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Evaluation of Compacted Forage Feed on Kupang Cattle Feeding Behavior

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ABSTRACT

Forage compact feed has the ability to cut the adaptation period of grazing cattle when transported, because they are used to consume forage. The effect of the form and type of forage formulation on the feeding behavior of cattle needs to be studied further to determine the preferences of cattle for this compact feed. This study used 36 cattle with 3 replications in each treatment. The 2 factor groups with factorial design consisting formulation and form of feed was applied in this study. The forms of feed used in this study were wafers, pellets, dried pellets, and cubes. The formulations used in this study were formulation 1 (10% molasses, 30% indigofera leaves, 50% straw, 10% elephant grass); formulation 2 (10% molasses, 30% indigofera leaves, 60% straw); formulation 3 (10% molasses, 20% indigofera leaves, 65% straw, 5% hemp). The parameters observed in this study were eating behavior of cattle which consisted of the frequency and duration of eating, drinking, rumination, and resting. The results showed that there was an interaction on eating frequency and cattle duration. Formulation 3 on wafer treatment had the highest feeding frequency ($P<0.05$). Formulation 1 on wafer treatment had the highest duration of rumination ($P<0.05$). In the conclusion, Formulation 1 and 3 with wafer shape showed the best behavior for eating.

Keywords: Compacted feed, Feed logistics, Feeding behavior, Forage Pellet, Kupang cattle

Introduction

Cattle transportation is an effort that had been made to send cattle between business actors for the sustainability for the beef production cycles (Van engen and Coetzee, 2018). Delivery on the same island could use land transportation modes, while delivery on different islands should use water or air transportation modes (Schwartzkopf-Genswein and Grandin, 2014). Beef production system usually consists of several categories such as pasture-based cow-calf, stocker-back grounding, and feedlot finishing (Greenwood, 2021). Some farms produce all three types of cattle on their farms and some don't, depending on availability of pasture, feed cost, economic factors, and market specifications (Greenwood, 2021). When the cattle changing phases, distance becomes a limiting factor for business actors in the cattle industry sector (Swanson and Morrow-Tesch, 2001).

Feed adaptation period during cattle transportation needs to be considered. Cattle that are raised with forage-based system will find it difficult to consume a non-forage feed (Heazlewood *et al*., 1992). Cereals with forage pellet mixtures are implemented if the cattle are shipped for a long time (MLA, 2011) because forage requires a lot of space for storage (voluminous) (Arroquy *et al*., 2017) and easy to be fermented when the environmental temperature and humidity is high (Malik and Singh, 2004). Cattle that are given a concentrate during transport, need to adapt against the new type of feed so that the performance of the cattle does not decrease drastically due to a low feed consumption. Adaptation period is needed for cattle due to feed adaptation, fecal and digesta composition, ruminal fermentation, and rumen bacterial composition (Machado *et al*., 2016). In addition, farmers need to expend an additional effort to observe cattle behavior in order to adapt to new types of feed on adaptation period. On the other side, large farmers are also trying to speed up the adaptation period to cut the costs.

Efforts to eliminate the adaptation period could be done by providing compacted feed that is consisted of 100% forage. Compact feed is a feed that undergo a physical treatment, so the feed will become more compact and does not spend a large space during transportation (Widjaya *et al*., 2018). Cattle are expected to immediately getting used to consume the compacted feed, because the feed composition is familiar to the cattle nature. Some examples of compacted feed shapes are mash, wafer, pellet, dried pellet, and cube. Wafer and cube feed shapes mostly used for forages while pellet shape used for cereals (Lewis, 2013).

Before applying this feeding technique during transportation, it is necessary to conduct a study that observes the feeding behavior of cattle on forage compact feed at quarantine. This study was aimed to observe the feeding behavior of cattle on several feed ingredients, formulations, and shapes. The best feed ingredients will be formulated and formed into several types of compacted feed forms. The parameters observed in this study were feed adaptability and eating behavior of the cattle.

Materials and Methods

Feed screening (initial research)

In this initial research study, we evaluated several feedstuffs to find the most suitable feed ingredients that could be applied on a grazing cattle and then formulated it for following research. This research was conducted by giving 1 kg of certain feedstuff on Kupang Cattle to observe eating duration until the feedstuffs were totally consumed. There were 7 treatments of feedstuffs (elephant grass, rice straw, field grass, leucaena leaves, indigofera leaves, cassava dregs, and mash feed mixture for cattle) was observed in this study, each treatment was consisted of 3 repetition.

Feed formulations

The best results on eating duration of several feedstuffs obtained in previous studies will be used as a formulation ingredients in future research. Three formulations had been used in this study, 10% molasses, 30% indigofera leaves, 50% rice straw, 10% elephant grass (formulation 1); 10% molasses, 30% indigofera leaves, 60% rice straw (formulation 2); 10% molasses, 20% indigofera leaves, 65% rice straw, 5% cassava (formulation 3). Each formulation uses molasses, indigofera leaves, and rice straw. Molasses functions as an adhesive, a source of energy, and an appetite enhancer. Indigofera leaves act as a source of protein and energy because of their high digestibility. Rice straw serves as a source of neutral detergent fiber (NDF) to maintain rumen health. Formulation 2 is a feed composed of these 3 basic ingredients. Formulation 1 replaces 10% of rice straw use with elephant grass to determine the effect of providing a fiber source that is higher in NDF than the ADF. Formulation 3 added 5% cassava to evaluate the addition of non-forage concentrate on the feeding behavior of cattle.

