Buletin Peternakan 48 (2): 117-127, May 2024

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.v48i2.90285

Analysis of the Nutritional Quality of Local Feed Ingredients Commonly Used in the Concentrate Formula for Beef Cattle Feedlots in Indonesia

Thoriqul Irfah Al Huda[1], Ali Agus[1], Cuk Tri Noviandi[1], Siti Andarwati[2] and Andriyani Astuti[1*]

[1]Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia
[2]Department of Livestock Socioeconomics, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia

Article history
Submitted: 31 October 2023
Accepted: 21 March 2024

* Corresponding author:
E-mail: andriyaniastuti@ugm.ac.id

ABSTRACT

Indonesia's annual beef consumption is experiencing a steady rise. In 2021, the per capita beef consumption amounted to 2.56 kg per person per year, resulting in a total of 696 million kilograms consumed across the country. This quantity is equivalent to the slaughtering of approximately 3.98 million cattle annually. With the increasing growth of the feedlot industry, cattle farmers, including feedlot operators, have the opportunity to enhance the value of agricultural companies in Indonesia by utilizing local feedstuffs. The objective of this study was to assess the suitability and nutritional value of indigenous feed sources for beef cattle in Indonesia. The research utilized feedstuff varieties and characteristics sourced from feedlots spanning since 2012-2021. The employed methodologies encompassed surveys, interviews, and questionnaires. This research involved the collection of both primary and secondary data. The potential and quality of local feedstuff were described using descriptive analysis. This research showed that eight types of local feedstuff could be categorized as energy sources including dehydrated cassava chips with a total digestible nutrients (TDN) value of 84.2% and bran pollard with a TDN value of 66.6%. The fiber sources consisted of corn cob (37.7% crude fiber), coffee husk (38% crude fiber), cocoa bean shell (20% crude fiber), tapioca solid waste/*onggok* (22% crude fiber), and palm kernel meal (22.1% crude fiber). The protein source consisted of copra meal with a protein content of 22.4%. The physical test most frequently inspected the feed color (18.1%) and odor (18.1%). Moisture examination (24%) was the most frequently used of proximate analysis was employed to identify the chemical composition. In conclusion the existence of eight local ingredients which were categorized into three different types: energy source, protein source, and fiber source commonly used in the concentrate formula for beef cattle feedlots in Indonesia.

Keywords: Beef cattle, Feed, Indonesia, Potential local feedstuff, Quality

Introduction

The beef cattle population in Indonesia has experienced significant growth in recent years. According to the 2019 Statistik Peternakan dan Kesehatan Hewan, the beef cattle population in Indonesia has reached 19.930 million, indicating a growth of around 3.02% compared to 2018. A total of 504,802 metric tons of beef carcasses were produced in the year 2019 (Direktorat Jenderal Peternakan dan Kesehatan Hewan, 2020). Due to the rising population and the growing popularity of fast food, the annual demand for beef is surpassing the local production. From 2016 to 2020, there has been an annual increase of 3.98% in household beef consumption, and this upward trend is projected to continue in the future. In 2019, the average amount of beef consumed per person per year in households was 0.485 kg, which is a 4.48% increase compared to the previous year, 2018.

Effective agricultural management is essential to promote the growth of the animal population. Livestock fattening is an agricultural practice that seeks to augment the body mass of animals during the final phase of their growth. The cattle in the feedlot system were provided with a diet that was rich in concentrated nutrients for a period of 3 - 6 months prior to being sold. Cattle feedlots employ the genetic potential of the animals to accomplish efficient weight gain by providing them with high-energy and high-protein feed. This helps to increase muscle and fat deposition in the animals. the purpose of feedlots to accelerate and increase beef production (Haza, 2016).

The cost of feed constitutes the highest proportion of expenses in livestock production, accounting for as much as 60% – 70% of the total production cost (Suroso *et al.,* 2023). The concept of feed quality revolves around optimizing growth potential. Selection of raw materials is the main key in making quality feed because it really determines the quality of concentrate feed. In the feedlot industry itself, feed raw materials come from local or imported sources to make concentrate feed. Utilization of potential local feed raw materials is an effort to reduce dependence on imported feed raw material (Maluyu, 2021). Feed commodities are the main products used by cattle ranchers to provide the highest quality of feed. Beef cattle require a diet consisting of grass and high-energy concentrates. Cattle producers typically utilize a variety of feed sources, such as local forages and agricultural by-products, based on established customs and information shared by fellow farmers regarding feeding practices. Common agricultural and plantation leftovers can be used as local resources for feed (Sitindaon, 2013). The objective of this study was to investigate the viability and nutritional value of indigenous feed sources for beef cattle and the relationship between proximate analysis and raw material prices.

Materials and Methods

This study obtained concentrate feed ingredient records from PT Widodo Makmur Perkasa Tbk feed mill and feedlot farms for approximately ten years since 2012 - 2021. A survey was also conducted on two other feed mills, and questionnaires were used for interviews.

The questionnaire contains questions about the type of feed (concentrate and byproducts), feed quality, including odor, texture, contaminants, and quantity fed to animals.

A database of feed types and their quality was obtained with supporting data from feedlots for the last ten (10) years since 2012 – 2021. The research was conducted in the following order: collecting data from the database of feedstuff types and their quality, compilation of data, selecting respondents and surveys and interviewing feed mill owners/staff and feedstuff suppliers. Ethical approval: The conducted research was not related to either human or animal use.

Data collection. Data collected in this study consisted of primary and secondary data. Primary data (types of feedstuffs), were obtained from the feedlot database recorded at PT Widodo Makmur Perkasa Tbk, located in Cianjur, West Java and then processed. Additional data were obtained from surveys and interviews with questionnaires. The respondents were 27 raw material suppliers, 13 feedlot respondents and three feed mill respondents. The location of respondent were Jakarta, West Java, Central Java, East Java, Lampung, Central Kalimantan, and Yogyakarta. Secondary data were also obtained from relevant institutions such as the Livestock Agency (Ditjen PKH) and the Central Bureua of Statistics Indonesia (BPS). Other information related to this research was obtained from literature, books, and the internet to complement and then organize and compile the information described.

Survey. Surveys of cattle feedlots and feed mills were conducted to investigate the types of local feed used in beef cattle feed. The instrumentation was divided into two types of survey research, which include questionnaires, and interviews. Interviews were conducted with feedlot owners/staff and feed suppliers using a list of questions prepared for focus. The interviews were conducted face-to-face and assisted by telecommunication devices. The interviewees completed the questionnaires by filling in the questionnaire form. The questionnaire's content included the type of feed ingredients used, price, location, availability, proportion in the feeding process, source of raw materials, transportation and delivery time. Feedlot respondents were selected with a cattle population of 100 head - 20,000 head in several locations in Indonesia. Feed mill respondents were selected with production above 300 tons per month. Supplier selection was random where the supplier supplied goods to several feedlots and feed mills.

