. The cooperative is challenged to provide high-quality concentrate at an affordable price. Some cooperatives possibly failed to meet this demand so that their business might collapse at any time. And then, the farmers must rely on their own efforts to provide feed for their cows. Therefore, cooperatives must have good performance in producing concentrate, and supply chain performance is one of the successful indicator achievements.

Supply chain is a system that covers all processes from the supply of raw materials to finished products, which are accepted for final consumption or can be said to be used by consumers (Cimorelli, 2013). Generally, a business or industry will measure supply chain performance to make the business survives within the scope of competition and even initiates improvements. An organization manufacturing can use supply chain evaluation to ascertain continuous innovation in product and process (Junior *et al.*, 2011). Quality determines product value, so it is a significant part of supply chain performance because it impacts consumer trust (Marimin and Safriyana, 2018). Food and other industrial product supply chain performance has been widely discussed and measured, but information about animal feed supply chain performance, especially in cooperatives, is still limited. Supply chain performance extensively includes reliability, responsiveness, flexibility (agility), cost, and asset which are related to all customer interactions, all physical material transactions, and all market interactions (SCC, 2012). That can be adapted in dairy farming, cooperative or other business processes. Cooperatives' main goal is not to compete with other companies because they prioritize member prosperity (Boland, 2017). Meanwhile, there are some problems in running a business at a cooperative, such as unprofessional management, lack of members' participation, and inadequate mastery of the technology (Azhari *et al.*, 2017). This condition causes low-quality products, nutrient of concentrate, that will make farmers suffer losses because the product unable to meet cows' requirements and influences milk production.

Therefore, it's necessary to help cooperatives maintain their concentrate production process by assessing their supply chain performance and controlling their product quality. The method in measuring supply chain performance is SCOR-AHP (supply chain operation reference-analysis hierarchy process) and product quality assessment as the determinant factor of supply chain performance. SCOR-AHP can evaluate the supply chain core and determine the decision making of complex problems in a hierarchy. Previous research SCOR using AHP combination and without combination had been carried out in the performance measurement (Pretorius *et al.*, 2013; Marimin and Safriyana, 2018). The purposes of this study are to measure supply chain performance of dairy cow concentrate in cooperative using SCOR-AHP and develop improvement based on the performance result, to analyze the quality suitability of the post-production and the distributed concentrate feed as a basis to develop comprehensive quality standard and its quality control mechanism.

Materials and Methods

The study has been conducted in KPSBU, one of the biggest dairy cooperatives in West Java, Indonesia, from October 2019 - February 2020. Proximate composition of concentrate has been analyzed at Animal Logistics Laboratory, Faculty of Animal Science, IPB University. While, evaluating the concentrate feed mixture homogeneity was conducted at the Dairy Nutrition Laboratory, Faculty of Animal Science, IPB University.

The tools used included supporting data collection tools for SCOR-AHP measurement (questionnaires), and sample analysis support tools for taking and storing concentrate samples (probes, plastic zip-lock, digital scales, and freezers), NIRS tools (near-infrared reflectance spectroscopy) brand NIRFlex N-500 Buchi, and a set of salt test equipment with Mohr method (Ward and Carpenter, 2010).

Supply chain performance measurement

Supply chain performance was measured using SCOR (Supply Chain Operation Reference). The method was developed by Supply Chain Council combined with AHP in 3 level comparison includes business process, performance attributes, and performance matrices. The first level is five core processes (plan, source, make, deliver and return). Table 1 shows the second and the third level (performance attributes and performance matrices).

Data of performance attributes were obtained by interviewing the head of affairs in the animal feed division at the cooperative to get secondary data related to the performance measurement. The secondary data were analyzed to get the value of order fulfillment, perfect condition, delivery performance, flexibility, lead time, order fulfillment cycle, total cost, cash to cash cycle time, and daily inventory using equation according to SCC (2012) and Apriyani *et al.* (2018). All the mentioned matrices have different units. Thus, the data were normalized to equalize the attributes' unit become percentage using benchmarking with the cooperative performance target (Bolstroff and Rosenbaum, 2003) with provisions higher is better or lower is better based on Cano *et al.* (2017).