Feed nutrient content (Table 1) is adjusted to the nutritional needs of cattle during long trips according to MLA (2011) in Table 2. TDN is recommended to be more than 59.59% to ensure cattle meet their energy needs. The protein content is in the range of 10.5%-12% so that the protein needs of the cattle are met and the protein intake should not be too high to prevent the increase of ammonia during the trip. High levels of ammonia in the air can cause respiratory problems in cattle and workers. The starch content should not be too high to prevent bloat. To ensure rumen health, feed acid detergent fiber (ADF) levels play an important role in preventing bloat.

Feed shapes

There were 4 feed shapes used in this research, those were pellets, wafers, dried pellets, and cubes. Each of 3 formulations on Table 1 were processed into these 4 feed shapes. Pellet feed was made using a cylindrical pellet machine with a hammer mill type with a die width of 1cm and a length of 3 cm. Dried pellets were made using a roller mill pellet machine with a die width of 1 cm and a length of 3 cm. Water was added in the manufacture of dried pellets, then put into the oven for 24 hours to dry. Wafers are made using a wafer machine with a total of 25 prints, with a size of 7×7×10 cm (L×W×H) when inserted. The wafer shrinks to a size of 7×7×7 cm after compaction. Compaction is carried out using a hydraulic machine to press the wafer to make it more solid. One wafer production cycle takes as much as 20 minutes. Cube hay is made using a manual cube tool with a cube size of 1×1×1 m. The cube is tied using a rope while it is still in the tool before being pulled out once the production process takes as much as 10 minutes and weighs 7 kg.

Physical quality evaluation of compacted feed

Measurement of physical properties were carried out on wafer, pellet, dried pellet, and cube feed shape. Measurement of these physical properties was carried out to determine their effect on the production process including bulk density, compacted bulk density, mass density, and durability index. The measurement procedures were conducted by using methods that was implemented by Khalil (1999).

Bulk density was calculated by pouring the material up to a volume of 100 mL into a measuring cup (500 mL). The method of entering the material into the measuring cup is the same for every observation in both the method and the height of the pouring. The pouring of the ration was assisted by a plastic funnel, in order to minimize the shrinkage of the bulk volume due to the weight itself when it was poured out and there was a need to avoid shocks in the measuring cup. The bulk density was calculated by the formula:

$$\text{Bulk density (g/dm}^3\text{)}: \frac{\text{feed weight (g)}}{\text{volume (dm}^3\text{)}}$$

The compaction density of the pile was determined in the same way as the determination of the bulk density, but the volume of the material

Table 1. NIRS (Near Infrared-Spectroscopy) results of nutrient content for each formulation

	DM(%)	CP(%)	Fat(%)	CF(%)	NDF	ADF	Ash (%)	Starch (%)	TDN(%)
T1	87.26	12.18	2.91	22.94	42.08	32.47	13.42	10.00	63.68
T2	87.46	11.82	3.02	23.28	43.02	33.35	13.89	10.00	62.74
T3	87.33	9.83	2.97	22.58	43.02	32.29	14.13	11.83	63.88

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3; DM = dry matter; CP = crude protein; CF = crude fiber; NDF = neutral detergent fiber; ADF = acid detergent fiber; TDN = total digestibility nutrient.

Table 2. Nutrient requirements for shipping cattle (MLA, 2011)

Nutrient	TDN	Protein	Starch	ADF	Moisture
Requirements	>59.59	10.5-12	<20%	>25%	<12%

TDN = total digestibility nutrient; ADF = acid detergent fiber.

was read after the compaction process was carried out by shaking the measuring cup until the volume did not change anymore. The value of the pile density is highly dependent on the intensity of the compaction process, while the volume read is the smallest volume obtained during vibration. The vibration was carried out in no more than 10 minutes. The compacted bulk density was calculated by the formula:

$$\text{Compacted bulk density } (g/dm^3): \frac{\text{feed weight (g)}}{\text{volume}(dm^3)}$$

Mass density was calculated by pouring 100 grams feed into a measuring cup containing 300 mL of water and stirred to accelerate the removal of air spaces between feed particles. Volume readings were conducted after the water volume was stable. Mass density was calculated by the formula:

$$\text{Mass density } (g/dm^3): \frac{\text{feed weight (g)}}{\text{volume difference } (dm^3)}$$

The durability index measurement was carried out by inserting a sample of 500 grams into the friction tester (durability pellet tester) for 10 minutes. The sample was removed and filtered using sieve number 8 to calculate the weight of the pellet that was still intact using a scale. Durability index was calculated using the formula:

$$\text{Durability index (\%)}: \frac{\text{weight after tested (g)}}{\text{weight before tested (g)}} \times 100\%$$

Feeding behavior

The cattle used were Kupang cattle that had been shipped from Kupang to Tanjung Priok port, Jakarta for 7 days. After that, the cattle then transported by truck to a shelter located at Cibitung, Bekasi. The feed was given at the 8 days when the cattle arrived at the shelter. The traits of the cattle used in this study were 2-4 years old bull with 280-300 kg body weight and the cattle also had never consumed feed aside forages such as pellet, wafer, mash, and cube. There were 36 cattle used in this study, with 3 replications in each treatment. The experimental design used in this study was a 2-factor factorial completely randomized design consisting of feed form as factor a and feed formulation as factor b. Observations were carried out for 10 hours from 10 am to 8 pm. Total of 6 panelists were involved in this study, each panelist recorded the eating behavior of 6 cattle.

