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Effect of Molasses Level on Hardness, Storage Durability and Chemical Composition of Densified Complete Feed

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Effect of Molasses Level on Hardness, Storage Durability and Chemical Composition of Densified Complete Feed

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Abstract. Densified complete feed (DCF) is a formulated feed that produces through the blending of feedstuffs in the desired proportion to provide balanced nutrition for animals. The DCF gives a good impact on animal performance and reduce the feed cost for farmers. However, there is lacking of DCF production for goat consumption. Therefore, the aim of this study was to investigate the effects of different levels of molasses as binder on hardness, durability and chemical composition of DCF. In preparation of DCF, the locally available feed ingredients such as oil palm frond were collected and the making process of complete feed blocks was referred. The DCF was made manually including 3% and 6% molasses level, and then prepared to fulfil the nutrient requirement of growing goats as recommended by National Research Council. The durability was carried out on days 0, 7, 14 and 28 by comparing the hardness, dry matter (DM), and colony forming unit (CFU) of each molasses rate of DCF. Both molasses of DCF had shown a decreasing trend on durability from days 0 to 28. Regardless of durability, the DCF with 3% molasses had greater hardness (2.1 kg/cm^2), higher DM content (93.2%) and lower CFU count (1.3×10^4 CFU ml^{-1}) than that of 6% molasses rate of DCF. Both different rates of molasses of DCF had no significant ($p > 0.05$) effect on crude protein, crude fibre, ether extract and ash contents. The present study suggests that 3% molasses of DCF is preferable in terms of longer storage, while 6% molasses of DCF may be more palatable for the ruminants.

1.0 Introduction

Feed is the major input cost in animal production, which accounts for 65-70% of the total cost. The farmers usually use locally available feed resources such as crop residues, forages and others feedstuff feed. Nutritive values of these poor quality and bulky feedstuffs can be enhanced by making of complete feed. Due to the high demand for meat consumption, the demand for livestock product is increasing. Therefore, in order to increase the productivity of livestock, it is essential to popularise an innovation called complete feed. In recent years, with the advancement of the technology, the densified complete feed (DCF) can be manufactured in different forms such as block, pellet, cube, mash or cylinder [1]. This complete feed is increasingly spreading many countries and adopting by the farmers due to the ability to enhance the performance of livestock and reduce the feed cost [2].

Hardness of the block is important to increase the durability. Different binders like cement, lime, molasses and bentonite have been used to make hard blocks. Molasses has high sugar content which makes the feed more palatable. Moreover, molasses can combine the ingredients and reduce the dust of finely ground feed [3]. It also consists of a high level of sulphur which acts as a preservative. However, information is scarce regarding the different levels of molasses of DCF on its hardness, storage durability and chemical composition. Therefore, this study was carried out to examine the effects of different levels of molasses on hardness, storage durability and chemical composition of DCF using locally available feed ingredients, where DCF is still low in awareness among the farmers.

2.0 Materials and methods

2.1 Location of study and feed ingredients used

This experiment was conducted at Faculty of Agro Based Industry, Universiti Malaysia Kelantan, Jeli, Kelantan, Malaysia. Oil palm frond (OPF) was collected from Kuala Selangor, and then chopped into smaller pieces. Other ingredients such as molasses, corn, soybean meal, sodium bentonite and salt were purchased from local supplier. All the feed ingredients were dried in an oven at 70°C for 48 h, and then blended to become small particles, except for soybean meal, salt and sodium bentonite. All ingredients were mixed manually, and then poured into the plastic tray that consists of compartment as cylinder form. The mixtures were compressed, dried and stored. A calculation was made based on total of 100 g feed produced to acquire a balanced ration. Table 1 shows the required quantity, metabolisable energy (ME) and crude protein (CP) values of each feed ingredient for making of experimental DCF.

Table 1. Amount (g), metabolisable energy (ME) and crude protein (CP) of feed ingredients used.

