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Research Paper

Effects of sunflower meal quality on the technical parameters of the pelleting process and pellet quality

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ARTICLE INFO

Article history:
Received 2 July 2015
Received in revised form
25 September 2015
Accepted 30 September 2015
Published online 11 November 2015

Keywords:
Sunflower meal
Pelleting
Physical quality
Technological parameters

The impact of sunflower meal quality (i.e. crude protein content and crude fibre content) on the technical parameters of the pelleting process and the physical properties of produced pellets was investigated. Five model mixtures were prepared for pelleting, with different ratios of corn, sunflower meal (SFM) and soybean meal (SBM). Three grades of sunflower meal were used in the experiments with crude protein contents of approximately 37%, 40%, and 43%. Within each of the mixtures, granulation of material and retention time in the steam conditioner were varied. In order to describe the effects of the test variables on the observed responses response surface methodology, standard score analysis and principal component analysis (PCA) were used. The increase in the protein content and the decrease in the crude fibre content of sunflower meals caused an increase in the pelleting temperature, specific energy consumption, pellet hardness, and pellet durability. In addition, an increase in retention time increased specific energy consumption of pellet press, and produced fines. In terms of pellet durability values, a longer retention time was more beneficial for SFM mixtures than for SBM mixture. The type of mixture was found to be the most influential variable for second order polynomial model calculation. Standard score analysis showed that the optimum values for energy consumption, quantity of the fines, and pellet durability indices were obtained for the mixture with 40% protein SFM, with no retention after conditioning and with the finest granulation of the components (0.933). PCA showed that the first two principal components (91.10% of the total variability) enabled a neat separation of the five mixtures.

1. Introduction

The composition of pelleted feed is driven by nutritive demands of the animals. However, the choice of ingredients is to some extent flexible. Thus, it is necessary to know the technical impact of selected raw materials on pellet quality. If a compound mixture with technically unacceptable ingredients is pelleted, the pellets obtained may be of poor quality (Buchanan & Moritz, 2009; Thomas, Rijm, & Van der Poel,

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http://dx.doi.org/10.1016/j.biosystemseng.2015.09.010

Nomenclature

Symbols

d	Pellet diameter (mm)
d_{HMSO}	Diameter of hammer mill screen openings (mm)
d_{gw}	Geometric mean diameter (μm)
E	Energy consumption during pelleting of experimental mixtures (kW)
E_0	Energy consumption of pellet press with no material added (kW)
E_{sp}	Specific energy consumption (kW/t/h)
F_s	Proportion of fines (%)
H	Pellet hardness (N)
PDI	Pellet durability index
Q	Pellet press feeder rate (kg/h)
Rt	Retention time (s)
S_{gw}	Geometric standard deviation (μm)
T_d	Pellet press die temperature (°C)
T_p	Pellet temperature (°C)
X	Variable
Y	Response

Greek symbols

β	Constant regression coefficient

Statistical abbreviations

ANOVA	Analysis of Variance
PCA	Principal component analysis
r^2	Coefficient of determination
RSM	Response surface methodology
SOP	Second order polynomial
SD	Standard deviation
SS	Standard score

Abbreviations

SBM	Soybean meal
SFM	Sunflower meal

2000). Cereals, which are rich in starch, are mostly used to provide the required energy for domestic animals and they represent the largest proportion of compound mixtures.

1.1. Protein meals in pelleting diets

Numerous references describe the positive impact of protein on pellet quality (Abdollahi, Ravindran, and Svihus, 2013; Maier & Briggs, 2000; Winowiski, 1988). Leguminous and oilseed meals are commonly used as a source of protein in compound mixtures for monogastric animals, with soybean meal (SBM) being most frequently used. Hence, the effect of the addition of SBM on physical pellet quality was described in several papers (Briggs, Maier, Watkins, & Behnke, 1999; Moritz et al., 2002). Sunflower meal (SFM) is a feedstuff that can be used as both as a source of protein and amino acids for monogastric animals (Rehman, Asad, Qureshi, & Iqbal, 2013). The high concentration of methionine, and its low concentration of lysine, allow SFM to be combined with SBM enabling the formulation of diets without the addition of synthetic amino acids (de Oliveira et al., 2014). Depending on the technical process used for oil extraction from sunflower kernel, and additional technologies for protein enrichment, the protein and crude fibre content of SFM can vary in wide range of concentrations (Briones, Serrano, & Labidi, 2012; Mushtaq et al., 2009). Although a widely used ingredient, little research on the physical quality of SFM pellets is available. Israelsen, Busk, and Jensen (1981), as well as MacMahon and Payne (1991), estimated the effects of different raw materials on physical quality of SFM pellets. According to their estimates and classification reports, SFM can be regarded as having a more positive effect on pellet physical quality than SBM. However, within these estimates there was no data on the applied process parameters.

1.2. Objectives of the present study

Although there are a few reports comparing SFM to other raw materials in terms of its impact on the physical quality of pelleted feed, differences in SFM quality have not yet been taken into consideration. Therefore, the main objective of this study was to investigate the impact of SFM quality (i.e. crude protein and crude fibre content) on the pellet quality and the dependent technical parameters of the pelleting process. Additionally, the influence of the independent process variables, the diameter of the hammer mill screen openings (d_{HMSO}) and retention time in the steam conditioner (Rt), on the physical quality of the pellets and the technical parameters of the process was examined for each of the model mixtures examined.

2. Materials and methods

2.1. Raw materials and model mixtures

Raw materials used in this study were corn, SFM and SBM. Corn, sort NS 300, was grown in the northern province of Vojvodina, Serbia. SFM was provided by local oil producing factory Victoria Oil, Šid, Serbia, while SBM was provided by soy processing factory Sojaprotein, Bečej, Serbia. The chemical composition of oilseed meals is shown in Table 1. Three grades of SFM were provided, differing in crude protein and crude fibre content: SFM 1, SFM 2 and SFM 3 with the crude protein content of approx. 37%, 40%, and 43% respectively.

The listed materials were used to prepare five model mixtures. The model mixtures were used so a comparison of the impact of specific oilseed meals on the pellet quality and the

Table 1 – Chemical composition of oilseed meals used in the experiment (dry matter basis).

	SFM 1	SFM 2	SFM	SBM
Composition (g kg^{-1})				
Crude protein	374	403	427	472
Crude fibre	207	192	178	27
Crude ash	80	86	83	62
Crude fat	27	28	37	13
Nitrogen free extract	312	291	275	426