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Effect of Feed Materials on Pellet Properties, Capacity and Energy Consumptions Values

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Abstract: In this study, it was aimed to determine the power consumption, work capacity and some properties of the pellet feed of the pelletizing machine used in the pelleting of animal feeds consisting of small and granular mixtures.
A pellet machine with a die hole inlet diameter of 8 mm, an outlet diameter of 5 mm and a flat die with a diameter of 195 mm was used to pellet the feeds. In the experiments, two different feed materials consisting of mixed feed and barley only were used. The bulk weight of the pellets (kg m-3), durability (%), compression resistance (N mm-2), pellet moisture (%) were determined. In addition, hourly pelleting capacity (kg h -1), required energy consumption (kW), specific energy consumption (kW kg -1) of the pelletizing machine were determined.As a result of the trials, the capacity of the pellet feed making machine was 172.80 kg h-1 in the pelleting process from barley and 170 kg h-1 in the pelleting process from mixed feed. The required electrical energy consumption was 7.63 kW, in barley pelleting and 9.18 kW in mixed feed pelleting. Specific energy consumption 0.044 kW kg^{-1} in barley pelleting, 0.054 kW kg^{-1} in mixed feed pelleting

Keywords: Capacity, durability, mold, pellet, energy consumption

Pelet Yem Yapma Makinesi Bazi İşletme Özelliklerinin ve Pelet Özelliklerinin Belirlenmesi

Öz: Bu çalışmada, küçük ve granül karışımlardan oluşan hayvan yemlerinin peletlenmesinde kullanılan peletleme makinesinin güç tüketimi, iş kapasitesi ve pelet yeminin bazı özelliklerinin belirlenmesi amaçlanmıştır. Yemleri peletlemek için kalıp deliği giriş çapı 8 mm, çıkış çapı 5 mm ve çapı 195 mm olan düz kalıbı olan bir pelet makinesi kullanılmıştır. Denemelerde karma yem ve sadece arpadan oluşan iki farklı yem maddesi kullanılmıştır. Peletlerin yığın ağırlığı (kg m^{-3}), dayanıklılık (%), sıkıştırma direnci (N mm^{-2}), pelet nemi (%) belirlenmiştir. Ayrıca peletleme makinesinin saatlik peletleme kapasitesi (kg h^{-1}), gerekli elektrik motoru gücü (kW), özgül güç tüketimi (kW kg^{-1}) belirlenmiştir. Denemeler sonucunda pelet yem yapma makinesinin kapasitesi arpadan peletleme işleminde 172,8 kg h^{-1}, karma yem peletleme işleminde ise 170 kg h^{-1} olmuştur. Gerekli elektrik motoru gücü arpa peletlemede 7,63 kw, karma yem peletlemede 9,18 kw olarak bulunmuştur. Spesifik enerji tüketimi 0,044 kW kg^{-1} arpa peletlemede, karma yem peletlemede ise 0,054 kW kg^{-1} olarak bulunmuştur.

Anahtar Kelimeler: Dayanıklılık, kalıp, kapasite, pelet , enerji tüketimi

1.Introduction

Giving the feed raw materials in the form of a mixture because the deficiencies of each feed raw material are completed by the other raw materials in the mixture, giving the mixed feed to the animals has many nutritional benefits compared to giving a single raw material. (Ergül, 2005; Gül, 2007).

Feed costs have the largest share in production costs in the livestock sector. Due to the degradation of meadow-pasture areas and the decrease in agricultural lands, the livestock sector has turned to the search for alternative and cheap feed resources (Yılmaz, 2010).

High capacity animals require high quality feeds. Compound feeds allow animals to benefit from raw materials with different nutrients at the highest level. Raw materials that are not willingly consumed by animals are turned into compound feed and consumed by animals. In Turkey and in the world, factory feeds are produced in powder, pellet and granule forms. With the recent increase in animal production, there has been an increase in compound feed production. The balanced nutrition that animals need has an important role in preventing health problems and increasing the yield of animal products (Najwa et al., 2017).