Data analysis. The compilation of feedstuff types data and their quality were tabulated and analyzed based on descriptive methods. There were eight (8) types of feedstuffs used: bran pollard (27 samples), copra meal (35 samples), palm kernel meal (23 samples), dried cassava chips (29 samples), corn cobs (23 samples), cocoa bean shells (16 samples), coffee husks (27 samples) and tapioca solid waste/*onggok* (41 samples). Samples were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), extract ether (EE), and ash according to AOAC (2005). Nitrogen free extract (NFE) was determined using a calculation with the model as follows:

$$\text{NFE} = 100 - \text{Crude Protein} - \text{Ash} - \text{Crude Fiber} - \text{Extract Eter}$$

In addition, total digestible nutrients (TDN) was calculated using several model as follows:

$$\text{TDN of feedstuff class 4 (energy source)} = -202.686 - 1.357\ (\text{CF}) + 2.638\ (\text{EE}) + 3.003\ (\text{NFE}) + 2.347\ (\text{CP}) + 0.046\ (\text{CF})^2 + 0.647\ (\text{EE})^2 + 0.041\ (\text{CF})\ (\text{NFE}) - 0.081\ (\text{EE})\ (\text{NFE}) + 0.553\ (\text{EE})\ (\text{CP}) - 0.046\ (\text{EE})^2\ (\text{CP})$$

$$\text{TDN of feedstuff class 5 (protein source)} = -133.726 - 0.254\ (\text{CF}) + 19.593\ (\text{EE}) + 2.784\ (\text{NFE}) + 2.315\ (\text{CP}) + 0.028\ (\text{CF})^2 - 0.341\ (\text{EE})^2 - 0.008\ (\text{CF})(\text{NFE}) - 0.215\ (\text{EE})(\text{NFE}) - 0.193\ (\text{EE})(\text{CP}) + 0.004\ (\text{EE})^2\ (\text{CP})$$

All of calculation model of NFE and TDN followed the description of Hartadi *et al.* (1990).

The types of raw material tests collected during the survey were physical tests and chemical tests. The physical quality of raw materials test color test distinguishes light, dark, pastel, and deep colors. The odor (smell) tests were performed to detect pleasant aromas, rancid smells, bad smells, and other aromas of the feed material. Brix is a commonly used term to indicate molasses' sugar content. A density test was used to calculate the specific weight, which can be applied to check the authenticity of the feed material. Chemical analysis includes proximate analysis, aflatoxin, Ca:P, energy, Van Soest, carbohydrate and Na:Cl. The regression analysis between the nutritional content of the proximate analysis with the price of feedstuffs.

Results and Discussion

Classification and nutritional composition of feed ingredients as determined by surveys and questionnaires

The recapitulation of feedstuff types used in local cattle feed is presented in Table 1. The surveys provided to feedlot owners/staff, feed suppliers, and feed mills revealed that the feedstuffs utilized in feed processing were sourced locally Approximately, 4.7% of the respondents used local feeds at a rate lower than < 50% In contrast, 48.8% of the respondents relied on local feeds for 51% – 99% of their feed requirements, while 45.6% exclusively used 100% local feedstuffs.

Table 1. Local feedstuffs used in local cattle feed based on surveys and questionnaires

Feedstuff name	Number of respondents (n)	Percentage (%)
Palm kernel meal	28	11.97
Tapioca solid waste/*onggok*	23	9.83
Molasses	21	8.97
Dried cassava chips	20	8.55
Coffee husk	17	7.26
Copra meal	17	7.26
Bran pollard	16	6.84
Corn gluten feed (CGF)	14	5.98
Rice bran	12	5.13
Rice husk	12	5.13
Corn cob	12	5.13
Byproduct of biscuit	9	3.85
Cocoa bean shell	8	3.42
Cracked maize	5	2.14
Soybean meal (SBM)	4	1.71
Peanut shell	3	1.28
Soybean pulp	3	1,28
Beer dregs	2	0.85
Kapok seeds meal	2	0.85
Corn husks	1	0.43
Byproduct of corn/*ampok*	1	0.43
Palm kernel solid waste	1	0.43
Full fat soya	1	0.43
Cumin	1	0.43
Distillers' dried grains with solubles (DDGS)	1	0.43

Table 1 presents the survey results that the most frequently used feedstuff was palm kernel meal (11.97%). Palm kernel meal from the *Elaeis quineensis jacq* plant was extracted by mechanical process (BSN, 2017). The availability of raw material for palm kernel meal, commonly used for beef cattle feed, is abundant. Based on the 2021 Plantation statistics data, Indonesia was the largest palm oil producer in the world, where Sumatra is the largest producing region. As a result, the abundant oil palm byproducts are the most widely used raw material for feed. Palm kernel meal contains high levels of crude fiber, which is good for ruminant's nutrition if it can be digested optimally. Palm kernel cake is considering high fiber co product. The content of palm kernel cake ranging 16% – 18%, is acceptable most ruminant, but may not be suitable include the high level in poultry pig diets. The CF content of PKC can be significantly reduced throught fermentation (Azizi *et al*., 2021). Palm kernel meal was fed to ruminants 15-35% of the ration (Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, 2013).

Tapioca solid waste/ *onggok* (9.83%) was local feedstuffs used local cattle feed. *Onggok* itself was a byproduct of the tapioca flour industry, which is made from cassava (Riani *et al*., 2023). *Onggok* was a concentrated feed ingredient that is a byproduct of the production of tapioca flour, which contains soluble carbohydrates that are easily soluble (Rahmawati *et al*., 2020). Cassava can potentially be used as animal feed (Kaur and Ahluwalia, 2017). The use of *onggok* for ruminant animals amounts to 40% of the ration (Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, 2013). Molasses (8.97%) can be fed to livestock directly after processing into single-cell proteins and amino acids. The advantages of molasses for animal feed are its high carbohydrate content (48 - 60% as sugar), mineral content and palatability to livestock. Molasses can be used at 15% in ruminant rations (Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, 2013). Dried cassava chips (8.50%) were a processed cassava product made by a drying process. Cassava chip, and its' processed products are useful as an energy source especially when used with urea to improve ruminant productivity (Wanapat and Kang, 2015).

