Effects of Sepiolite Supplementation to Dairy Concentrate on Pellet Quality Characteristics

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***Abstract*—The purpose of this experiment was to determine the effects of sepiolite usage on pellet quality characteristics for dairy cattle concentrate feed under industrial conditions. Experiment consisted of one control and one treatment group with 10 batches each and 1 ton per batch. Pellets were produced in a commercial feed factory in Turkey. Basal feed (control group) produced contained 17.95% crude protein, 8.81% crude fibre and 4.61% ether extract. For the treatment group, 1% sepiolite (Exal T, Tolsa Turkey Company-Polatlı, Türkiye) was added as top dressed in the mixer. Pelleting disc having 4 mm hole diameter was used. Moisture losses during pellet production were reduced, pellet durability indexes were enhanced, fine particles were reduced by using 1% sepiolite. Water activity values of pellet feeds were not affected by sepiolite addition. The results indicated that 1% sepiolite supplementation as top dressed may be used during pellet manufacturing of dairy cattle concentrates to improve their pellet quality characteristics such as pellet durability index and water activity**.

***Index Terms*—dairy cattle concentrate, pellet durability, sepiolite, water activity**

I. Introduction

Pelleting is one of the most common processing techniques used in feed manufacturing. It is a process to obtain feed in the form of pellets with improved physical and nutritional quality as well as it reduces the transportation and handling cost of feed in terms of energy consumption [1]. When compared to mash feed, pelleting process has a great number of advantages such as better flow properties, higher bulk density, no segregation etc. [2]. Pelleting also reduces the resistance of starch against ruminal degradation by 15% [3].

Pellet quality is affected by several factors such as particle size of the mash feed, conditioning time and temperature, pellet production rate, diet formulation and composition, specifications of the pellet die and cooling of the pellets [4]. Pellet Durability İndex (PDI) and hardness are two main physical parameters used to determine pellet quality [1]. Among different feed components, starch, protein and fat are of significant importance determining the hardness and durability of the final feed [5]. Moritz *et al.* [6] reported that increasing starch gelatinisation improved the pellet quality. Similarly, protein denaturation has also resulted in better pellet quality due to its function as a binding agent during the pelleting process [7]. However, Briggs *et al.* [8] showed that adding high levels of fat to diets reduced pellet durability. Since fat inclusion reduces the friction between die wall and feed ingredients, by decreasing the compression on feed particles inside the die holes, it has negative effect on pellet durability.

In feed technology, sepiolite, based on its sorptive and chemical inertness, is used as a binder to improve pellet physical quality [9], [10]. Sepiolite, a natural clay mineral is a hydrated magnesium aluminium silicate within the group of phyllosilicates. Sepiolite supplementation to daily calf diet at the rate of 2% had positive effects on body weight gain and prevention of diarrhoea [11]. Sepiolite may also replace growth factors in poultry diets as therapeutic agents [12]-[14]. Some researchers reported that adding 1% sepiolite to the diets of dairy cattle and fattening cattle [15], broilers [16] and laying hens [17] enhanced the pellet durability index. Furthermore, during the conditioning process, it is more difficult to preserve moisture when adding fat in diets [18]. In such cases, addition of sepiolite can significantly lead to an improvement in pellet durability even if high levels of fat is used [7], [19].

Water Activity (Aw) is another key factor concerning the quality of feed. Measuring the water activity helps in the development and production of high quality products that are safe and shelf stable. The number of studies measuring the pellet quality of feed with the supplementation of sepiolite and other clay minerals are limited, and also no research is available regarding the determination of water activity in pelleted feeds. Therefore, the objective of this experiment was to evaluate the effects of sepiolite usage in concentrate feeds of dairy cattle on some pellet quality characteristics including pellet durability index and water activity.