Electricity consumption of compound feed varies according to the content of the prepared feed rate. The extension of the enclosures to the mix and their ratio effect the electricity consumption. So much so that less electricity is consumed (3.5-7 kWh t^{-1}) in the grinding of oily beans and more electricity is consumed during the grinding of meetings (7-15 kWh t^{-1}) (Gill, 1998; Boyar, 2006). The possible importance of the time-to-start-up durability of the pellets is of great importance. Pellets with high durability provide advantage in transportation, handling by hand or any vehicle and storage works (Lehtikangas, 2001). Pellets with 80% or more durability are considered high quality, between 70-80% medium quality and 70% of pellets low quality (Tabil &Sokhansanj, 1996; Tabil &Sokhansanj, 1997).

With the positive physical effects of pellet feed better yields from animals consuming this feed has played an important role in popularizing its use (Dozier, 2001). Pellet durability index and pellet hardness physical measurement parameters are used to determine pellet strength or pellet quality (Yalcın et al. 2018).

Miranda et al. (2011) and Miranda et al. (2012) reported that the moisture content of pellet feed is effective in reducing the pellet durability index, and the durability rate is between 85.83% and 97.08% depending on the feed raw material ratio in the mixture, pellet moisture content and types.

The material that gives the pellet its shape is called mould.The die has an important and large home in the elements in the energy use and pellet care centers where they press. For consumers who use the right mold to improve pellet quality. Widening the matrix hole from which the pellet feed comes out provides the total thickness required to prevent the matrix from disintegrating and reduces the effective thickness of the matrix, ensuring the appropriate ratio between matrix thickness and matrix hole diameter. According to the diameter and thickness of the mold, the effective area of the mold increases. The large area of this area extends the residence time of the feed in the mold holes, reduces the energy consumption for each ton of pellet feed production and increases the production efficiency (Fairfield, 2003).

The physical quality of the pellet feed is very effective on the passage time through the digestive system and degradation in the feeding of animals. Pellet feeds with high physical quality can be better utilized by animals (Gürbüz et al., 2003)

While it is easy to pellet raw materials such as wheat, barley and canola, pelleting of feed raw materials such as corn is more difficult. Energy consumption will increase due to increased friction in the presses, as pellets made from ground feeds with more small particles than necessary are more durable. Good results were obtained in pelleting powdered feeds in the period when the pelleting process was started for the first time. While pelleting the feeds with very small particles was done at the beginning, the pelleting of the feed with larger particles decreased the level of meeting the desired expectations (Basmacıoglu, 2004).

It has been reported that the use of pellet feed improves live weight by 27% and feed conversion efficiency by up to 17% compared to powder feed in broiler breeding (Karabulut et al., 2000).

In this study, it was aimed to make feed pelleting of two different feed raw materials in the form of mixture and using only barley, without using any adhesive material. Determination of the volume weight of the pellets (kgm^{-3}), Pellet density (kg.m^{-3}), durability (%), compression resistance (Nmm^{-2}), pellet moisture (%), as well as the hourly pelleting capacity of the pelletizing machine (kgh $^{-1}$), the required electric energy consumption (kW) and specific energy consumption (kW kg^{-1}).

2. Material and Method

MEDYAMAK brand and MY200 model feed pelleting machine used in the trials turns small animal feeds into cylindrical shaped pellets. With the electric motor, the pellet mold, which is the reducer shaft line, is moved. The mold is in a shelter in a body and the three compression cylinders on the mold rotate around itself with the width of the mold. The material feed tank is located just above the mold and clamping cylinders to provide continuous material inflow. The material taken from the rollers and the mold inlet tank is compressed and comes out as cylindrical pellets from the holes on the mold and is sent to the machine from the pellet delivery port (Figure 1). The technical specifications of the pelletizing machine are given in Table 1, and the label information of the electric motor powering the machine is given in Table 2.