The observed parameter in this study was cattle feeding behavior on several feed shapes and formulations. The procedures that conducted in this research were similar with the research conducted by Kusuma *et al*. (2015). The parameters in eating behaviors were the frequency and duration of eating, drinking, resting, and rumination. Frequency is the number in which the experimental unit repeats a certain activity after previously stopping the activity. Duration is the length of time the experimental unit carries out certain activities before carrying out other activities. Feeding behavior begins when the cattle takes feed and continues to record the duration for chewing the feed. Rumination begins when the cattle performs chewing activities without taking the feed beforehand. Drinking begins when the cattle takes a drink until it is finished. Rest is recorded when the cattle does not carry out any activities of taking feed, chewing, or drinking.

Results and Discussion

Feed screening

Feed screening was aimed to observe several feed ingredients acceptability on cattle. The results then determined what kind of feed ingredients would be used for the feed formulations. Good feed formulations for a grazing cattle mixtures are formulations that are consisted by grasses and legumes. Grasses such as elephant grass and rice straw acts as a source of NDF while legumes such as leucaena and indigofera leaves acts as a source of energy and protein. Non forage feed such as cassava dregs and cattle feed mixtures were observed in this research to compare non forage and forage feed acceptability on grazing cattle.

Cattle consumption on several feedstuffs is showed on Table 3. There was no significant result found between forage treatments (P>0.05). Cattle did not eat cassava dregs and concentrate on 1 hour observation. This showed that cassava dregs and concentrate do not have a good adaptability for cattle. Meanwhile, all forages has a good adaptability and low eating duration. Elephant grass, rice straw, and forage grass could be used as a fiber source (Jayanegara *et al*., 2019) for the formulation. Indigofera and leucaena

Table 3. Cattle eating duration on 1 kg feedstuffs *(asfed)* as initial research

Feed stuffs	Duration	
	Second	Minutes
Elephant grass	171.33±5.86	2.86±0.10
Rice straw	225.00±10.58	3.75±0.18
Pasture grass	194.33±9.02	3.24±0.15
Leucaena leaves	156.67±7.10	2.61±0.12
Indigofera leaves	194.33±11.85	3.24±0.20
Casssava dregs	0.00±0.00	0.00±0.00
Feed mixtures	0.00±0.00	0.00±0.00

leaves would be used as protein and energy source, because it have a high protein content and digestibility (Abdullah, 2010).

Physical quality of compacted feed

The results in Table 4 showed the physical quality of wafers, pellets, dried pellet, and cube. Wafer had a higher stack density and stack compaction density compared to pellets and indigofera wafers, but had a lower durability index. Cube had a bulkiness of 0.26 (L/kg) and a cylinder feed of 0.21 (L/kg). The hardness of the feed cube is 12.5 lbs and the cylinder is 9.66 lbs. Hygroscopic feed cube 3.3% and cylinder 2.41% (Munasik *et al*., 2013).

It could be seen that pellets had a lower stack density compared to wafer. This was because in the manufacture of pellets, the material must be ground to be finer while the wafer is not milled too finely. McElhiney (1994) states that pellets are the result of mechanical processing of ration raw materials which are supported by water content, heat, and pressure factors. Besides that two factors, another factors that affect the durability and physical quality of pellets are the characteristics and particle size of the material.

The difference in the durability quality of pellets and wafers is closely related to the durability of pellets and wafers against the handling and transportation processes (Dozier, 2001). A good pellet is a pellet that is compact, sturdy and not easily brittle (Murdinah, 1989). Pellets have a higher resistance with friction compared to wafers. Pellets must have a good resistance index (PDI) so that they have a good level of strength and resilience during the handling and transportation process. The standard specification of durability index used is a minimum of 80% (Dozier, 2001). The physical quality of pelleted feed such as durability is influenced by the chemical composition of the material such as fat, starch, protein and fiber (Ginting, 2009). The influence of fiber elements on the physical quality of pellets is determined by the chemical properties of the constituent elements of the fiber. Water-soluble fiber elements, such as glucan, arabinoxylan and pectin have a high viscosity properties, so they tend to increase pellet durability, while insoluble fiber elements (NDF) such as cellulose, hemicellulose and lignin can reduce pellet durability (Thomas *et al.*, 1998).

Feeding behavior test on forage compacted feed needs to be observed further. Producers tend to prefer materials with a high bulk density and long lasting (not easy to be fermented) when transporting long distances because it could save packaging and material storage costs. However, high density feed ingredients have the possibility of being disliked by grazing cattle who had been used to consume forage daily because the high density feed have more compact physical quality, while forage has a bulky trait. Therefore, research on the feeding behavior of grazing cattle needs to be carried out to determine the cattle ability to consume wafers and forage pellets.

Cattle eating duration and frequency

The results in Table 5 showed the result on cattle eating duration and Table 6 showed the results on cattle eating frequency that had been caused by the treatments. There was no interaction effect between feed form and feed formulation treatment on cattle eating duration ($P>0.05$), but there is a significant effect of different feed shape treatment on cattle eating duration ($P<0.05$). Wafer has the highest eating

Table 4. Physical quality of compacted feed

	Bulk density (gdm^{-3})	Compacted bulk density (gdm^{-3})	Mass density (gdm^{-3})	*Durability index*
Wafer	420,71±19,5[b]	475,1±12,44[b]	426,5±42,6[b]	54,23±2,74[b]
Pelet	755,35±22,6[a]	783,3±10,58[a]	1045,7±27,4[a]	94,6±1,92[a]
Dried pellet	747,24±20,8[a]	750,2±13,67[a]	932,8±12,7[a]	95,2±1,04[a]
Cube	80,02±7,3[c]	102,7±8,6[c]	139,8±14,1[c]	12,4±2,36[c]

[a,b,c] Different superscript shows a significant difference between treatments ($P<0.05$).