Ardiansyah *et al*. (2019) stated that raw materials used for the production of concentrates in feed mills are palm kernel meal, copra meal, wheat bran, distiller's grain, soybean meal, tapioca solid waste and *elot* (precipitate of tapioca flour). Kasenta *et al*. (2017) stated that concentrate ingredients used are molasses, dried tapioca solid waste, pollard, copra meal, palm kernel meal, bran polard, Destillers Dried Grains with Solubles (DDGS), cornmeal, mineral, limestone and salt. The raw materials for cattle feed used for concentrates are palm kernel meal, copra meal, bran, limestone, salt, coffee husk, pineapple hulls hulls, pineapple hulls, molasses, wet tapioca solid waste, dry tapioca solid waste, pressed tapioca solid waste, and premix (Wulandari *et al*., 2017).

There were slight differences between the results of the survey data obtained and the data from the database. Some materials obtained were not included in the database. Some feed raw materials were not included in this study because their availability fluctuated throughout the year. Molasses was not included as it was not analyzed and checked regularly. Besides that, some feedstuffs were imported and not listed in the questionnaire, such as SBM, DDGS, corn gluten feed (CGF), and soya full fat.

Physical quality and chemical compositions tests of raw materials by respondents to their feed samples

Quality control is used in determining the quality of raw materials physically. The feedstuffs' physical characteristics are presented in Table 2. Based on the description above, the physical tests most frequently inspected the feed color (18.1%) and odor (18.1%). The inspection was carried out upon the arrival of materials and periodically during storage. Color and odor were the easiest physical checks to determine the quality of raw material qualitatively. Physical tests were performed by looking at appearances that can be assessed with the five senses. Color and odor testing was done to check raw material impurities. This test distinguishes light, dark, pastel, and deep colors which indicates whether the raw material is normal or abnormal. The abnormal color of raw materials indicates that there has been excessive heating.

Table 2. Types of specific physical quality of raw materials based on the survey and questionnaires

Parameters	Frequency (%)
Odor	18.1
Color	18.1
Texture	16.1
Humidity	14.6
Contaminant	11.1
Brix	7.5
Taste	7.0
Density	6.5
Customer Specification	1.0
Total	100

A texture test (16.1%) was used to examine the feed materials' texture. A contaminants test (11.1%) was used to detect if the feedstuff was mixed with other materials, such as soil, sand, and other pollutants. An example was *onggok*, where the contaminants are sand or soil. Raw materials are often contaminated or intentionally mixed with foreign objects, which can reduce quality, so it is necessary to do physical testing to determine the purity of the material. The brix test (7.5%) was used to check the level of glucose in molasses. The taste (7.0%) was tested to know the flavor of feedstuff: fresh, salty, bitter, sweet, and sour (Jaelani, 2021). A density test (6.5%) was used to calculate the specific weight, which can be applied to check the authenticity of the feed material. Specific weight is the ratio between the weight and the volume of the material (Jaelani, 2021).

The proximate and chemical composition of feed samples are shown in Table 3. Moisture examination was the most frequently used chemical test (24%). The material was dried in an air oven at 100 - 105°C until constant weight of the resulting dry material residue is obtained. Loss weight during drying is the amount of water contained in the analyzed material (AOAC, 2005). Much water in feedstuffs will make them less durable and make it easier for putrefying bacteria to damage. Moisture content is an important and widely used indicator in food processing and testing. The terms moisture and water content have been used to specify the amount of water in a product (Uyeh *et al*., 2021). Moisture content can affect the quality of feed ingredients. Good feedstuffs have little moisture content (Grace *et al*., 2018). Storage of feed/feed ingredients to keep quality remains stable feed moisture content not more than 14% (Bidura, 2016). Crude protein (17.7%), extract ether (16.7%), crude fiber (14,6%), and ash (13.5%) tests were also conducted to analyzed the chemical quality of the feedstuffs.

Table 3. Chemical compositions of feedstuffs and other tests carried out by respondents to their feed samples

Parameters	Frequency (%)
Moisture test	24.0
Crude protein	17.7
Extract ether	16.7
Crude fiber	14.6
Ash	13.5
Aflatoxin	5.2
Ca:P	3.1
Energy	2.1
Van Soest analysis	1.0
Carbohydrate	1.0
Na:Cl	1.0
Total	100

Classification and nutritional value of feed ingredients according to the database

The feedstuff samples from databased included bran pollard, copra meal, palm kernel meal, dried cassava chips, corn cob, cocoa bean shell, coffee husk, and tapioca solid waste/ *onggok*. The analysis was based on a database since 2012-2021. The number of feedstuff samples was varied. The result of the study about classification of feedstuff type are presented in Table 4.

There was a total of eight feedstuff databases, which were categorized into three distinct types: energy source, protein source, and fiber source. Following Hartadi *et al*. (1990) international food ingredients classification, number four (4) is the energy source, and number five (5) is the protein source. The energy source includes raw material with a minimum crude protein of 20%, crude fiber of less than 18%, or a cell wall of less than 35 % (Hartadi *et al*., 1990). Examples of energy sources are grain, milling byproducts, fruit, legumes, roots, tubers, and silages. The protein source was raw material with crude protein of 20% and originating from animal products or oilseed, cake, bran, and some other ingredients.

Fiber source contain a fiber level above 18%. Based on the data, feedstuffs as an energy source were mainly from dried cassava chips and bran pollard. Feedstuff as a protein source was a copra meal. Fiber sources are corn cob, coffee husk, cocoa bean shell, solid tapioca waste/*onggok*, and palm kernel meal.

This result according with Handayani (2020) stated that the nutrient content in the cassava chip, especially protein, was very low, but cassava was a potential source of energy potential. Copra meal is rich in protein (21.2% – 21.4%, dry matter basis), ideal as a protein source for feeds for livestock (Mat *et al*., 2022). Copra meal can be used as one of the ingredients in animal feed rations because it has a

Table 4. Classification of feedstuff based on databases

Feedstuff	Average value (%)						
	DM	CP	Fat	CF	Ash	NFE	TDN
Energy source							
Dried cassava chips (n:29)	88.6	2.4	0.7	2.4	2.3	92.2	81.2
Bran pollard (n:27)	88.5	17.2	4.3	11.5	6.3	60.7	66.6
Fiber source							
Corn cob (n:23)	68.5	3.9	0.9	37.7	4.1	55.2	62.7
Coffee husk (n:27)	87.1	9.0	1.0	38.0	8.2	46.2	40.2
Cocoa bean shell (n:16)	91.3	15.2	5.8	20.0	10.3	48.7	46.3
Tapioca solid waste/*onggok* (n:41)	83.4	2.6	0.6	22.1	7.4	68.1	60.2
Palm kernel meal (n:23)	94.4	16.0	9.8	22.1	4.9	48.3	78.6
Protein source							
Copra meal (n:35)	91.1	22.9	7.7	15.3	7.2	47.9	69.1

high protein content, which is quite high, reaching 21.5% (Rokhayati, 2019). Dyah *et al*. (2021) stated that the results of the analysis showed that the crude fiber content of the corncobs was 42.90%, so the crude fiber was high. Crude fiber Palm kernel meal content ranges from 28% –42.2% (Yatno, 2011).