The mixed feed material used in pelleting has 16.2% moisture. Pellet has 16.20% moisture, 588 kg m^{-3} in weight contains 50.80% corn, 31.60% sunflower + alfalfa residues and 17.60% barley (Figure 2A). As the other feed material, barley with a volume weight of 570 kgm^{-3} thousand grain weight 65 g and a moisture content of 13.60% was used (Figure 2B).

Pellet compression resistance, pellet output values obtained by Aydın & Öğüt (1991) were measured by pressing the pellet extraction stationary platform on the mobile bottom platform of the biological material testing device (Figure 3). The hardness of the pellets was measured with a 2 mm high probe connected to the dynamometer. The experiments were carried out at a speed of 50 mm min^{-1}.

(A) **(B)** **(C)**

Figure 1. Pelletizing machine and parts: (A) Pellet making machine,(B) Compression rollers,(C) Pellet mold
Şekil 1. *Peletleme makinesi ve parçaları (A) Pelet yapma makinesi, (B) Sıkıştırma silindirleri, (C) pelet kalıbı*

(A) **(B)**

Figure 2. Peletting materials; (A) Mixed feed, (B)Barley
Şekil 2. *Pelet materyalleri; (A) Karma yem, (B) Arpa*

Table 1. Pelletizing machine technical specifications
Çizelge 1. Peletleme makinesi teknik özellikleri

	Compressors Cylinder	**Pellet Mold**
Diameter	95mm	195mm
Width	45mm	34mm
Number of holes	22x4 (88 pcs)	272
Hole diameter	6mm	Inlet diameter: 8 mm Output diameter: 5 mm
Mold working speed		196 minutes $^{-1}$
Die circumference speed		2 ms $^{-1}$

Table 2. Electric motor label information
Çizelge 2. Elektrik motoru etiket bilgileri

V	A	Hz.	cosφ	Transfer	kW
400	21.0	50	0.83	1465	11th
690	12.1	50	0.83	1465	11th

Three replications were taken to determine the moisture content of the material. An oven with a temperature range of between 1^{o} C and 200^{o} C was used to weigh 0.5g precision and 15 kg precision scales. Pellet samples were dried in a drying oven at 105±2°C for 24 hours. After drying in the oven, they were weighed again. The moisture rate was calculated on the basis of wet weight with the following eg.1 (Toruk, 1997).

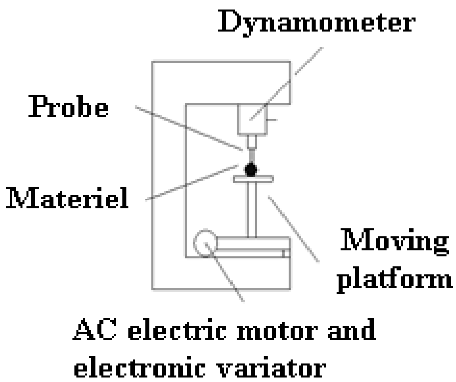

Figure 3. Biological material testing device (Aydın and Öğüt, 1991)
Şekil 3. *Biyolojik materyal test cihazı (Aydın ve Öğüt, 1991)*

Pelleting machine for both feed materials can be determined, the electrical energy consumption is measured. According to the machine capacity and its electrical energy consumption has been calculated. The hourly pellet making capacity of the pelletizing machine was determined as kg h^{-1} by collecting and weighing the pellets made in a certain time after the machine started to extract pellets and entered the regime. The electrical energy consumption of the pelletizing machine was used by a 3-phase electrical energy analyzer. By dividing the electrical energy consumption to the hourly pellet making capacity of the machine, the specific electrical energy consumption of the pellet making machine was calculated as kWh kg-1.

$$Ny = ((M\,y - M\ \ )/\ M\,y) \times 100 \qquad (1)$$

Here
Ny : Product moisture content (wb.) (%)
My : Initial weight of samples taken (g)
Mk : The weight of the samples taken after drying (g)

Pelleting machine for both feed materials can be determined, the electrical energy consumption is measured. According to the machine capacity and electrical energy consumption, its electrical energy consumption has been calculated. The hourly pellet making capacity of the pelletizing machine was determined as kg h^{-1} by collecting and weighing the pellets made in a certain time after the machine started to extract pellets and entered the regime. The electrical energy consumption of the pelletizing machine was used by a 3-phase electrical energy analyzer. The electrical energy consumption of the pellet- making machine was calculated as kWh kg^{-1} by proportioning the electrical energy consumption of the machine usage and pellet making uses.