Table 5. Cattle eating duration on 3 different feed formulation and 4 different feed form

	T1 (minutes)	T2 (minutes)	T3 (minutes)	Total (minutes)
Pellet	142.33±70.12	17.33±21.39	61.67±29.20	73.78±67.59[b]
Wafer	225.33±21.08	179.00±104.46	218.67±23.54	207.67±58.72[a]
Dried Pellet	1.67±2.08	5.33±9.24	11.67±20.21	6.22±11.99[c]
Cube	87.00±2.65	131.67±35.92	110.33±19.55	109.67±28.18[b]
Total	114.08±90.65	83.33±91.09	100.58±82.45	99.33±86.54

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3
[a,b,c] Different superscript shows a significant difference between treatments ($P<0.05$).

Table 6. Cattle eating frequency on 3 different feed formulation and 4 different feed form

	T1	T2	T3	Total
Pellet	11.33±4.04^{cd}	3.67±3.06^{e}	7.67±1.53^{d}	7.56±4.25
Wafer	12.33±1.53^{bc}	11.33±1.53^{cd}	16.33±3.06^{a}	13.33±2.96
Dried Pellet	1.00±1.00e	0.33±0.58^{e}	1.33±2.31^{e}	0.89±1.36
Cube	11.33±0.58^{cd}	15.67±0.58^{ab}	14.33±1.53^{abc}	13.78±2.11
Total	9.00±5.21	7.75±6.51	9.92±6.45	8.89±5.98

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3.
^{a,b,c,d,e} Different superscript a,b,c,d shows a significant difference between treatments (P<0.05).

duration results compared to other treatments. There is an interaction between feed form and feed formulation treatments on cattle. Combination between wafer and formulation 3 is the highest results on cattle eating frequency.

Results of eating performance showed in Table 5 and Table 6 were higher on wafer compared to the research conducted by (Kusuma *et al.*, 2015) that resulted in 147 minutes eating duration and 3.33±0.78 times eating frequency on Bali Sobangan cattle. Wafer treatment resulted in the highest eating duration because wafer (7 cm (length) × 7 cm (width) × 3 cm (height) for each wafer) has a higher particle size compared to pellet (1cm (diameter) and 3 cm (height) for each pellet). As forage particles increase in size, the number of mastication is also increases which lead into higher eating duration and frequency (Grant *et al*., 1990). Cube has the second highest eating duration time because cube has a higher particle size (forages at cube production process was given as whole forages, but the forages at wafer and pellet production process were mashed) and still has long fibrous substrate. Cattle that are fed alfalfa hay with a particle size of 30 mm had longer eating times than cattle fed the same hay with a particle size of 15 mm (Nasrollahi *et al.*, 2012). Whereas, time spent eating and total time spent chewing are not significantly different on cattle that are fed using hay with particles measuring 5.40, 8.96 and 77.90 mm (Suarez-Mena *et al*., 2013). Mastication increases to break down the fibrous substrate (O'Driscoll *et al.,* 2010). Cattle that are fed with a high fibre diet which also need longer time to consume, would decrease their performance time of oral abnormal behaviours in general (Brouns *et al.*, 1994). Concentration of NDF and particle size have a high correlation in cattle chewing time (Beauchemin, 1991). Eating minutes/kg dry matter intake and neutral detergent fibre intake tended to increase linearly as forage length increased (Suarez-Mena *et al.*, 2013).

The results at Table 6 showed that the highest cattle eating frequency was found on wafer feed shape and formulation 3 combination. This was caused by the wafer feed shape that is preferable by the cattle and also caused by the formulation 3 that contain the best nutrient availability. Formulation 3 is the formulation that contain cassava dregs which high in TDN which is easy to digest by the cattle. Chacon *et al.* (1976) recorded that only 20% of the eating bites of grazing cattle were mastication bites. The feed treatments aside cube has different physical quality compared to fresh forage. This could affect the mastication bites behavior of the grazing cattle and could lead in changing its eating behavior.

Cattle ruminating duration and frequency

Table 7 shows the result on cattle ruminating duration and Table 8 shows the results on cattle ruminating frequency that had been caused by the treatments. On Table 7, there is an interaction effect between feed form and feed formulation treatment on cattle ruminating duration (P<0.05). Combination between cube shape and three different is the lowest results on cattle ruminating duration. There is no interaction between feed form and feed formulation treatments on cattle ruminating frequency (P>0.05), but there is a significant effect of different feed shape treatment and feed formulation on cattle ruminating duration (P<0.05). Cube feed shape and formulation 3 has the highest ruminating frequency results compared to other treatments. According to the research conducted by Kusuma *et al.* (2015) that showed 142.8 minutes ruminating duration and 4 times ruminating frequency, ruminating duration in this research was lower (135.31±86.96) while the ruminating frequency was higher (6.83±2.48).