Ingredients	Treatment 1			Treatment 2		
	Amount (g)	ME (MJ)	CP (%)	Amount (g)	ME (MJ)	CP (%)
Molasses	30	0.35	0.1	60	0.70	0.2
Corn	400	5.40	3.3	350	4.73	2.9
Soybean meal	220	3.00	10.3	240	3.26	11.3
Oil palm frond	300	1.70	1.0	300	1.70	1.0
Sodium bentonite	40	0	0	40	0	0
Salt	10	0	0	10	0	0
Total	1000	10.5	14.7	100	10.4	15.4

MJ, mega joule.

2.2 Measurement of hardness and storage durability

The DCF was compressed using the penetrometer to identify the compactness and hardness. For storage durability (days 0, 7, 14 and 28), spread plate technique, hardness measurement and determination of dry matter (DM) were performed on days 0, 7, 14 and 28. Numbers of isolated bacterial colonies were counted. About 1g of DCF was blended with the 9 ml distilled water in a sterile blender for 2 min. Another 5 test tubes with 9 ml distilled water in each test tube was prepared. The 10 ml solution with the mixture of samples and distilled water were poured into the first test tube.

A serial dilution technique was conducted by pipetting out 0.1 ml of solution from the first test tube (10^{-1} or $10\times$) and placed on agar media plate. An inoculum spreader was sterilized and used to swirl the solution evenly on the agar media plate. One (1) ml of solution was taken out from the first test tube and put it into the second test tube. About 0.1 ml solution was pipetted out from the second test tube (10^{-2} or $100\times$), placed and swirled evenly on agar media plate. The dilution step was continued followed by a third test tube. The agar plates were incubated at 25°C for 48 h by placing them inverted in the incubator. The agar media plate which showed a different number of bacterial colonies after incubation was observed. A marker pen was used to mark the counted colonies on the back of the Petri dish. Multiplication of counted colonies based on the number of dilutions was made after finding out the desired dilution agar plate. Assuming the third test tube (10^{-3} or $1000\times$) has a total number of 120 counted colonies which is between 30 to 300 colonies had the dilution factor of 10^4 as 0.1 ml of volume plated was multiplied with the 10^{-3} of dilution. The total colonies grow was then divided by 10^4 in order to find out the colony forming unit (CFU) and roughly determined the microbes in the original sample. A formula is shown as below:

CFU/ml = Total colonies grow/(volume plated in ml $\times$ total dilution used)

2.3 Chemical and statistical analyses
Dry matter content of respective DCF was determined. Three replications from each treatment were tested every week until week 4. A knife was used to scrape off about 1g of sample from a prepared DCF. Sample was dried in an oven at 105°C for 24 h. Nitrogen (N), crude fibre, ether extract (EE) and ash were determined described by standard method [4]. Crude protein concentration was calculated as $N \times 6.25$. Data were analysed using one-way ANOVA in a completely randomized design. Duncan Multiple Range Test was used to observe the difference between treatment means at $p<0.05$.

3.0 Results and Discussion
3.1 Nutrients composition of feed ingredients
As shown in Table 2, the soybean meal consisted the highest DM, CP and ash, whereas OPF had the highest EE and crude fibre (CF). It has been reported that molasses had 75.1% DM, 3.2% CP and 14.0% ash [5]. Conversely, in this study, the molasses contained high DM (88.5%), low CP (0.6%) and ash (5.9%) contents. The CP value in this study was 0.6%, which was closer with the findings of FAO [6]. The causes of the difference in composition of molasses may be due to over-drying and long exposure to heat and thereby the occurrence of nutrient loss. Besides, the analysis of OPF in this study had shown similar values with the findings of [7]. Furthermore, the data obtained of corn and soybean meal from this study was slightly different with the findings of Kwan and Kim [8], which showed that the corn had the highest DM (88.1%) and EE (2.9%). The results of corn and soybean meal in this study were similar with the findings of Liu *et al.* [9] who reported that the soybean meal had 17.3 MJ ME/kg, 88.7% DM, 45.0% CP, 1.5% EE and 5.8% ash. Liu et al. [9] also compared the soybean meal with the corn and found out that the corn had low ME (16.0 MJ/kg), DM (86.6%), CP (8.3%) and ash (1.1%), but high in EE (2.2%).