Crude protein

The results of protein analysis based on the database are shown in Table 5. Table 5 indicates that from eight types of feedstuffs, the highest protein content was in copra meal at 22.9%, while the lowest was in dried cassava chip at 2.4%. The low crude protein content of dried cassava indicates that it is not a protein source. Copra meal is the cake obtained after coconut oil is extracted using the expeller method from the coconut flesh. The crude protein content of copra meal is 20% (Alimon, 2009). Hartadi *et al*. (1990) stated that the international food ingredient number 5 was a protein source with more than 20% protein content. Feedstuff included in this category was a copra meal with a crude protein level of 22.9%. The most common crude protein content of copra meal was 24%. Hartadi *et al*. (1990) reported that the crude protein level of copra meal is 21%. BSN (1996) suggested two standards of crude protein for copra meal: standard 1, 18%, and 16% for standard 2. Based on the databases, 27 samples (84%) contained crude protein belonging to standard 1, 3 samples (9%) belonging to standard 2, and 2 samples (6%) out of standard/ protein under 16%. Standard deviation of the copra meal's crude protein content means the highest was 5.2%. The minimum CP value from database was 7%, and the maximum was 37.1%, indicating a high crude protein range. The protein content of copra meal depends on the production process, where copra with solvent extraction has a higher CP value. Copra meal can be used as 30% of ruminant feed (Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, 2013).

The average protein content of 25 samples of dried cassava chips was 2.4%. The most common crude protein content of dried cassava chips was 2%. This finding follows Dwi *et al*. (2019), who discovered that crude protein analysis from the results of dried cassava chips from various types was 1.86-3.84%. Based on the Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi (2013) the average crude protein of dried cassava chips was 1.93%. Dried cassava chip is an energy source with low crude protein levels. Wanapat and Kang (2015) stated that cassava roots can be processed as dried chip or pellet. Cassava roots rich in soluble carbohydrate (75% – 85%) but low in crude protein (2% – 3%). The effect of using cassava meal in feeds at the level of 40% on the productivity and rumen fluid profile of crossbred Limousine bulls had the highest nutrient intakes compared to other treatments and DM intake reached 95.96 g/kg0.75/day or equal to 2.24% body weight and highest value of ADG 1.35 kg/head/day (Retnaningrum, 2019).

Crude fiber

The crude fiber contents of the feedstuffs are shown in Table 6. Table 6 indicates the highest crude fiber level is found in coffee husk at 38%, while the lowest is dried cassava chips at 2.4%. Feedstuffs included as fiber sources were palm kernel meal, cocoa bean shells, solid tapioca waste/ *onggok*, corn cob, and coffee husks with 20-38% crude fiber.

Two fiber categories are insoluble and soluble (Almatsier, 2009). The total content of crude fiber can represent lignocellulose content. Tillman *et al*. (1998) state that fiber consists of cellulose, hemicellulose, lignin, and a minor pectin compound. As a result, biomass's total crude fiber content greatly determines the total content of each

Table 5. Crude protein analysis result based on database

Feedstuff types	Number of sample (n)	Average (%)	Min (%)	Max (%)	Std Dev (%)	Modus (%)
Copra meal	32	22.9	7.6	37.1	5.2	24
Bran pollard	25	17.2	11.3	23.9	3.2	17
Palm kernel meal	20	16.0	11.0	19.9	2.4	17
Cocoa bean shells	15	15.2	10.9	19.6	2.3	17
Coffee husks	22	9.0	4.4	13.8	2.2	9
Corn cob	20	3.9	2.0	8.2	1.4	4
Solid tapioca waste/*onggok*	37	2.6	1.0	7.0	1.0	2
Dried cassava chips	25	2.4	0.5	4.4	1.0	2

Table 6. Crude fiber analysis of sampled feed obtained from database

Feedstuff types	Number of sample (n)	Average (%)	Min (%)	Max (%)	Std Dev (%)	Modus (%)
Dried cassava chips	25	2.4	1.3	4.2	0.8	2
Bran pollard	25	11.5	7.4	25.9	3.7	11
Copra meal	31	15.3	9.5	24.4	4.1	12
Palm kernel meal	19	22.1	12.8	37.7	5.5	19
Cocoa bean shells	15	20.0	13.0	32.3	4.2	18
Solid tapioca waste/*onggok*	36	22.1	15.4	31.6	3.6	20
Corn cob	19	37.7	4.3	59.4	11.8	38
Coffee husks	21	38.0	22.6	69.6	11.0	36

fraction of lignocellulosic (cellulose, hemicellulose, and lignin). Crude fiber contains cellulose, lignin, and hemicellulose, depending on the species and growth phase of the plant material (Anggorodi, 1994).

The 25 samples of dried cassava chips in Table 6 showed an average crude fiber content (CF) of 2.4%, while most samples contain 2% crude fiber. The analysis of the crude fiber content conducted by Antari and Umiyasih (2009) resulted in 4.18%. The research findings by Prasetyo *et al*. (2019) indicate that the analysis of dried cassava chips' crude fiber content ranges from 2.93% to 3.91%. The smallest standard deviation for cassava chips was 0.8%. The difference in crude fiber content of cassava chips may be due to differences in the manufacturing process, namely the inclusion of the skin or the exclusion of the skin, if used the skin, the crude fiber content will be higher. The use of cassava in rations on the basis of some ruminant researchers 40 – 90% (Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, 2013). Kartika (2019) said that the use of 40% manioc flour in concentrate showed the best response in increasing the body weight of Limousin breeders by 1.43 ± 0.24 kg/head/d. Recommended to use cassava chip as an alternative source of energy to corn meal when the price is economical and it is locally available (Wanapat and Kang, 2015).

Moreover, the highest crude fiber content found among 21 samples was coffee husks, with an average crude fiber (CF) of 38%. The most frequently reported means of crude fiber content (CF) value was 36%. This result was consistent with the findings of Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi (2013), which reported a crude fiber content of coffee husks at 38.67%. Isharyudono and Mar (2019) stated that the crude fiber content of coffee husks at 41.69%. The standard deviation for coffee husks was also high at 11%, indicating a wide distribution of values. The origin of the coffee skin in the database comes from Lampung, Bengkulu and East Java so that the value of crude fiber content varies. Wardhana *et al*. (2019) stated that the crude fiber content of coffee husks from West Java ranged from 30.15% to 36.98%. Aswanto *et al*. (2023) stated that the crude fiber content of dried coffee husk samples from each village West Lampung range 28.04% - 29.76%.