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II. Materials and Methods

Commercial concentrate for dairy cattle was used in this experiment. Pellets were produced in a private feed manufacturing facility in Turkey. The concentrate feed contained mainly wheat middlings (200 kg/t), sunflower seed meal (150 kg/t), corn DDGS (147 kg/t), corn bran (144 kg/t), corn (134 kg/t), barley (80 kg/t), rice bran (40 kg/t), soybean meal (30 kg/t) and molasses (20 kg/t). Experiment consisted of one control group and one treatment group. Ten batches (1 ton/batch) of concentrate feeds were produced for each of the experimental groups. In the treatment group, 1% sepiolite (Exal T, Tolsa Turkey Company-Polatlı, Türkiye) was added to the mixer as top dressed.

Pellet diameter was 4 mm. No water was added to the mixer. The steam temperature was 59-61^{o}C during pellet processing. The parameters for manufacturing processes are shown in Table I.

Samples from each batch of experimental groups were collected at different stages of pellet making such as from the mixer, after the conditioner and from pelleted feed after cooling & after loading the truck. Moisture content was analysed in all of the samples collected [20]. Crude protein, crude fibre, ether extract, ash and starch analysis of dairy concentrate feed were determined [20]. Metabolizable energy level was calculated according to the formula proposed by TSI [21]. Moisture and ash content of sepiolite were measured [20]. Mineralogical composition of sepiolite was analysed by D8 Advance Diffractometer AXS (Bruker, Germany). Pellet durability index values of pelleted concentrate feeds after cooling and after loading were measured with a Pfost Box Equipment using the sieve with the hole diameter of 2.80 mm [22]. Fine particles were also measured using the sieve with hole diameter of 1.00 mm. Water activity values of pellet feeds after cooling and after loading were measured by using water activity equipment (LabSwiftaw, Novasina, Switzerland). The temperature at which water activity measurement performed was also recorded. Quadruplicate measurements were done with each sample.

TABLE I. Parameters for Pellet Manufacturing Processes

Parameter	Control	Sepiolite
Production, t	10	10
Mixer capacity, t	1	1
Production per batch, t	1	1
Water added in mixer	No	No
Disc hole diameter, mm	4	4
Disc hole length, mm	70	70

Statistical analysis was performed by using the ANOVA procedure of the SPSS 23.0 (SPSS Inc., Chicago, IL, USA). The experimental unit was 10. The normality of data distribution was checked using the Kolmogorov-Smirnov test. Comparison between groups was examined with independent samples t test. Level of significance was taken as $P<0.05$ [23]. Data were given as mean ±standard error of mean.

III. Results and Discussion

Sepiolite is a feed additive (E-562) used as a binder and anti-caking agent up to 2% in all feeds for all animal species [24]. Ingredients and composition of sepiolite (Exal T) are given in Table II. Sepiolite used in this trial contained high amounts of sepiolite (65%). The nutrient composition of dairy cattle concentrate feed is shown in Table III. Crude protein and metabolizable energy of concentrate feed were 17.95% and 2596 kcal/kg, respectively.

TABLE II. Ingredients and Composition of Sepiolite

Ingredients	%	Composition	%
Sepiolite	65	Moisture	8.23
Attapulgite	9	Ash	88.70
Dolomite	18		
Calcite	8		

TABLE III. Nutrient Composition of Dairy Concentrate

Content	
Dry matter, %	90.26
Crude protein, %	17.95
Crude fibre, %	8.81
Ether extract, %	4.61
ADF, %	12.91
NDF, %	33.06
Starch, %	24.45
Sugar, %	2.85
Ash, %	7.20
Metabolizable Energy, kcal/kg	2596

Moisture content of samples collected during pellet manufacturing is shown in Table IV. Moisture content of sepiolite added pellet feeds after cooling and after loading was higher ($P<0.05$) as compared to control groups. The differences in moisture content of mixer feeds and pellet feeds after cooling and after loading were significantly higher ($P<0.05$) for control groups than that of sepiolite added groups. However, in dairy cattle and fattening cattle concentrates, Yalçın *et al.* [15] reported no significant differences among experimental groups (control and 1% sepiolite group) for moisture content of samples taken from mixer, after conditioner and from pellets after cooling. The disagreement in results of both studies may be due to the different factory conditions, or ingredients and chemical composition of the diets used.