Pellet particle density was designed by measuring the size of the resulting pellets. 15 randomly selected pellets from each pellet sample were weighed, their weights were recorded, and the pellet portion was used. Then, the diameter and length of 50 randomly selected pellets were measured with a digital caliper and the pellet volume was calculated (Eg.2). The pellet particle density was calculated as kg m^{-3} with the layers of the pellet weight to the pellet volume with the freedoms given below (Eg.3) (Adapa et al., 2006).

$$V_u = \frac{\prod d^2 \ell}{4} \qquad (2)$$

$$P_u = \frac{M_u}{V_u} \qquad (3)$$

In equations;
V_u : Single pellet volume (m^3)
d : Pellet diameter (m)
ℓ: Pellet length (m)
P_u : Pellet density (kg m^{-3})
M_u: Single pellet weight (kg)

Endurance resistance of the pellets is determined according to the EN 15210-1 (2009) standard. The resulting pellets completely fill the outside of a cone from a height of approximately 200-300 mm into the 5 liter container. Then, the excess pellets in the limited upper part were scraped with a flat material and the excess pellets were given as a container. The large gaps in the upper part of the container are filled. The pellet bulk density was calculated in kg m^3 with the following freedom (Eg.4).

$$Phy = \frac{M}{V} \qquad (4)$$

In equality;
Phy: Pellet bulk density (kg m^{-3})
M: Pellet weight (kg)
V: Cabin net volume (m^3)

Of the pellets is determined according to the EN 15210-1 (2009) standard. The pellet samples in the body of 500 grams, which were sieved with a 4 mm round hole sieve and separated from the dust, were put into the pellet turning box and allowed to be rotated for 10 minutes. This process was repeated 3 times for each pellet sample. After the spinning process, all of the pellets were taken out and sieved again using a round perforated sieve with 4 mm diameter holes. The lifetimes of the pellets were calculated as percent (%) with the following (Eg.5)

$$Dt = \frac{M_{ilk}}{M_{son}} \qquad (5)$$

In equality;
Dt : Endurance resistance (%)
M_{first} : Weight of sifted pellet before test (g)
M_{end} : Screened pellet weight after test (g)

3. Research Findings and Discussion

The lengths, diameter, weight and moisture values of the pellets obtained as a result of the trials are given in Table 3. Although the length, weight and moisture values of the pellets obtained from both feed materials reflect the patterns, the pellet diameter values were found to be the same.

Table 3. Pellet properties
Çizelge 3. *Pelet özellikleri*

Pellet properties	Mix feed	Barley
Length (mm)	21.800	22.2000
Diameter (mm)	5.000	5.000
Weight (g)	0.055	0.049
Pellet moisture (%)	13.200	13.600

As a result of the trials, the work capacity, required electrical energy consumption and spescific energy consumption values of both feed materials of the pellet making machine are given in Table 4. The work capacity of the pellet making machine in obtaining pellets from mixed feed material is less than obtaining pellets using barley.

Required electrical energy consumption and spescific energy consumption values in using barley production were also found to be higher in mixed feed pellet production. The reason for this is that the amount of corn in the mixed feed is higher and the corn has a harder structure than barley.