Ether extract (EE)

The data of feedstuff's ether extract (EE) content is shown in Table 7. Table 7 shows that palm kernel meal contains the highest ether extract (EE) content (9.8%), and dried cassava chips contain the lowest EE (0.8%). The observation on 20 palm kernel meal samples showed an average EE of 9.8%. The most frequently stated EE value was 10%. Palm kernel meal EE content of quality 1 was 9%, and quality 2 was 10% (BSN, 2017) . The results showed that eight samples, or 40% of palm kernel meal, were included in quality 1, while those included in quality 2 were two or 10%, and ten samples, or 50%, were not included in SNI quality. The EE content of palm oil cake was 9.66% (Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, 2013). Hartadi *et al*. (1990) stated that the EE content of palm kernel meal was at 12.9%. Sukaryana *et al*. (2013) state that the EE content of palm kernel cake is 13.67%. Azizi et al. (2021) state that the EE content in palm kernel cake is 3 – 9%. The various nutrient content in palm kernel meal is due to differences in plant age, extraction techniques, area of origin, and type of oil palm (Wulandari *et al*., 2015). Chemical composition of palm kernel cake varies depending on the type of the fruits palm, source of sample and method of processing oil extraction (screw pressing or solvent extraction). Also, 30% palm kernel cake is a source of energy and protein in feedlot cattle and sheep (Abdeltawab and Khattab, 2018). The high EE content in palm kernel meal can cause rancidity, thereby shortening the shelf life of the feed ingredients (Nurhayati *et al*., 2006).

The average EE of 35 solid tapioca waste/*onggok* samples was 0.6%. Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi (2013) analyzed

Table 7. Ether extract analysis result of sampled feed obtained from database

Feedstuff type	Number of Sample (n)	Average (%)	Min (%)	Max (%)	Std Dev (%)	Modus (%)
Palm kernel meal	20	9.8	5.1	13.1	2.1	10
Copra meal	32	7.7	0.4	24.7	5.8	9
Cocoa bean shells	15	5.8	3.4	10.8	1.9	4
Bran pollard	25	4.3	1.7	8.6	1.9	3
Coffee husks	22	1.0	-	2.9	0.7	1
Corn cob	19	0.9	-	2.2	0.7	0
Dried cassava chips	24	0.7	-	2.4	0.6	1
Solid tapioca waste/*onggok*	35	0.6	-	2.5	0.7	0

the *onggok* EE with a result of 0.35%. Sukaryana *et al*. (2013) stated that the EE content of *onggok* was 0.54%. Musita (2018) reported that the EE content of dried cassava chips was 0.11 – 0.17%.

The chemical composition contained in dried cassava chips varies, depending on the drying of cassava, climate and topography, the efficiency of the extraction process, losses during starch extraction, and the quality of raw materials (Nurhasan and Pramudianto, 1993).

Ash

The description of the raw materials' ash content is presented in Table 8. Table 8 shows that that the highest ash content was in cocoa bean shells (10.3%), while the lowest was in dried cassava chips (2.3%). The ash content measurement was used to determine the mineral content in the material sample. The ash content is specified based on the weight loss after combustion. At the endpoint, combustion is stopped before ash degradation occurs (Sudarmadji *et al*., 2003).

This study reported that 15 cocoa bean shell samples' average ash content was 10.3%. The most common ash content value is 9%. Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi (2013) suggested an average ash content of 8.63%. Azizah *et al*. (2014) stated that the total ash content of cocoa bean shell was 7.41%. However, the mineral content in the cocoa bean shell was varied, mainly due to its geographic origin. The uptake of minerals by the plant was highly dependent on the availability of minerals in the soil, being, therefore, dependent on the soil's type and quality (Soares and Oliveira, 2022). The ash content was determined to be between 5.96% and 11.42%, which is influenced by the roasting process, and this value increases by around 15% (Rojo-Poveda *et al*., 2020). Soeharsono *et al*. (2017) stated that supplementation 40% cocoa beans waste to young male Bali cattle increased daily body weight gain, and resulted in better feed efficiency.

Observing 26 dried cassava chip samples indicated that the ash content was 2.3%. The most common ash content value was 2%. This result agrees with the analysis of Sukaryana *et al*. (2013) that the ash content of dried cassava chips was 2.25%. Sudarmadji *et al*. (2003) stated that the ash content in the feed is related to the mineral content in the feed. The higher the ash content, the higher the minerals.

Nitrogen free extract (NFE)

The data of feed raw materials' nitrogen-free extract are presented in Table 9. Analysis of the eight raw materials showed that the highest nitrogen-free extract (NFE) was in dried cassava chips (92.2%), and the lowest was in coffee husks (46.2%). The results of the study of 25 samples of dried cassava chips contained 92.2% NFE. The most frequently obtained NFE value is 92%. Muchlas *et al*. (2014) reported that the NFE content of dried cassava flour was 91.06%. The total carbohydrate content was expressed in form of % NFE and was obtained by difference. Carbohydrate contents ranged from 70.38% - 85.73% (Edet *et al*., 2023). Non-Nitrogen Extract Ingredients (NFE) are food ingredients containing carbohydrates, sugar and starch. NFE is a soluble carbohydrate, including monosaccharides, disaccharides and polysaccharides, which are easily soluble in acid and alkaline solutions and have high digestibility (Anggorodi, 1994).

The 23 coffee husk samples analysis showed that the average NFE was 46.2%. The most frequently obtained NFE content of coffee husk was 47%. The NFE content of coffee husks was low due to the high crude fiber content. Sutowo (2016) state that the content of crude fiber in the material will affect the content of the Basic Ether Extract-Nitrogen-Free Extract in the feed.