AHP weight is determined by interviewing five experts to know the importance level in each performance hierarchy, and the comparison

Table 1. Determination of matrices performance of each SCOR attribute

Attribute	Matrix performance
Reliability	Order fulfillment
	- (How many customers' demand in a year)
	- (How many delivered orders in a year)
	Perfect condition
	- (How many products returned in a year)
	Delivery performance
	- (How many orders' fulfilled without waiting)
Flexibility	Flexibility
	- (How long is the average day needed to fulfill order changes includes searching raw material cycle, packaging cycle, and delivering cycle)
Responsiveness	Lead time
	- (How long is the average time needed since order submitted until delivered to the customer)
	Order fulfillment cycle
	- (How long is the average time needed to fulfill one cycle demand includes planning, shortage, package, and delivery time)
Cost	Total cost
	- (How much is the total cost for production in a year)
	- (How much is the total cost prepared in a year)
Asset	Cash to cash cycle time
	- (How long does the customer purchase the concentrate feed)
	- (How long does the cooperative purchase the raw material to the supplier)
	Daily Inventory
	- (How long can stock be estimated to meet the needs)
	- (How much average stock in a month)
	- (How many average requirements in a month)

Source : (SCC, 2012), adapted.

Table 2. AHP pairwise comparison

Entity value	Definition
1	Equally important
3	A little more important
5	Obviously more important
7	Clearly more important
9	Absolutely more important
2,4,6,8	Value between two adjacent comparisons

Source: Saaty, 2008.

values are shown in Table 2. The data was then processed using expert choice version 11.0 to get AHP weight with consistency index <0.1 (Asrol *et al.*, 2017). After that, the value was multiplied with the normalized SCOR value. The results were compared with the performance standard in Table 3.

Measuring product quality

Samples were taken according to the sampling techniques listed in SNI 19-0428-1998 (BSN, 1998). Ten post-production concentrate samples and 27 samples of concentrate sent to farmers were taken in each different working area. Meanwhile, for testing homogeneity of the mixture, samples were taken from five mixer machines with five replications for each machine in one-day production process. Proximate composition was measured using NIRS devices. TDN was determined by calculation using the equation from Moran (2005) in calculating TDN in SNI. Concentrate mixture homogeneity was evaluated by testing the salt content (NaCl) using the Mohr method (Ward and Carpenter, 2010).

Data analysis of product quality

Post-production concentrate sample data were tested by one-tailed one-sample t-test compared to SNI. The concentrate samples distributed to farmers' data were tested by two samples independent t-test compared to post-concentrate by SPSS 25.0 software. For determining homogeneity, the salt data were analyzed descriptively by calculating the coefficient variation. The result was compared with standard refers to Herrman and Behnke (1994). If the salt content <10% homogeneity is very good, 10-15% is good, 15-20% is sufficient and >20% is poor.

Results and Discussion

Supply chain performance measurement of dairy cow concentrate

SCOR is combined with AHP to be able to describe problems with many complex factors or criteria into a hierarchy. Figure 1 shows the weighting results from the AHP analysis. At the first level, the highest value is plan and the lowest is return. Plan has the highest value because the business process starts with the plan maturity so that the business process will run well. Plan is the primary core of business processes and is the most substantial part of all processes that were carried out (Marimin and Safriyana, 2018). Besides, long-term planning will also affect the quality of the products produced (Lombard *et al.*, 2014). Source is a relationship that occurs between suppliers with manufacturing companies (Zhou *et al.*, 2011). This process value is lower than plan value because the relationships between suppliers and manufacturers have usually been formed for long time, thus most important thing is to maintain relationships and improves networks to make continuous availability of feedstuff stocks. Make is transformation raw material into a product as the next major part of

Table 3. Classification of performance standard values

Value	Performance criterion
95-100	Excellent
90-94	Above average
80-89	Average
70-79	Below average
60-69	Poor
<60	Unacceptable

Source : (Monczka. *et al.*, 2011).