Table 4. Capacity and energy consumption values obtained as a result of the trials
Çizelge 4. *Denemeler sonucunda elde edilen kapasite ve güç değerleri*

Pellet properties	Mix feed	Barley
Hourly pellet making capacity (kg h^{-1})	170.000	172.800
Required electrical energy consumption (kW)	9.180	7.630
Specific energy consumption (kW kg^{-1})	0.054	0.044

As a result of the trials, the bulk density, durability, compression resistance, pellet particle density values of the pellets obtained from both feed materials are given in Table 5. The bulk density, durability, compression resistance, pellet particle density values of the pellets obtained from both feed materials as a result of the trials are given in Table 5. The bulk density and particle density of pellets obtained from barley are higher than pellets obtained from mixed feed. Larsson and Rudolfsson (2012) reached the lowest pellet moisture content and the highest pellet bulk density in the pellets they obtained from biomass materials with different moisture contents.

Durability and compression resistance in pellets obtained from mixed feed values are higher than in pellets obtained from barley. It has been concluded that the durability and compression resistance of pellets obtained from mixed feed raw materials is better than pellets made from a single raw material, due to the diversity of feed.

Abdollahi et al. (2013) found in a study that pellets of wheat-based feeds contain more crude protein because wheat proteins are of gliadin nature. and therefore more durable than corn-based ones.

Strength and compression resistance values were found to be higher in pellets obtained from mixed feed. It can be explained as the moisture value of the pellets obtained from barley is higher than the moisture value of the mixed feed pellets.

The pellets to be able to identify most of the parts obtained especially by mechanical or pneumatics , it is helpful to control the quality of the pellets by compression, and hence the quality of the pellets . Pellets with high durability in production are classified as high- quality pellets in terms of quality (Kaliyan & Morey 2009).

Table 5. Volume and particle density, durability and compression resistance values of pellets
Çizelge 5. Peletlerin hacim ve parça yoğunluğu ile dayanıklılık ve sıkıştırma direnci değerleri

Pellet properties	Mix feed	Barley
Bulk density (kg m^{-3})	505.00	507.00
Pellet particle density (kg m^{-3})	1279.00	1309.00
Durability (%)	92.30	86.00
Compression resistance (N mm^{-2})	8.57	7.47

Miranda et al. (2011) and Miranda et al. (2012) reported that pellet strength resistance decreases with greater than pellet moisture content, and the strength toughness remains between 85.83% and 97.08% depending on the type of materials used, mixing ratios, and pellet moisture content.

Çakmak (2019) reported that the durability index of pelleted feeds varied between 89.47% and 92.74%.

Gürbüz (2003) found that the durability of pellets obtained from pelletizing powdered compound feed with three different binders were 96.50%, 96.70% and 96.85%.

Pellet feeds obtained from mixed feed and barley are given in Figures 4, after trials with the pellet feed machine.

In pelleting with the pellet feed machine , it was concluded that the durability and resistance of the pellets obtained from the mixed feed raw materials (Figure 4a) compared to the pellets made from the barley raw material (Figure 4b), were better due to more feed consumption. The fact that feed storage is rich in some nutritional products increases the limitation of the pellet and increases its durability. Pellet bulk density and pellet particle density are not very different in both pellet feeds.

(A) (B)

Figure 4. Produced pellets; (A) Pellet from mixed feed, (B) Pellet from barley
Şekil 4. *Üretilen peletler ; (A) Karma yemden elde edilen pelet,(B) Arpadan elde edilen pelet*

The pelleting capacity is not determined in both feed raw materials, the electrical power required for the feed raw material in the mixture is 16% and the skilled power consumption is 20% higher.

4.Conclusion

The pelleting of feed materials such as barley and oats, which are found in the form of particles or powder mixtures, also allows the use of quality feeds in animal husbandry. Factors affecting the production of quality pellet feed can be explained as the physical properties of the mixed feed, the particle size of the feed raw material, the variety and proportions of the raw materials in the composition of the mixed feed, as well as the manufacturers' ignorance of the quality factor in order to provide economy. In addition to these, the pelleting technique is also one of the factors affecting the quality. Along with the raw materials to be pelleted, it is also important to choose the most suitable pellet mold for pellet feed production of the desired quality. Necessary studies should be carried out in order to produce quality pellets and to ensure the continuity of quality in an economical way.

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