Total digestible nutrient (TDN)

The total digestible nutrient analysis on the feed raw materials is presented in Table 10. Table 10 shows that dried cassava chips contain the highest TDN value of 84.2%, and coffee husks contain the lowest of 42.0%. The analysis of 24 samples indicates that the average TDN of dried cassava chips was 84.2%. The most frequently

Table 8. Ash analysis result analysis result of sampled feed obtained from database

Feedstuff type	Number of Sample (n)	Average (%)	Min (%)	Max (%)	Std Dev (%)	Modus (%)
Cocoa bean shells	15	10.3	6.6	20.6	3.3	9
Coffee husks	22	8.2	1.2	14.1	2.7	9
Solid tapioca waste/*onggok*	38	7.4	1.6	27.0	5.8	2
Copra meal	33	7.2	3.7	8.8	1.0	8
Bran pollard	26	6.3	4.2	13.5	2.3	6
Palm kernel meal	21	4.9	3.5	15.4	2.7	4
Corn cobs	21	4.1	2.5	2.5	1.9	4
Dried cassava chips	26	2.3	1.1	6.0	0.9	2

Table 9. Nitrogen free extract analysis result of sampled feed obtained from database

Feedstuff type	Number of Sample (n)	Average (%)	Min (%)	Max (%)	Std Dev (%)	Modus (%)
Dried cassava chips	25	92.2	86.9	95.5	2.0	92
Solid tapioca waste/*onggok*	37	68.1	48.2	79.6	7.2	72
Bran pollard	25	60.7	34.9	69.4	6.8	61
Corn cop	20	55.2	32.8	94.3	14.7	50
Cocoa bean shells	15	48.7	23.5	57.4	7.6	49
Palm kernel meal	20	48.3	37.0	72.8	7.8	46
Copra meal	32	47.3	30.7	64.4	8.4	40
Coffee husks	23	46.2	24.8	809	10.8	47

Table 10. Total digestible nutrient analysis result of sampled feed obtained from database

Feedstuff type	Number of Sample (n)	Average (%)	Min (%)	Max (%)	Std Dev (%)	Modus (%)
Dried cassava chips	24	84.2	73.9	90.1	4.1	83
Palm kernel meal	20	78.6	37.1	95.0	12.5	75
Copra meal	32	67.7	26.6	94.6	16.5	80
Bran pollard	25	66.6	14.6	80.9	14.9	71
Corn cob	20	62.7	-	82.9	18.2	65
Solid tapioca waste/*onggok*	37	60.2	10.3	84.3	21.0	64
Cocoa bean shells	15	49.3	(8.9)	72.8	18.9	58
Coffee husks	22	42.0	22.1	81.1	13.8	35

Table 11**.** Proximate analysis and prices regressions based on database

Parameter	Proximate	Regression	R	R^2	*p*
Price	DM	Y = 75.291 + 0.005 X	0.588	0.35	0.219
Price	CP	Y = 0.542 + 0.005 X	0.77	0.59	0.730
Price	EE	Y = 0.079 + 0.002 X	0.528	0.28	0.281
Price	CF	Y = 45.060 – 0.10 X	0.962	0.92	0.002
Price	Ash	Y = 5.752 + 0.000 X	0.184	0.03	0.219
Price	NFE	Y = 54.073 + 0.000 X	0.03	0.00	0.955
Price	TDN	Y = 52.034 + 0.005 X	0.475	0.22	0.341

DM = Dry matter, CP = Crude protein, CF = Crude fiber, EE = Ether extract, Ash, NFE= Nitrogen free extract, TDN = Total digestible nutrient, r = Corelation coefficient, R^2 = Determination coefficient.

found TDN value of dried cassava chips was 83%. Antari and Umiyasih (2009) stated that dried cassava chips contained a TDN of 52.88%.

The observation on 22 coffee husk samples showed an average TDN of 42%. The most frequently found TDN content of coffee husks was 35%. Syafrudin *et al*. (2020) stated that coffee husk contained a TDN 42.90%. Hari *et al*. (2014) stated that TDN value of coffee husk was 46.54%. Souza *et al*. (2006) tested different levels of inclusion of coffee husk (0.0%, 8.75%, 17.5%, and 26.25%) as substitute for maize in Holstein X Zebu heifer diets, they found that digestibility, consumption, and weight gain were not affected up to 17.5% coffee husk were included in the diet. In both ruminant and non-ruminant animals, the digestibility of the hull or pulp can be increased by to chemical treatment or the silage process, its digestibility and utilization can be increased (Oropeza *et al*., 2022). Saputro *et al*. (2016) stated that the TDN value was closely related to organic matter, which illustrates of nutrients in digestible feed. TDN levels of general feed ingredients are inversely proportional to crude fiber (Anggorodi, 1994). Total digestible nutrient (TDN) is the total energy of food substances in livestock that is equal to energy from carbohydrates. It can be obtained by biological tests or calculations using data from proximate analysis. In general, the total digestible nutrient (TDN) value of a feedstuff is proportional to the digestible energy, varying according to the digestibility of the food energy can be digested and the type of feed or ration (Parakkasi, 1998).

Relationship of proximate analysis value with price of raw material

The results of the regression analysis between the nutritional content of the proximate analysis with prices are presented in Table 11. Regression analysis between proximate composition and prices showed a positive correlation in DM, CP, EE, Ash, NFE and TDN, while crude fiber showed a negative correlation. The regression results between crude fiber and price have a correlation coefficient of 0.962 or 96.2% and a determination coefficient of 0.92 or 92% with P < 0.01 (significant). The high value of the coefficient of determination indicated that the crude fiber content in these raw materials greatly influenced the price. The regression results between crude protein and price have a correlation coefficient of 0.77% or 7.7% and a determination coefficient of 0.59% or 59% with P > 0.05 (nonsignificant). This indicated that the crude protein content in these raw materials did not affect the price. The regression results between TDN and price have a correlation coefficient of 0.475 or 4.75% and a determination coefficient of 0.22 or 22% with P > 0.05 (nonsignificant). This indicated that the TDN content in these raw materials did not affect the price. Rosalina (2005) stated that if the correlation coefficient was greater than 0.6%, the relationship between variables was considered strong or close. If the correlation coefficient was less than 0.6% the relationship between variables was considered weak.

Conclusion

Based on the database and survey, it can be concluded that there are 8 (eight) types of local feed of local feed raw materials that most frequent utilized in the concentrate formula for beef cattle feedlot in Indonesia. These raw materials (dried cassava chips and bran pollard) can be classified as energy sources with a TDN value of 66% – 81.2%, while copra meal as a protein source with a crude protein value of 22.4% and corn cobs, coffee husks, cocoa bean shells, solid tapioca waste/*onggok*, and palm kernel meal as fiber sources with a crude fiber value of 20% – 38%. The physical test most frequently inspected the feed color (18.1%) and odor (18.1%). Moisture examination (24%) was the most frequently used of proximate analysis was employed to identify the chemical composition. The high value of the coefficient of determination indicated that the crude fiber content in raw materials greatly influenced the price.

Conflict of interest

The authors have no conflict of interest to declare. All authors have seen and agree with the contents of the manuscript.

Acknowledgement

The author would like to thank to PT Widodo Makmur Perkasa Tbk for support this research.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: A.A, A.Ag and T.I.; data collection: T.I.; analysis and interpretation of results: T.I, A.A, A.Ag, CTN, S.A.; draft manuscript preparation: T.I, A.A, A.Ag, CTN, S.A. All authors reviewed the results and approved the final version of the manuscript.