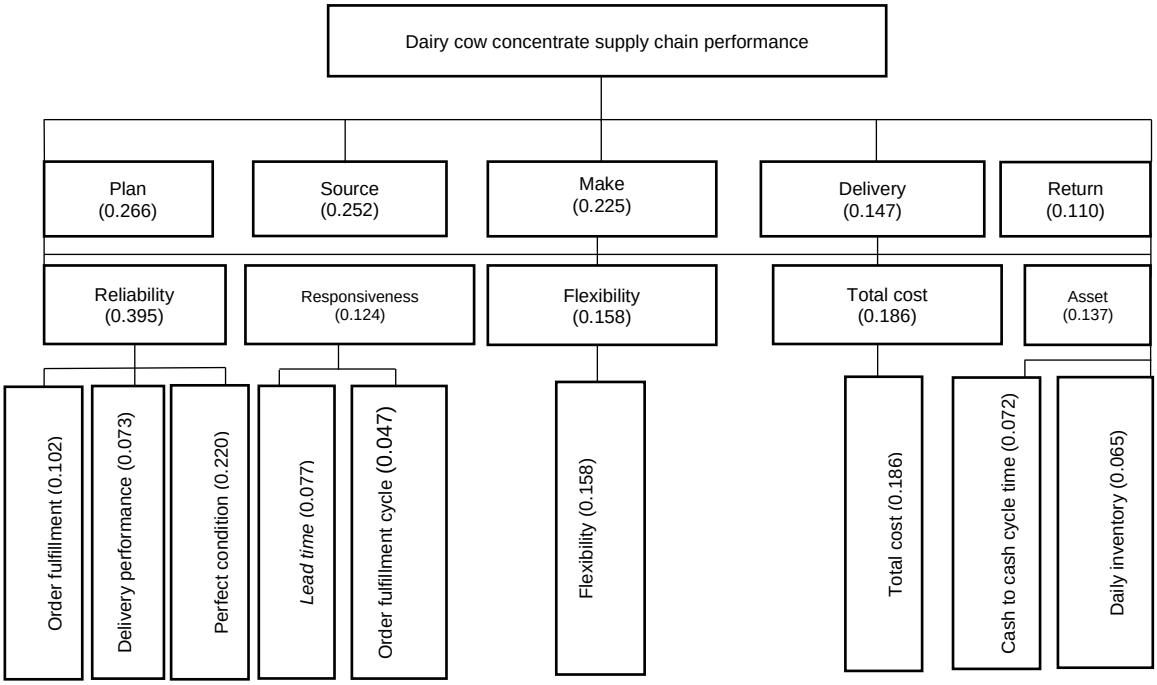

Figure 1. Hierarchy results in weighting of supply chain performance using AHP.

the process after source. The delivery process was in fourth place, and the smallest value was the return that shows one of the customer complaints forms. It is shown from the absence of consumer complaints in Bukhori *et al.* (2015).

At the second level, the highest weighting is reliability. It is related to customer trust that affects the purchasing process sustainability. Trust affects consumer loyalty and repurchase intention (Herrera and Blanco, 2011; Kato, 2020). Then, cost, flexibility, and asset are the next important role consecutively. The smallest weighting value at level two is responsiveness as the producers' ability to respond to consumer orders. Even so, responsiveness will become consumers' consideration in buying decisions, nowadays. In matric performance, product conformity is the highest weight because it generates customer trust directly and customer loyalty. Product quality, competitive price, and satisfying services can form customer loyalty (Romdonny and Rosmadi, 2019). The performance value of the supply chain of dairy cow concentrate in the cooperative is presented in Table 4.