Table 2. Chemical composition (%) of experimental feed ingredients of densified completed feed.

Ingredients	Mean ± standard deviation				
	Dry matter	Crude protein	Ether extract	Crude fibre*	Ash (%)
Molasses	88.5 ± 0.04	0.6 ± 0.09	-	-	5.9 ± 0.07
Corn	89.4 ± 0.03	8.2 ± 0.24	2.9 ± 0.16	1.9	1.8 ± 0.11
Soybean meal	89.8 ± 0.12	50.6 ± 0.39	1.9 ± 0.02	4.2	7.9 ± 0.45
Oil palm frond	49.4 ± 0.28	9.7 ± 0.16	3.9 ± 0.09	36.6	6.0 ± 0.45
Sodium bentonite	-	-	-	-	-
Salt	-	-	-	-	-

*Obtained from secondary data [8, 10].

Table 3. Effect of molasses rate on proximate composition in densified completed feed.

Proximate components (%)	Molasses rate (mean ± standard deviation)		*p*-value
	3%	6%	
Dry matter	94.1 ± 0.30	93.8 ± 0.25	0.386
Crude protein	18.5 ± 0.22	19.2 ± 0.74	0.209
Ether extract	1.4 ± 0.05	1.5 ± 0.04	0.328
Crude fibre	6.9 ± 0.03	7.0 ± 0.07	0.257
Ash	9.2 ± 0.36	9.4 ± 0.41	0.592

3.2 Nutrient composition of densified complete feed
The proximate components of DCF was not affected ($p>0.05$) by the molasses rate (Table 3). The treatment with 3% molasses had higher DM (94.1%) than the treatment with 6% molasses (93.8%). The DM obtained in this study was closer with the findings of Santhiralingam and Sinniah [11] who reported the DCF blocks had DM value in the range of 86.6-90.5%. Santhiralingam and Sinniah [11] obtained CP content of DCF blocks between 12.6-15.7% which was relatively lower compared to the CP result in this study (Table 3). The CP content of DCF was higher than the calculation of each feed ingredient proportions (Tables 1 and 3), which might be due to the error of representative samples

obtained from the formulated DCF. Santhiralingam and Sinniah [11] recorded EE content of DCF blocks in the range of 3.6-5.5%, which was relatively higher than the EE content in this study. The findings of CF in this study were relatively lower compared to the findings of Santhiralingam and Sinnia [11]. This may be due to the small amount of roughages have been used in this current study. The ash content of DCF in this study was nearly similar to the study of Somasiri *et al*. [12] who reported that the leaf meal block had the ash level in the range of 7-8%. The nutrient requirements of ruminant's feed should contain 10-11 MJ/kg DM of ME and 14-16% of CP to achieve a balanced ration [13], and these ME and CP contents are in line in this study.