Cattle ruminating duration is strongly correlated with eating, rest, and drinking duration. The higher eating, rest, and drinking duration, the less cattle ruminating duration will be. Cattle spent more time ruminating when the feeding times and intakes are high (Schirmann *et al.*, 2012). High feed consumption causes less ruminating time per unit of dry matter fiber intake that is occurred (Deswysen *et al.*, 1987; Welch and Smith, 1969). This could be caused by the increase in efficiency

Table 7. Cattle ruminating duration on 3 different feed formulation and 4 different feed form

	T1 (minutes)	T2 (minutes)	T3 (minutes)	Total (minutes)
Pellet	83.00±44.14^{ab}	200.33±74.27^{c}	166.00±39.84^{ab}	149.78±70.66
Wafer	74.33±13.87^{a}	92.67±44.97^{ab}	96.00±22.61^{ab}	87.67±27.99
Dried Pellet	297.33±63.22^{d}	193.67±61.21^{c}	235.67±76.79^{cd}	242.22±73.82
Cube	61.33±12.22^{a}	63.33±10.60^{a}	60.00±10.00^{a}	61.56±9.62
Total	129.00±107.29	137.50±77.83	139.42±80.16	135.31±86.96

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3.
^{a,b,c,d} Different superscript a,b,c,d shows a significant difference between treatments (P<0.05).

Table 8. Cattle ruminating frequency on 3 different feed formulation and 4 different feed form

	T1	T2	T3	Total
Pellet	5.00±1.00	7.33±1.53	7.67±1.53	6.67±1.73[a]
Wafer	5.00±1.00	5.00±1.00	5.33±1.16	5.11±0.93[a]
Dried Pellet	4.33±2.08	5.67±1.53	6.67±1.53	5.56±1.81[a]
Cube	9.00±1.73	10.67±2.31	10.33±1.53	10.00±1.80[b]
Total	5.83±2.33[a]	7.17±2.69[ab]	7.50±2.28[b]	6.83±2.48

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3.
[a,b] Different superscript a,b,c,d shows a significant difference between treatments (P<0.05).

of ruminating as intake increases to reduce particle, also the reticulo-omasal orifice accepts larger particles when the intake level is high (Bae *et al.*, 1979; Bae *et al.*, 1981; Deswysen *et al.,* 1987). NDF consumption is positively correlated with time spent ruminating (Maekawa *et al*., 2002; Yang dan Beauchemin, 2006; Klinger *et al*., 2007; Aikman *et al*., 2008). All the treatments contain similar NDF content, so the rumination process in this research was not affected by its nutrient content.

Ruminating process is strongly affected by the feed shape and feed formulation on this experiment. Low ruminating time indicates less material in the rumen to digest (Kennedy *et al.*, 2009). Rumen load is not correlated with oral manipulation of feed which is a behavioral need in cattle (Lindstroem and Redbo, 2000). Time spent ruminating depends mainly upon the characteristics of the roughage and the rate at which the roughage is eaten (Freer *et al.*, 1962). Freer *et al.* (1962) suggest that the time spent for eating roughages depends upon the rate at which the roughage is broken down in the rumen and on the contribution that mastication, during eating and ruminating, makes to achieve this breakdown. Thus, time spent ruminating depends upon the characteristic of the roughage, and the rate at which the roughage is eaten. The rumination time of dairy cattle increases as high particle length of a total mixed diet increases (Santini *et al.*, 1983). Also, the more similar feed shape with forages as its natural feed, the lower ruminating process will be occurred.

Cube is a feed shape that has a high similarity with forage as its natural feed, so it has the shortest duration and has the highest frequency on cattle ruminating activities. This was caused because cube has a higher particle length compared to other treatments (forages at cube production process was given as whole forages, but the forages at wafer and pellet production process were mashed). The rumination time of dairy cattle increased as mean high particle length of a total mixed diet increased (Santini *et al.*, 1983). Feed shape other than cube has higher ruminating frequency. This was caused because the feed shape is less similar with its natural feed. The less similar feed with its natural feed, the ruminating process would be higher also. This was caused by the rumen bacteria population has already being adapted by their usual feed. If a new feed is introduced to cattle, rumen bacteria need to adapt to its new rumen environment and it will make the ruminating duration longer. When ruminating duration longer, the lower ruminating frequency would be occurred. This was caused when the unfamiliar ingredient was being consumed by cattle, the cattle was reducing the other activities such as eating, resting, and drinking in order to ruminate. When there are no other activities other than ruminating, cattle ruminating frequency will be reduced.

Cattle resting duration and frequency

Table 9 shows the result on cattle resting duration and Table 10 shows the results on cattle resting frequency that had been caused by the treatments. There are no significant effect on interaction between feed formulation and feed shape in cattle resting duration and frequency (P>0.05). But there is a significant effect in feed shape treatment on cattle resting frequency and duration (P<0.05). The shortest cattle resting duration was found on wafer treatment and the longest was found on cube. The highest cattle

Table 9. Cattle resting duration on 3 different feed formulation and 4 different feed form

	T1 (minutes)	T2 (minutes)	T3 (minutes)	Total (minutes)
Pellet	262.33±48.40	210.33±102.26	244.67±46.00	239.11±65.22[bc]
Wafer	100.00±38.32	141.67±75.00	149.00±21.63	130.22±49.14[a]
Dried Pellet	115.67±28.02	211.67±71.06	186.33±96.36	171.22±75.08[ab]
Cube	319.67±18.01	184.33±49.00	258.00±23.07	254.00±65.25[c]
Total	199.42±102.60	187.00±71.80	209.50±66.17	198.64±79.95

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3
[a,b,c] Different superscript a,b,c,d shows a significant difference between treatments (P<0.05).