Based on the results, the supply chain performance of dairy cow concentrate in the cooperative was 98.94%. According to the standard performance in Table 3, it is in the excellent category. This result indicates that supply chain management (SCM) has been implemented so well there since the excellent application of SCM can boost supply chain performance (Marinagi and Trivellas, 2014). Almost every target set by the cooperative for each supply chain matrix performance has been achieved and shows a high value.

Every order submitted by farmers as the customer is perfectly fulfilled, and almost all the concentrate was accepted in perfect condition. In a year, the orders were about 480,000 bags and a whole order could be fulfilled by the cooperative. The product return is rare because less than 100 bags were returned in a year which means the order was accepted by farmers mostly in perfect condition. These findings show that the cooperative is responsible for fulfilling orders submitted by the farmers. Meanwhile, the value delivery performance isn't quite perfect, but the value was still high. The cooperative had fixed the delivery schedule, but sometimes the delivery could change due to traffic jam in certain areas. In a month, there was about 125 delivery process was set, but only about 103 delivery schedule recorded was suitable with the schedule. Improved delivery performance has functions to increase sales volume and increase the price (Peng and Lu, 2017). A cooperative is not a

Table 4. Dairy cow concentrate supply chain performance by using SCOR-AHP

Attribute	Matrices performance	Normalize SCOR value (%)	SCOR-AHP value (%)
Reliability	Order fulfillment	100.00	10.23
	Perfect condition	99.97	21.95
	Delivery performance	82.40	6.02
Flexibility	Flexibility	100.00	15.80
Responsiveness	Lead time	100.00	7.69
	Order fulfillment cycle	85.71	4.04
Cost	Total cost	110.33	20.52
Asset	Cash to cash cycle time	92.00	6.67
	Daily inventory	93.33	6.02
Total			98.94

profit-oriented business. Selling concentrate feed every month has been calculated so that there is no demand to increase sales volume or increase prices as a way to gain profit. However, with this value of performance, the cooperative must improve its delivery performance to create new opportunities to expand its market in the future. The next matrix is lead time which shows perfect value. It means that the cooperative can deliver the orders within the agreed time.

Lead time relates to the cooperative responsiveness in responding to farmers' orders from the beginning of submitting orders, the delivery process, and product acceptance by farmers. The cooperative always confirms orders every 15 days to farmers through regional officials. The lead time is about three days so that the order will be targeted to be sent within that time. This is another reason delivery performance cannot reach a perfect score. The delivery will be delayed to the next day provided the delivery time range is not more than the lead time. Next, the order fulfillment cycle is all the time needed from the start of the planning process to the final product delivery of the final product without lead time. Cooperative targeted 14 days to finish this cycle, but it can be delayed up to 16 days. It can take a long time for the planning process and feedstuff delivery from the supplier. The time taken up in this process is quite long, especially in the feedstuff searching process, for about up to 4 days. Feedstuff is often not available from suppliers, so the cooperative needs to wait, even look for feedstuff from another place. Besides some of the feedstuff delivery is late sometimes, up to 6 days. Although this can be overcome by ordering feedstuff earlier, the problem with local ingredients still exists due to there is competitive usage with other users.

The flexibility value is high because the cooperative always estimates changes in demand and makes calculations in the planning process by adding stock, obtaining several suppliers of feedstuff, and assigning some substitution feedstuff. The time needed to anticipate the demand changes is about 6 days. While, budget flexibility was conducted by providing 12.5% reserve budget over the operational cost. In 2018, the cost target included logistics and concentrate production and management cost was about IDR 5,500,000,000 in a year, but the fact the cost spent about IDR 4,900,000,000. The cost target in 2018 was 12.2% above the real cost. The reserve budget was used to anticipate the changing price of feedstuffs due to its price volatile characteristics in which the price will be easily affected by market conditions. Daily inventory and cash to cash cycle time show a slight gap. These two matrices are related which the shorter the daily inventory can cause shorter cash to cash cycle time. The cash to cash cycle time was about 27 days, and daily inventory was about 32 days which were 2 days longer than the target. Stock extension will extend cash to cash cycle although payable is not distracted. Inventory can guarantee business process continuity, but longer daily inventory will cause an additional charge for business (Bahagia, 2006).