References

Abdeltawab, A. M. and M. S. A. Khattab. 2018. Utilization of palm kernel cake as a ruminant feed for animal: a review. Asian Journal of Biological Sciences 11: 157–164.

Adi Suroso, G. G., K. Adhianto, M. Muhtarudin, and E. Erwanto. 2023. Evaluasi kecukupan nutrisi pada sapi potong di KPT Maju Sejahtera Kecamatan Tanjung Sari Kabupaten Lampung Selatan. Jurnal Riset dan Inovasi Peternakan 7: 147–155.

Alimon, A. R. 2009. Alternative raw materials for animal feed. Wartazoa 193: 117-124.

Almatsier, S. 2009. Prinsip Dasar Ilmu Gizi. Gramedia, Jakarta.

Anggorodi. 1994. Ilmu Makanan Ternak Umum. Gramedia, Jakarta.

Antari, R. and D. U. Umiyasih. 2009. Pemanfaatan tanaman ubi kayu dan limbahnya secara optimal sebagai pakan ternak ruminansia. Wartazoa 19: 191-200.

Ardiansyah, D., N. Irwani, and Y. Priabudiman. 2019. Tata laksana pengelolaan pakan sapi potong. Jurnal Peternakan Terapan 1: 1–7.

AOAC. 2005. Official Methods of Analysis 18th ed. Association of Official Analytical Chemist. Arlington, USA.

Aswanto, A. A., M. Muhtarudin, F. T. Farda, L. Liman, and S. Tantalo. 2023. Potensi nutrien limbah kulit kopi untuk pakan ternak ruminansia di Kecamatan Kebun Tebu Kabupaten Lampung Barat. Jurnal Riset dan Inovasi Peternakan 7: 306–311.

Azizah, D. N., E. Kumolowati, and F. Fahrauk. 2014. Penetapan Kadar flavonoid metode AlCl3 pada ekstrak metanol kulit buah kakao (*Theobroma cacao L*.). Kartika Jurnal Ilmiah Farmasi 2: 45–49.

Azizi, M. N., T. C. Loh, H. L. Foo, and E. L. T. Chung. 2021. Is palm kernel cake a suitable alternative feed ingredient for poultry? Animals 11: 1–15.

BSN. 1996. Bungkil Kelapa Bahan Baku Pakan - SNI 01-2904-1996/Rev 1992. 1–3. Badan Standardisasi Nasional, Jakarta.

BSN. 2017. Bungkil Inti Sawit - Bahan Pakan Ternak SNI 7856 2017. SNI. 1–4. Badan Standardisasi Nasional, Jakarta.

Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi. 2013. Buku Hasil Pengujian Bahan Pakan dan Hijauan Pakan Ternak. Balai Pengujian Mutu dan Sertifikasi Pakan Bekasi, Bekasi.

Bidura. 2016. Bahan Ajar Bahan Makanan Ternak. Universitas Udayana, Denpasar.

Direktorat Jenderal Peternakan dan Kesehatan Hewan. 2020. Statistik Peternakan dan Kesehatan Hewan 2020, Jakarta.

Dwi, P. G., A. D. Kartika, and Mashudi. 2019. Nilai kecernaan BK dan BO tepung gaplek dari berbagai jenis tanaman singkong (Manihot utilissima) secara *In Vitro*. Jurnal Nutrisi Ternak Tropis 2: 33-37.

Dyah, S., N., F. Y. Adriyani, R. Hevrizen, and A. Maryanto. 2021. Peningkatan kualitas janggel jagung sebagai pakan sapi induk bunting melalui proses amoniasi-fermentasi (Amofer). Jurnal Riset Agribisnis dan Peternakan 6: 21–30.

Edet, I. V, T. M. Akpomie, A. U. Augustine, T. F. Samoh, E. Ekam, D. D. Nzegbuna, and E. J. Ekam. 2023. Comparative analysis on the proximate composition of processed cassava products obtained from Nigeria. Chemical Science International Journal 32: 50–63.

Grace, F., I. Marbun, R. Wiradimadja, I. Hernaman, and J. Sumedang. 2018. The effect of storage time on the physical characteristics of rice bran. Jurnal Ilmiah Peternakan Terpadu 6: 163-166.

Handayani, L. 2020. Pemanfaatan limbah ubi kayu sebagai pakan ternak bergizi. Prosiding Seminar Nasional Hasil Pengabdian 185-192.

Hari, E. W., M. Cristanto, and E. Rianto. 2014. Potensi limbah kulit kopi sebagai complete feed yang sesuai untuk pakan ternak domba. Jurnal Libang Provinsi Jawa Tengah 12: 33-42.

Hartadi, H., S. Reksohadiprodjo, S. Lebdosukodjo, and A. Tillman. 1990. Tabel Komposisi Pakan Untuk Indonesia. Gadjah Mada University Press, Yogyakarta.

Haza, M. B. 2016. Penggemukan Sapi (Feedlot) Dengan Menggunakan Beta Agonis 2 Perspektif Hukum Islam. Universitas Islam Negeri Maulana Malik Ibrahim, Malang.

Isharyudono, K. and I. Mar. 2019. Penggunaan bahan inkonvensional sebagai sumber bahan pakan. Jurnal Pengelolaan Laboratorium Pendidikan 1: 1-6.

Jaelani, A. 2021. Proses Produksi dan Uji Kualitas Fisik Pada Industri Pakan. Zuxzes Express, Banjarbaru.

Kartika, A. D. 2019. Pengaruh Pemberian Konsentrat dengan Level Tepung Gaplek Berbeda Terhadap Konsumsi Pakan, Pertambahan Bobot Badan Harian dan Konversi Pakan Sapi Peranakan Limosin. Universitas Brawijaya, Malang.

Kasenta, M., L. N. Aini, and Riyanto. 2017. Manajemen penggemukan sapi *Brahman cross* bx di Pt Fortuna Megah Perkasa Bogor Jawa Barat. Jurnal Inovasi Penelitian 1: 49-54.

Kaur, K. and P. Ahluwalia. 2017. Cassava as potential crop for the food and fermentation industry: a review. International Journal of Food and Fermentation Technology 7: 1-12.

Maluyu, H. 2021. Teknologi Pakan Ruminansia. Raja Grafindo Persada, Depok.

Mat, K., Z. A. Kari, N. D. Rusli, H. C. Harun, L. S. Wei, M. M. Rahman, H. N. M. Khalid, M. H. M. A. Hanafiah, S. A. M. Sukri, R. I. A. R. Khalif, Z. M. Zin, M. K. M. Zainol, M. Panadi, M. F. M. Nor, and K. W. Goh. 2022. Coconut palm: food, feed, and nutraceutical properties. Animals 12: 1-19.