Table 10. Cattle resting frequency on 3 different feed formulation and 4 different feed form

	T1	T2	T3	Total
Pellet	16.00±2.65	10.00±5.29	15.00±2.00	13.67±4.18[c]
Wafer	9.67±2.52	9.00±5.57	14.33±2.08	11.00±4.09[bc]
Dried Pellet	6.33±1.53	7.00±0.00	5.67±1.16	6.33±1.12[a]
Cube	11.33±2.08	9.33±4.16	10.67±1.16	10.44±2.56[b]
Total	10.83±4.11	8.83±3.90	11.42±4.12	10.36±4.09

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3
[a,b,c] Different superscript a,b,c,d shows a significant difference between treatments (P<0.05).

resting frequency was found on pellet treatment and the lowest was found on dried pellet treatment. Compared to the research that had been conducted by Faresty (2016) that showed 484.69±47.13 resting duration and 22.33±1.91 in resting frequency, the results in this research has a lower value. It means that cattle were more active in eating and ruminating rather than resting.

Wafer was a novel feed that had never been introduced to the grazing cattle before. Wafer treatment tends to have a high eating and ruminating duration on grazing cattle which caused in reducing cattle resting duration. Time spent ruminating and eating varied inversely with the time spent resting (Freer and Campling, 1965). Cube is a feed that has the highest similarities with their natural feed which caused the cattle to eat and ruminate efficiently because they are easily getting used to consume. Dried pellet has the lowest consumption among other feed shape treatments. Low consumption frequency indicate a lower ruminating frequency. When the consumption and ruminating frequency are low, the resting frequency is also low. Pellet and dried pellet is a feed that is unfamiliar for the cattle. The difference is, pellet is more preferable compared to dried pellet because the structure of dried pellet is rough, while pellet is smooth. The similarities is the cattle was confused at how they should eat it. This lead in low activities on cattle which will also increase the cattle resting frequency.

Resting is necessary for regeneration while disturbances are also crucial to be associated with insufficient recuperation, discomfort or pain, frustration, and increased risk for health problems such as lameness and lesions (Plesch *et al*., 2010). Cattle may spend up to 14 h per day lying (Wierenga and Hopster, 1990) with about half of the resting period ruminating. Disturbances of resting may be associated with insufficient recuperation, frustration (Munksgaard and Simonsen, 1996), experience of discomfort or pain and increased risks for health problems such as lameness (Singh *et al*., 1994; Bowell *et al*., 2003) or lesions (Wechsler *et al*., 2000; Norring *et al.*, 2008). Wafer and dried pellet treatments have a low in resting duration. This could indicate that cattle were uncomfortable on consuming it.

Cattle drinking duration and frequency

Table 11 shows the result on cattle ruminating duration and Table 12 shows the results on cattle ruminating frequency that had been caused by the treatments. There are no significant effect on interaction between feed formulation and feed shape in cattle consumption (P>0.05). There are no significant effect in feed formulation treatment on cattle consumption but has significant effect in feed form treatment (P>0.05). Compared to the result of the research conducted by (Kusuma *et al*., 2015) that showed 1.17±0.72 times drinking frequency, this research had a higher drinking frequency.

There are no effect between feed shape combined with feed formulation treatments on cattle drinking duration and frequency. The average of cattle drinking duration with the different feed shape and feed formulation is 9.39 minutes/10 hours (Table 11). Drinking is a crucial requirement for cattle to help digestion process of food in the body. The addition of water to the rumen per fistula will not decrease forage intake (Moore *et al.,* 1961; Thomas *et al.,* 1961). Less drinking time could reduce saliva production on cattle and low production of saliva during ingestion of low DM herbage could reduce the digestion rate and hence intake (Meyer *et al.,* 1964). Some factors that are also affect drinking behavior in cattle are the environmental temperature, rain intensity, humidity, sunlight and water temperature. Cattle need four to five times per day to drink water depending on temperature of the environmental and individual cattle. Cattle drink water to fulfill fluids requirement inside their body. Drinking activity is carried out to balance eating activity and also maintain constant rumen osmolality.

Table 11. Cattle drinking duration on 3 different feed formulation and 4 different feed form

	T1 (minutes)	T2 (minutes)	T3 (minutes)	Total (minutes)
Pellet	11.33±4.04	3.33±5.77	8.33±4.62	7.67±5.48
Wafer	2.67±3.79	8.33±6.11	6.33±1.16	5.78±4.41
Dried Pellet	5.67±2.08	9.00±4.36	20.67±22.14	11.78±13.23
Cube	6.00±4.36	19.00±19.08	12.00±10.44	12.33±12.44
Total	6.42±4.52	9.92±10.85	11.83±12.08	9.39±9.72

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3.

Table 12. Cattle drinking frequency on 3 different feed formulation and 4 different feed form

	T1	T2	T3	Total
Pellet	2.67±1.53	0.67±1.16	2.33±1.16	1.89±1.45
Wafer	3.00±2.65	5.00±3.61	3.33±0.58	3.78±2.44
Dried Pellet	3.00±2.65	2.67±1.16	3.33±2.52	3.00±1.94
Cube	1.00±0.00	3.00±1.73	2.00±1.00	2.00±1.32
Total	2.42±1.93	2.83±2.44	2.75±1.42	2.67±1.93

T1 = treatment 1; T2 = treatment 2; T3 = treatment 3.

Conclusions

Several compacted feed with 100% forage ingredients content was expected to remove adaptation period on grazing cattle feeding. Different formulations did not significantly affect the feeding behavior of the cattle compared to the feed shapes. Wafer feed shape showed the highest feeding behavior results followed by cube and pellet. Further researches on cattle feeding at longboard transport while applying compacted feed need to be observed.