3.3 Hardness (kg/cm^2) of densified complete feed

The hardness of both treatment molasses rates were affected ($p<0.05$) by the storage duration (Table 4). However, no differences ($p>0.05$) were observed on the hardness for treatment 3% molasses among days 0, 7 and 14. Besides, there were no differences ($p>0.05$) on the hardness for treatment 3% molasses among days 7, 14 and 28. The 3% molasses on day 0 showed the highest hardness (2.4 kg/cm^2) of DCF, whereas 3% molasses on day 28 showed the lowest hardness (1.9 kg/cm^2) of DCF. Furthermore, there were no differences ($p>0.05$) on the hardness of 6% molasses between days 0 and 7. No differences ($p>0.05$) were observed on the hardness for treatment 6% molasses between days 7 and 14. Similarly, there were also no differences ($p>0.05$) between days 14 and 28 on the hardness for treatment 6% molasses. The highest hardness of 6% molasses was recorded by day 0 (2.3 kg/cm^2), while the lowest hardness of 6% molasses recorded by day 28 (1.5 kg/cm^2). In addition, there were no differences ($p>0.05$) on the hardness of days 0, 7 and 14 between 3% and 6% molasses rates. However, there were differences ($p<0.05$) on hardness of day 28 between 3% and 6% molasses rates, which 3% molasses had the highest hardness (1.9 kg/cm^2) than 6% molasses (1.5 kg/cm^2) on day 28.

The hardness in this study is not in line with the findings of Santhiralingam and Sinniah [11] who reported that the least durability of DCF was failed to form due to not sufficient of the binder was used. In fact, they used 10% of molasses with the combination of 56.7% of calcium carbonate which both of the ingredients are commonly treated as the binders in animal feed. Oguntunde *et al.* [14] also reported that the faster the speed in compressed the complete feed, the higher the hardness value obtained. According to Munasik *et al.* [15], the blocks were considered high durability when they can be handled easily during storage and transportation. Furthermore, the DCF block can be stored for at least 1 year which was helpful during the season of drought and flooding [16]. Hence, the DCF of both 3% molasses and 6% molasses can be indicated to remain compact longer than the study period but the 3% molasses DCF could be sustained longer than the 6% molasses DCF. One of the causes of the high hardness on 3% molasses DCF may be due to the high drying rate of least molasses.

Table 4. Effect of molasses rate on hardness (kg/cm^2) of densified complete feed.

Duration of storage (days)	Molasses rate (mean ± standard deviation)		p-value
	3%	6%	
0	2.4 ± 0.15[a]	2.3 ± 0.20[a]	0.411
7	2.1 ± 0.20[ab]	1.9 ± 0.15[ab]	0.315
14	2.1 ± 0.17[ab]	1.7 ± 0.26[bc]	0.094
28	1.9 ± 0.17[Ab]	1.5 ± 0.15[Bc]	0.031
p-value	0.035	0.005	

[abc] Mean values with different superscripts in a column differ significantly ($p<0.05$). [AB] Means values with different superscripts in a row differ significantly ($p<0.05$).

3.4 Dry matter content of densified complete feed

As shown in Table 5, the DM of both 3% and 6% molasses rates were affected ($p<0.05$) by the storage duration. However, no differences ($p>0.05$) were observed on DM of 3% molasses between days 0 and 7. There were also no differences ($p>0.05$) on DM of 3% molasses between days 7 and 14. The highest DM value of 3% molasses was recorded by day 0 (94.1%), while the lowest DM value of 3% molasses was recorded by day 28 (91.8%). In addition, there were no differences ($p>0.05$) on DM of 6%

molasses between days 7 and 14. However, there were differences ($p>0.05$) on DM of 6% molasses between days 0 and 28. The 6% molasses on day 0 had the highest value of DM (93.8%), while the 6% molasses on day 28 had the lowest value of DM (91.1%). In contrast, there were no differences ($p<0.05$) between DM on days 0, 7, 14 and 28 between 3% and 6% molasses levels.

The findings in this study showed that the storage period was important for the feed as DM of both molasses rate of DCF decreased with increasing storage duration. Oguntunde *et al.* [14] found that the complete feed blocks had low hardness value as the moisture content increased. The animal feed was unable to stay in its original form when it contained high levels of moisture content and low level of DM. Micheal [16] mentioned that the stored animal feed with moisture levels of 10% or less might be adopted well before fed to the animal. The factor that caused the decreased trend of DM may be due to high humidity of storing environment as the humidity in Jeli area is very high. On June to August 2019, the humidity was 82-79% and the highest can be reached at 87%.

Table 5. Effect of molasses rate on dry matter (%) content of densified complete feed.