Homogeneity of concentrate mixture

Mixture uniformity is an important point in food manufacturing (Poozesh *et al.*, 2020). Similarly for animal feed manufacture includes mixing as one of the processes. It must be a concern to avoid harming the cows because of the improper mixture. Determination of the mixture homogeneity in the mixing process can be done by testing the micromineral used in the mixture of ingredients (Chen *et al.*, 2014). At the cooperative, salt is the least amount of material used. Salt content data obtained from five mixing machines at the cooperative are presented in Table 5. Based on the result, the salt coefficient of variation value is 0.26 or 26%, and the value was classified in the poor category. According to Behnke (1996), the results of mixing can be influenced by machine operators, the filling capacity of machines and properties of feedstuff such as particle size and shape, specific gravity, hygroscopic properties, density, viscosity, and material adhesion.

The type of machine used at the cooperative is a vertical mixer. Vertical mixers will produce low homogeneity when compared to horizontal mixers especially with micromineral existence. Most micro materials have a higher density than other feedstuff sources, thus when these materials are mixed together in the vertical mixer the gravity will affect this process and cause the micro mineral tends to stay at the bottom. The top layer in a mixture mostly consisted of lighter particles, some layers beneath the top layers consisted of heavier particles, and the bottom contains the heaviest particle (Li *et al.*, 2010). The national homogeneity standard is not established yet so that homogeneity checking is limited to the appearance of the feed which can be subjective. Whereas, evaluating homogeneity regularly will

Table 5. Salt content of concentrate

Number of machine	Salt (NaCl) content (%)				
1	1.73	1.43	1.65	1.50	1.75
2	1.75	1.55	2.05	2.25	0.80
3	2.08	1.83	1.75	2.20	1.30
4	1.63	1.20	2.45	2.68	1.28
5	1.25	1.85	1.48	2.35	2.15
				CV	0.26

CV: coefficient variation.

improve mixing uniformity (Axe, 1995). The low quality of mixing can be caused by operators who lack attention to the sequencing process and the mixing time. Besides, the four machines' capacity is relatively smaller than machine number 1, but the mixing process is conducted with the capacity as same as machine number 1. However, there are several ways in the mixing process to maximize uniformity, such as giving attention to the sequencing process of feedstuff, mixing time, and mixing speed (Gandhi *et al.*, 2017).

Nutrient content of concentrate

The quality of the concentrate can be varied so that national standards are required as a reference. At that time in the cooperative, one type of concentrate was produced and the majority of livestock ownership was cow. Table 6 shows a comparison of nutrient content contained in the concentrate produced at the cooperative and the values listed in the SNI for lactation cows. Based on the data presented in Table 6, the nutrient content contained was conformed to SNI. The concentrate produced is likely to fulfill the nutritional needs of dairy cows. This result shows that product quality is affected by supply chain performance. The implementation of good supply chain management produces high-performance values and high-quality products. Supply chain activities (manufacturing/processing and logistics activities) can affect product quality (Manzini *et al.*, 2014).

It is not sufficient to test the quality after the production process, but it should also be tested when the product is accepted by farmers who will use the product. This is quite important to assess product consistency. Besides, the concentrate will be stored by farmers for 2 weeks and possibly the concentrate quality will be degraded during storage. Thus, the accepted product is expected to be suitable with the post-production product. Data of the comparison concentrates produced at the cooperative with concentrates received by farmers after the distribution process is presented in Table 7. Almost all nutrient content tested at farmers had different values with post-production nutrients except TDN, but the result is still in the national standard range.