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References

Abdullah, L. 2010. Herbage production and quality of shrub Indigofera treated by different concentration of foliar fertilizer. Med. Pet. 33: 169–175.
Aikman, P. C., C. K. Reynolds, and D. E. Beever. 2008. Diet digestibility, rate of passage, and eating and rumination behavior of Jersey and Holstein cows. J. Dairy Sci. 91: 1103–1114.
Arroquy, J. I., C. J. Lopez-Fernandez, and A. Lopez. 2017. Use of cotton plant byproducts as a source of fiber in feedlot diets. Rev. de Investig. Agropecu. 44: 1-7.
Bae, D. H., J. G. Welch, and A. M. Smith. 1979. Forage intake and rumination by sheep. J. Anim. Sci. 49: 1292-1299.
Bae, D. H., J. G. Welch, and A. M. Smith. 1981. Efficiency of mastication in relation to hay intake by cattle. J. Anim. Sci. 52: 1371-1375.
Beauchemin, K. A. 1991. Ingestion and mastication of feed by dairy cattle. Vet. Clin. North Am. Food Anim. Pract. 7: 439-463.
Bowell, V. A., L. J. Rennie, G. Tierney, A. B. Lawrence, and M. J. Haskell. 2003. Relationships between building design, management system and dairy cow welfare. Anim. Welfare. 12: 547–552.
Brouns, F., S. A. Edwards, and P. R. English. 1994. Effect of dietary fibre and feeding system on activity and oral behaviour of group housed gilts. Appl. Anim. Behav. Sci. 39: 215-223.
Chacon, E., T. H. Stobbs, and R. L. Sandland. 1976. Estimation of herbage consumption by grazing cattle using measurements of eating behaviour. J. Br. Grassl. Soc. 31: 81-87.
Deswysen, A. G., W. C. Ellis, and K. R. Pond. 1987. Interrelationships among voluntary intake, eating and ruminating behavior and ruminal motility of heifers fed corn silage. J. Anim. Sci. 64: 835-841.
Dozier, W. A. 2001. *Pellet* quality for more economical poultry meat. J. Feed Int. 52: 40-42.
Faresty, C. 2016. Feeding behaviour of dairy cattle at Kebon Pedes Bogor. IPB Press: Bogor(ID). 6-7p.
Freer, M. and R. C. Campling. 1965. Factors affecting the voluntary intake of food by cows. Br. J. Nutr. 19: 195-207.
Freer, M., R. C. Campling, and C. C. Balch. 1962. Factors effecting the voluntary intake of food by cows. Br. J. Nutr. 3: 279-295.
Ginting, S. P. 2009. Prospek penggunaan pakan komplit pada kambing tinjauan manfaat dan aspek bentuk fisik pakan serta respon ternak. Wartazoa 19: 64-75.
Grant, R. J., V. F. Colenbrander, and D. R. Mertens. 1990. Milk fat depression in dairy cows: role of particle size of alfalfa hay. J. Dairy Sci. 73: 1823–1833.
Greenwood, L. P. 2021. Review: An overview of beef production from pasture and feedlot globally, as demand for beef and the need for sustainable practices increase. Animal. 15: 100295.
Heazlewood, P. G., A. Kelly, J. Z. Foot. 1992. Effect of distance of trucking on feeding behaviour and liveweight change of sheep during preshipping feedlotting. Proc. Aust. Soc. Anim. Prod. 19: 456.
Jayanegara, A., M. Ridla, E. B. Laconi, and Nahrowi. 2019. Elephant grass, rice straw and maize silage as feeds: a dynamic modelling approach on their degradation kinetic. IOP Conf. Ser. Earth Environ. Sci. 387: 1-5.
Kennedy, E., M. McEvoy, J. P. Murphy, and M. O'Donovan. 2009. Effect of restricted access time to pasture on dairy cow milk production, grazing behavior, and dry matter intake. J. Dairy Sci. 92: 168-176.
Khalil. 1999. Pengaruh kandungan air dan ukuran partikel terhadap sifat fisik pakan lokal: kerapatan tumpukan, kerapatan pemadatan tumpukan dan berat jenis. Media Peternakan 22: 1-11.
Klinger, S. A., H. C. Block, and J. J. McKinnon. 2007. Nutrient digestibility, fecal output and eating behavior for different cattle background feeding strategies. Can. J. Anim. Sci. 87: 393-399.
Kusuma, I. M. D, N. L. P. Sriyani, and I. N. T. Ariana. 2015. Differences in feeding behaviour of Balinese Cattle raised in landfill of Pedugan Village and Balinese Cattle breeding Center Sobangan. J. Trop. Anim. Sci. 3: 667–678.
Lewis, L. D. 2013. Feeding and Care of the Horse. John Wiley & Sons, New Jersey (US).
Lindstroem, T. and I. Redbo. 2000. Effect of feeding duration and rumen fill on behavior in dairy cows. Appl. Anim. Behav. Sci. 70: 83-97.

Machado, M. G., E. Detmann, H. C. Mantovani, S. C. V. Filho, C. B. P. Bento, M. I. Marcondes, and A. S. Assunção. 2016. Evaluation of the length of adaptation period for changeover and crossover nutritional experiments with cattle fed tropical forage-based diets. Anim. Feed Sci. Tech. 222: 132-148.

Maekawa, M., K. A. Beauchemin, and D. A. Christensen. 2002. Effect of concentrate level and feeding management on chewing activities, saliva production, and ruminal pH of lactating dairy cows. J. Dairy Sci. 85: 1165–1175.

Malik, V. K. and S. Singh. 2004. Effect of temperature and relative humidity on teliospore germination in Ustilago hordei. J. Mycol. Plant Pathol. 34: 410-411.