Duration of storage (days)	Molasses rate (mean ± standard deviation)		*p*-value
	3%	6%	
0	94.1 ± 0.30^a	93.8 ± 0.25^a	0.386
7	93.6 ± 0.35^{ab}	92.8 ± 0.52^b	0.087
14	93.2 ± 0.10^b	92.6 ± 0.49^b	0.104
28	91.8 ± 0.72^c	91.1 ± 0.75^c	0.281
p-value	0.001	0.002	

[abc] Mean values with different superscripts in a column differed significantly ($p<0.05$).

Table 6. Effect of molasses rate on colony forming unit (CFU ml⁻¹) of densified complete feed.

Duration of storage (days)	Molasses rate (mean ± standard deviation)		*p*-value
	3%	6%	
0	$3.8 \times 10^3 \pm 208.17^d$	$4.0 \times 10^3 \pm 152.75^d$	0.148
7	$1.1 \times 10^4 \pm 709.46^c$	$1.2 \times 10^4 \pm 1059.87^c$	0.416
14	$1.3 \times 10^4 \pm 702.38^b$	$1.5 \times 10^4 \pm 1153.26^b$	0.209
28	$2.2 \times 10^4 \pm 568.62^{Ba}$	$2.5 \times 10^4 \pm 1350.31^{Aa}$	0.047
p-value	0.000	0.000	

[abcd] Mean values with different superscripts in a column differ significantly ($p<0.05$). [AB] Mean values with different superscripts in a row differ significantly ($p<0.05$).

3.5 Colony forming unit (CFU ml⁻¹)

As shown in Table 6, the CFU of both 3% and 6% molasses rates were affected ($p<0.05$) by the storage duration. There were differences ($p<0.05$) on CFU of 3% molasses among days 0, 7, 14 and 28. The CFU of 3% molasses on day 28 was the highest (2.2×10^4 CFU ml⁻¹) followed by day 14 (1.3×10^4 CFU ml⁻¹), day 7 (1.1×10^4 CFU ml⁻¹) and day 0 (3.8×10^3 CFU ml⁻¹). Similarly, there were differences ($p<0.05$) on CFU of 6% molasses among days 0, 7, 14 and 28, which the highest value of CFU was recorded by day 28 (2.5×10^4) followed by day 14 (1.5×10^4 CFU ml⁻¹), day 7 (1.2×10^4 CFU ml⁻¹) and day 0 (4.0×10^3 CFU ml⁻¹). However, no differences ($p>0.05$) were observed on CFU at days 0, 7 and 14 between 3% and 6% molasses rates. The CFU had significant ($p<0.05$) differences on day 28 between 3% and 6% molasses rates, which the CFU value of 3% molasses on day 28 was lower (2.2×10^4 CFU ml⁻¹) compared to CFU value of 6% molasses on day 28 (2.5×10^4 CFU ml⁻¹). Interestingly, 6% molasses of DCF in this study had higher CFU value rather than 3% molasses of DCF from the beginning to the end of the study; it may be due to reducing of DM and increase of moisture content of DCF which in turn promoted the growth of microorganism. The differences of

CFU between 3% and 6% molasses rates of DCF can be explained through the findings of Shalini *et al.* [17] who claimed that the growth of microorganisms raised as the concentration of carbon source like sugar cane molasses increased.

3.6 Effect of molasses rate

As shown in Table 7, the hardness of DCF was affected ($p<0.05$) by the molasses rate. Regardless of storage durability, the higher hardness value was recorded by 3% molasses (2.1 kg/cm^2) while lower hardness value was recorded by 6% molasses (1.9 kg/cm^2). This indicated that the 3% molasses DCF could sustain the heavy load and more suitable to be transferred for a long distance. Meanwhile, 6% molasses DCF may be more preferable to be consumed by the ruminants compared to that of 3% molasses DCF as it provides more palatability and high acceptance of flavour. The factors that caused the differences between 3% and 6% molasses rates of DCF might be occurred due to the drying rate and moisture content of the feed. However, no differences ($p>0.0.5$) were observed on DM and CFU of DCF between 3% and 6% molasses rates regardless of storage durability.