Muchlas, M., Kusmartono, and Marjuki. 2014. Pengaruh penambahan daun pohon terhadap kadar VFA dan kecernaan secara in-vitro ransum berbasis ketela pohon. Jurnal Ilmu-Ilmu Peternakan 24: 8–19.

Musita, N. 2018. Study of physicochemical properties of large industry and small industry. Majalah Teknologi Agro Industri 10: 19-24.

Nurhasan, and Pramudianto Bb. 1993. Buku Panduan Penanganan Limbah Cair Industri Kecil Tapioka. 1st ed. Yayasan Bina Karta Lestari, Jakarta.

Nurhayati, O. Sjofjan, and Koentjoko. 2006. The nutritional quality of palm kernel cake and tapioca waste mixture fermented by Aspergillus niger. Jurnal Indonesia Tropical Animal Agricultural 3: 172-178.

Oropeza, M., E., M. E. O. Cerrilla, J. G. H. Haro, E. J. R. Bribiesca, and T. S. Ríos. 2022. Use of pulp and husk of coffee in animal feed. Agro Productivida 15: 150-158.

Parakkasi, A. 1998. Ilmu Nutrisi dan Makanan Ternak Ruminansia. Universitas Indonesia Press, Jakarta.

Prasetyo, G. D., A. D. Kartika, and Mashudi. 2019. Nilai kecernaan BK dan BO tepung gaplek dari berbagai jenis tanaman singkong (*Manihot utilissima*) secara *In Vitro*. Jurnal Nutrisi Tropis 2: 33-37.

Rahmawati, N., E. F. Lisnanti, M. Muladno, and A. Atabany. 2020. Potency of local feed ingredients and ability of livestock to use the feed: an in-vitro study. J. Adv. Vet. Anim. Res. 7: 92–102.

Retnaningrum, S. 2019. Pengaruh Penggunaan Tepung Gaplek (*Manihot utilissima*) Dalam Pakan Dengan Level Berbeda Terhadap Produktivitas Dan Profil Cairan Rumen Sapi Jantan Persilangan Limousin. Brawijaya University, Malang.

Riani, A., M. D. Mesgaran, and M. Wanapat. 2023. The effect of addition of onggok as a mixed material in the making complete feed silage on the overall digestibility of BK, BO, and NH_3 production *in vitro*. Frontier Advances in Applied Science and Engineering 1: 82–91.

Rojo-Poveda, O., L. Barbosa-Pereira, G. Zeppa, and C. Stévigny. 2020. Cocoa bean shell—a by-product with nutritional properties and biofunctional potential. Nutrients 12: 1-29.

Rokhayati, U. A. 2019. Meramu Bungkil Kelapa Sebagai Sumber Protein Nabati Untuk Pakan Ternak. UNG Press, Gorontalo.

Rosalina. 2005. Analisis Statistik Menggunakan Aplikasi Excell. Alfabeta, Bandung.

Saputro, T., S. D. Widyawati, and D. Suharto. 2016. Evaluasi nutrisi perbedaan rasio dedak padi dan ampas bir ditinjau dari nilai TDN ransum domba lokal jantan. Sains Peternakan 14: 27–35.

Sitindaon, S. H. 2013. Inventarisasi potensi bahan pakan ternak ruminansia di Provinsi Riau. Jurnal Peternakan 10: 18-23.

Soares, T. F. and M. B. P. P. Oliveira. 2022. Cocoa by-products: characterization of bioactive compounds and beneficial health effects. Molecules 27: 1-23.

Soeharsono, M. Amin, and A. Cahyono. 2017. The use of cocoa bean waste as a supplement in male Bali cattle feeding. Proseding of Internasional Seminar on Livestock Production and Veterinary Technology 45-49.

Souza, L. de, A., R. Garcia, F. S. Bernardino, J. M. de S. Campos, S. de Campos Valadares Filho, L. da Silva Cabral, and K. Fernanda Gobbi. 2006. Coffee hulls in dairy heifer diet: intake, digestibility, and production. Revista Brasileira de Zootecnia 35: 921-927.

Sudarmadji, S., B. Haryono, and Suhardi. 2003. Analisis Bahan Makanan dan Pertanian. 1st ed. Liberty, Yogyakarta.

Sukaryana, Y., Nurhayati, and C. U. Wirawati. 2013. Optimizing use palm kernel cake, cassava and cassava byproduct through fermentation technology with mold different as broilers material feed. Jurnal Penelitian Pertanian Terapan 13: 70–77.

Sutowo, I., T. Adelina, and D. D. Febrina. 2016. Kualitas nutrisi silase limbah pisang (batang dan bonggol) dan level molases yang berbeda sebagai pakan alternatif ternak ruminansia. Jurnal Peternakan 13: 41-47.

Syafrudin, A. I., E. Pangestu, and M. Christiyanto. 2020. Nilai total digestible nutrient pada bahan pakan by- product industri pertanian sebagai pakan kambing yang diuji secara *in vitro*. Jurnal Sain Peternakan Indonesia 15: 302–307.

Tillman, A., H. Hartadi, S. Reksohadiprodjo, S. Prawirokusumo, and S. Labdosoekojo. 1998. Ilmu Makanan Ternak Dasar. 6th ed. Gadjah Mada University Press, Yogyakarta.

Uyeh, D. D., J. Kim, S. Lohumi, T. Park, B. K. Cho, S. Woo, W. S. Lee, and Y. Ha. 2021. Rapid and non-destructive monitoring of moisture content in livestock feed using a global hyperspectral model. Animals 11: 1-17.

Wanapat, M. and S. Kang. 2015. Cassava chip (*Manihot esculenta crantz*) as an energy source for ruminant feeding. Animal Nutrition 1: 266–270.

Wardhana, I. D., E. Ruriani, and A. Nafi. 2019. Karakteristik kulit kopi robusta hasil samping pengolahan metode kering dari perkebunan kopi rakyat di Jawa Timur. Agritop. 17: 220–229.

Wulandari, D., S. Widjaya, and Suryani. 2017. Analysis of raw material supply control of cattle feed in CV Satriya Feeds Lampung in Terbanggi Besar Subdistrict, Central Lampung District. JIIA. 5: 250-257.

Wulandari, S., F. Fathul, and D. Liman. 2015. The effect of various composition of agricultural waste on water content, ash, and crude fiber in water. Jurnal Ilmiah Peternakan Terpadu 3: 104-109.

Yatno. 2011. Fraksinsi dan sifat fisiko-kimia bungkil inti sawit. Agrinak. 1: 11-16.