For broiler feed, increasing the moisture in the mixer during pellet production has improved pellet durability [25], [26]. Sepiolite has a fibrous structure containing micropores and internal channels that run parallel to the fibre length [9]. These channels can absorb substantial amount of liquid in the ambient [27]. It can be seen in Table IV that 1% sepiolite supplementation prevented the moisture loss during pellet production. Buchanan and Moritz [28] indicated that increased moisture content in

mixer helps in better quality pellets as well as it improves the starch gelatinization. It can be concurred that adding sepiolite to concentrates during pellet production can help in reducing the moisture losses, thus enhancing pellets quality as well as improving the pellet post-production storage time with minimum weight losses.

TABLE IV. MOISTURE CONTENT (%) OF FEEDS DURING PELLET MANUFACTURING

	Control	Sepiolite	P
Mixer	11.21±0.04	11.17±0.02	0.364
After conditioner	14.12±0.04	14.37±0.05	0.002
Pellet after cooling	10.97±0.09	11.22±0.07	0.037
Pellet after loading	11.02±0.04	11.16±0.05	0.043
Difference between mixer and pellet after cooling	0.24±0.10	-0.05±0.07	0.030
Difference between mixer and pellet after loading	0.19±0.05	0.02±0.06	0.045

Sepiolite acts as a filter and therefore decreases porosity in the pelleted feed. In this study, sepiolite supplementation improved the PDI values ($P<0.001$) as shown in Table V. Fine particles with 1.00 mm diameter sieve for sepiolite-added pellets after cooling and after loading to truck were less ($P<0.001$) than that of control group (Table V). A reduction in fine particles is beneficial in terms of feed losses and performance perspective for the animals and the farmer [15]. Yalçın *et al.* [15] has reported an improvement in PDI values of dairy cattle and fattening cattle feeds when supplemented with 1% sepiolite as top-dressed. Angulo *et al.* [19] also stated that sepiolite supplementation reduced the broken pellets and the percentages of fines and improved the performance of pelleted diets, especially those containing high levels of fat. Yalçın *et al.* [17] concluded that pellet durability index in the layer diet having 1% sepiolite was 78.06% higher than that of control diet in the conditions of commercial factory.

The improvement in pellet quality could be due to the absorptive and rheological properties of sepiolite as clay [9], [15], [17], [29].

TABLE V. PDI VALUES AND THE PERCENTAGE OF FINE PARTICLES OF PELLET FEEDS WITH 1.00 MM DIAMETER SIEVE

	Control	Sepiolite	P
Pellets after cooling			
PDI, %	91.88±0.32	94.09±0.18	<0.001
Fine particles under 1mm, %	4.23±0.19	3.38±0.06	<0.001
Pellets after loading			
PDI, %	90.90±0.30	93.71±0.21	<0.001
Fine particles under 1mm, %	4.19±0.09	3.11±0.07	<0.001

Sepiolite supplementation did not affect water activity values of pellet feeds after cooling and after loading. Water activity values of pellet feeds after cooling and after loading were less than 0.60 as shown in Table VI.

TABLE VI. WATER ACTIVITY VALUES OF PELLET FEEDS AFTER COOLING AND AFTER LOADING

	Control	Sepiolite	P
Pellet after cooling			
Water activity	0.533±0.005	0.537±0.006	0.625
Temperature (°C)*	23.10±0.15	22.50±0.37	0.160
Pellet after loading			
Water activity	0.593±0.003	0.580±0.011	0.274
Temperature (°C)*	22.80±0.19	23.03±0.15	0.349

*Temperature at which water activity was measured.

IV. CONCLUSION

The physical parameters including pellet hardness, pellet fine particles and moisture content have significant relation with pellet durability. Sepiolite supplementation at 1% to dairy cattle concentrate reduced the moisture losses during pellet production and improved pellet durability index as well as reduced the fine particles. Therefore, it is concluded that sepiolite can be useful for pellet manufacturing of concentrate feed for dairy cattle. Further research is needed using different levels of sepiolite with different diet formulations.

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