Table 7. Effect of molasses rate on hardness, dry matter and colony forming unit (CFU) of densified complete feed regardless of storage durability.

Parameters	Molasses rate (mean ± standard deviation)		*p*-value
	3%	6%	
Hardness (kg/cm^2)	2.1 ± 0.25^a	1.9 ± 0.36^b	0.036
Dry matter (%)	93.2 ± 0.93	92.6 ± 1.12	0.170
CFU (CFU ml^{-1})	1.3×10^4 ± 6913.81	1.4×10^4 ± 7765.00	0.710

^{ab} Mean values with different superscripts in a row differ significantly ($p<0.05$).

3.7 Effect of storage duration

As shown in Table 8, the hardness, DM and CFU of DCF were affected ($p<0.05$) by the storage duration. Regardless of molasses rate, there were differences ($p>0.05$) on the hardness of DCF among days 0, 7 and 28. However, no differences ($p>0.05$) were observed on the hardness of DCF between days 7 and 14. Similarly, the hardness of DCF on day 14 had no difference ($p>0.05$) with that of day 28. The highest value of hardness of DCF was day 0 (2.4 kg/cm^2) and the lowest hardness value of DCF was day 28 (1.7 kg/cm^2). Regardless of molasses rate, there were no differences ($p>0.05$) on DM value between days 7 and 14. However, the DM value of both days 7 and 14 had differences with days 0 and 28. The DCF on day 0 had the highest DM (93.9%) compared to the day 28, which had the lowest DM (91.5%). Meanwhile, there were differences on CFU of DCF among days 0, 7, 14 and 28. The highest CFU value of DCF was obtained by day 28 (2.4×10^4 CFU ml^{-1}) followed by day 14 (1.4×10^4 CFU ml^{-1}), day 7 (1.1×10^4 CFU ml^{-1}) and day 0 (2.9×10^3 CFU ml^{-1}). Regardless of molasses rate, it can be observed that the DCF of day 0 had the highest hardness, highest DM and lowest CFU value. In contrast, the DCF of day 28 had the lowest hardness, lowest DM, but highest in CFU value. This may be declined of nutritive value of DCF with increasing the storage duration as the growth of microorganisms increased, moisture content increased and compactness decreased.

Table 8. Effect of storage duration (days) on hardness, dry matter and colony forming unit (CFU) of densified complete feed regardless of molasses level.

Parameters	Storage duration (days) (mean ± standard deviation)				*p*-value
	0	7	14	28	
Hardness (kg/cm^2)	2.4 ± 0.18^a	2.0 ± 0.18^b	1.9 ± 0.30^{bc}	1.7 ± 0.28^c	0.001
Dry matter (%)	93.9 ± 0.28^a	93.2 ± 0.60^b	92.9 ± 0.46^b	91.5 ± 0.78^c	0.000
CFU (CFU ml^{-1})	2.9×10^3 ± 219.09^d	1.1×10^4 ± 885.44^c	1.4×10^4 ± 1066.61^b	2.4×10^4 ± 1608.31^a	0.000

^{abcd} Mean with different superscripts in a row differ significantly ($p<0.05$).

4.0 Conclusion

In conclusion, the proximate components of DCF were not affected by the molasses levels. However, the relationship of DCF on molasses rates between the hardness, DM and CFU was relatable. The results suggested that the 3% molasses of DCF was favourable than 6% molasses in terms of storage duration and transportation. Further studies are needed to extend the storage durability of DCF for more than a month in order to obtain the result of sustainability and shelf life accurately. In addition, feeding trials are needed for better gauging the performance of ruminants in terms of acceptance of flavour and chewing time.

Acknowledgement

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