McElhiney, R. R. 1994. Feed Manufacturing Technology IV. American Feed Industry Association, Inc. Arlington, Virginia.

Meat and Livestock Australia (MLA). 2011. Final Report: Review of Fodder Quality and Quantity in the Livestock Export Trade. Meat and Livestock Australia Limited: North Sydney (AU).

Meyer, R. M., E. E. Bartley, L. Morrill, and W. E. Stewart. 1964. Salivation in cattle. I. feed and animal factors affecting salivation and its relation to bloat. J. Dairy Sci. 47: 1339-1345.

Moore L. A., J. W. Thomas, and J. F. Sykes. 1961. A study of factors affecting the rate of intake of heifers fed silage. J. Dairy Sci. 44: 1471-1483.

Munasik, C. I. Sutrisno, S. Anwar, and C. H. Prayitno. 2013. Physical characteristics of pressed complete feed for dairy cattle. Int. J. Sci. Eng. 4: 61-65.

Munksgaard, L. and H. B. Simonsen. 1996. Behavioral and pituitary adrenalaxis response of dairy cows to social isolation and deprivation of lying down. J. Anim. Sci. 74: 769–778.

Murdinah. 1989. Studi stabilitas dalam air dan daya pikat makanan udang berbentuk *pellet*. Disertasi. Fakultas Pasca Sarjana. Institut Pertanian Bogor, Bogor.

Nasrollahi, S. M., M. Khorvash, G. R. Ghorbani, A. Teimouri-Yansari, A. Zali, and Q. Zebeli. 2012. Grain source and marginal changes in forage particle size modulate digestive processes and nutrient intake of dairy cows. Animal. 6: 1237–1245.

Norring, M., E. Manninen, A. M. dePassille, J. Rushen, L. Munksgaard, and H. Saloniemi. 2008. Effects of sand and straw bedding on the lying behavior, cleanliness, and hoof and hock injuries of dairy cows. J. Dairy Sci. 91: 570–576.

O'Driscoll, K., B. O'Brien, D. Gleson, and L. Boyle. 2010. Milking frequency and nutritional level affect grazing behavior of dairy cows: a case study. Appl. Anim. Behav. Sci. 122: 77-83.

Plesch, G., N. Broerkens, S. Laister, C. Winckler, and U. Knierim. 2010. Realibility and feasibility of selected measures concerning resting behaviour for the on-farm welfare assessment in dairy cows. Appl. Anim. Behav. Sci. 126: 19-26.

Santini, F. J., A. R. Hardie, and N. A. Jorgensen. 1983. Proposed use of adjusted intake based on forage particle length for calculation of roughage indexes. J. Dairy Sci. 66: 811-820.

Schirmann, K., N. Chapinal, D. M. Weary, W. Heuwieser, and M. A. von Keyserlingk. 2012. Rumination and its relationship to feeding and lying behavior in Holstein dairy cows. J. Dairy Sci. 95: 3212–3217.

Schwartzkopf-Genswein, K. and T. Grandin. 2014. Cattle transport by road. In Grandin T (ed.) Livestock Handling and Transport; Wallingford (UK). 143–173p.

Singh, S. S., W. R. Ward, J. W. Hughes, K. Lautenbach, and R. D. Murray. 1994. Behaviour of dairy cows in a straw yard in relation to lameness. Vet. Rec. 135: 251–253.

Suarez-Mena, F. X., G. I. Zanton, and A. J. Heinrichs. 2013. Effect of forage particle length on rumen fermentation, sorting and chewing activity of late-lactation and non-lactating dairy cows. Animal. 7: 272–278.

Swanson, J. C. and J. Morrow-Tesch. 2001. Cattle transport: historical, research, and future perspectives. Anim. Sci. J. 79: 102–109.

Thomas MDJ, van Zuilichem, AFB van der Poel. 1998. Physical quality of *pellet*ed animal feed.3. Contribution of Feedstuff component. J. Anim. Feed Sci. Tech.70: 59-78.

Thomas, S. W., L. A. Moore, M. Okamoto, and J. F. Sykes. 1961. A study of factors affecting the rate of intake of heifers fed silage. Int. J. Dairy Sci. 44: 1471-1483.

Van Engen, N. K., and J. F. Coetzee. 2018. Effects of transportation on cattle health and production: a review. Anim. Health. 19: 1–13.

Wechsler, B., J. Schaub, K. Friedli, and R. Hauser. 2000. Behaviour and leg injuries in dairy cows kept in cubicle systems with straw bedding or soft lying mats. Appl. Anim. Behav. Sci. 69: 189–197.

Welch, J. G. and A. M. Smith. 1969. Effect of varying amounts of forage intake on rumination. J. Anim. Sci. 28: 827-830.

Widjaya, F. E., Y. Retnani, Despal, L. Abdullah, and R. Priyanto. 2018. Regression analysis on physical quality of straw, elephant grass, leucaena, and indigofera leaves for shipping cattle feed. Harmonizing Livestock Industry Development, Animal Welfare, Environmental and Human Health. The Fourth International Seminar on Animal Industry ;2018 August 28-30; Bogor, Indonesia. Bogor: International

Seminar of Animal Husbandry. Pp. 250-254p.

Wierenga, H. K. and H. Hopster. 1990. The significance of cubicles for the behaviour of dairy cows. Appl. Anim. Behav. Sci. 26: 309–337.

Yang, W. Z. and K. A. Beauchemin. 2006. Effects of physically effective fiber on chewing activity and ruminal pH of dairy cows fed diets based on barley silage. J. Dairy Sci. 89: 217–228.