Differences in nutrient content can be caused by changes in feedstuff used in each production. The cooperative used prices as a reference in the preparation of the formula because of farmers' demand to not increase the price. Some substituent feedstuff is not always available because the supplier is limited, thus that can't be ordered in large quantities. Therefore, the formulation applied in the mixing process could change depends on the feedstuff availability. The kind of feedstuff used can be added or reduced so that it will cause the percentage of each type of feedstuff to changes and then affect the concentrate nutrient content. This is the major cause of differences in nutrient content between post-production and which is received by farmers. Besides, the feedstuff use and delivered concentrate were not completely first in first out (FIFO) so that there was a possibility the concentrate sent to consumers has been stored for several days in the warehouse. Some factors ultimately affect quality, such as temperature, humidity, and storage equipment (Ouyang *et al.*, 2010). High moisture can be caused by longer storage time and uncontrolled warehouse temperature (Ahmed, 2015). This is related to daily inventory which surpasses the

Table 6. Comparison nutrient content (%) of cooperative's concentrate with SNI for lactation cow

Parameters	SNI*	Cooperative
Moisture	≤14.00[b]	8.96±0.59[a]
Ash	≤10.00[b]	9.11±0.28[a]
Crude protein	≥16.00[b]	16.68±0.44[a]
Crude fat	≤ 7.00[b]	4.15±0.16[a]
Crude fiber	-	11.92±0.25
TDN	≥ 70.00[b]	75.62±0.43[a]

[a,b]Different superscripts at the same row indicate significant differences (P<0.05).
*Source BSN 2009.

Table 7. Comparison nutrient content (%) of cooperative's concentrate after production with concentrate at the field

Parameters	Cooperative	Farmer
Moisture	8.96±0.59[a]	10.30±1.00[b]
Ash	9.11±0.28[a]	9.88±0.65[b]
Crude protein	16.68±0.44[a]	15.99±0.68[b]
Crude fat	4.15±0.16[a]	4.37±0.20[b]
Crude fiber	11.92±0.25[a]	11.26±0.43[b]
TDN	75.62±0.43[a]	75.83±0.49[a]

[a,b]Different superscripts at the same row indicate significant differences (P<0.05).

target and can cause the stock was stored longer, both feedstuff and finish product.

The ash and crude fat content of the concentrate from the farmer showed a higher value than from the cooperative, but the crude protein and crude fiber were lower. The chemical quality of feed will change during storage, especially those stored at room temperature (Hossen *et al.*, 2011). This change can occur due to the influence of moisture content, storage conditions, temperature, oxygen availability, and changes in water vapor in the air (Bojanowska, 2017). The reduction of crude protein can be caused by environmental temperature changes (Guo *et al.*, 2015). Furthermore, the content of crude fiber in feed can decrease because of the degradation process due to microbial activity (Rostini *et al.*, 2017). Meanwhile, it is possible which crude fat is not expected to damage due to oxidation or hydrolysis because the crude fat and moisture content are relatively low. Hydrolysis is a damaging process of fat caused by high water content (Frankel, 2012). The high ash content of the product because ash as an inorganic matter is unsusceptible to the environmental condition and physiological activity (Zhang *et al.*, 2017). Meanwhile, the TDN content did not differ because although the crude protein and crude fiber received by farmers show lower value, the crude fat content is high.

Conclusions

The supply chain of dairy cow concentrate in the cooperative is excellent. Plan is the highest at level one, reliability at level two, and perfect condition at level three, even so, some matrices cannot be perfectly achieved in level three. The excessive total cost can be utilized to make some improvements to enhance performance. The nutrient content of the concentrate exceed the standard (SNI), but the homogeneity is still in poor category, thus it should be improved by giving attention to this process even conducting homogeneity test regularly. For the product quality accepted by farmers, the nutrient content of concentrate varies, except TDN. The cooperative should maintain its consistency by formulating feed not only based on price, but also concerning feedstuff nutrient content. Besides, the cooperative must stabilize the quality of feedstuffs from different suppliers, and calculating stock properly to avoid longer storage.

Acknowledgment

We are thankful for the cooperative's authority's permission and all parties that were involved from the beginning to the completion of this research.

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