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Use of new feed from brewery by-products for breeding layers

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Abstract

Brewery by-products decellulosed mixture was produced from brewery by-products (brewer's spent grain with hot sludge + protein sludge from press liquor + brewer's yeast). The new protein feed was produced by fractionation (sieving) of dried brewery by-products. This paper shows the technological production procedure, the chemical composition and the nutritive value of this non-conventional feed. The tested production procedure enables effective and economic production of new protein feed. Applied processing parameters make a good basis for designing mechanical – technological lines for industrial production of new feed in the breweries. Non-conventional protein feed (calculated on dry matter basis) is the concentrated source of crude protein (390 g/kg), crude fat (102 g/kg) and linoleic acid (49 g/kg). This new feed significantly increased ($p<0.05$) egg production, egg fertility and hatchability of fertilized eggs. The new feed has a comparative nutritive advantage in relation to soybean meal as a source of nutrients for breeding layers.

Keywords: brewery by-products, fractionation, passing material, decellulosed fraction, non-conventional feed, laying hens

Introduction

There are several by-products that can be obtained from production of beer, such as, brewers grains (wet or dried), brewers dried yeast, etc. These materials are considered to be good sources of un-degradable protein and water soluble vitamins [1-4]. They have been used in feeding both ruminant and monogastric animals [5-10]. Brewer's grain is the material that is remaining after fermentation of grain, during the beer making process. These materials can be used in the undried or dried form (WBG or DBG respectively). The nutritional content of the material will vary from plant to plant and depending upon the type of substrate (barley, wheat, corn, etc.), extent of fermentation and type of fermentative process. Brewers' yeast has been successfully used as a replacer for soya in diets of growing and fattening pigs and sows [11, 12]. Concerning a constant lack of some essential amino-acids in the diet of the growing and fattening pigs it is desirable to help with the balancing of the amino acids in cereal-based diets. Currently, use of brewery by-products to ruminants is relatively limited but the feed is very palatable and offers a good source of protein [13, 14]. Common characteristic of the brewery by-products is that they contain increased or high crude protein concentrations: brewer's grains 28-30 %, brewer's yeast 50 %, brewer's spent grain with hot sludge 50-60%, press liquor 40% or protein sludge from press liquor 50-60% (calculated on dry matter basis). Attractive protein feed may be obtained by blending mentioned by-products [2, 16-19].

Brewery by-products are used in several ways worldwide: direct inclusion of brewer's spent grains and brewer's yeast in animal diets, with majority of other by-products being discharged in the watercourses; drying of brewer's spent grains and yeast and their inclusion as separate concentrates in animal diets, with liquor by-products being discharged as wastewater; blending of all by-products in the combined feed and their marketing, thus allowing utilization of all brewery by-products in the form of an attractive feed of increased nutritional value. In recent times, a lot of-research efforts have been focused on this last way of usage, which is gaining more and more supporters [2, 3, 4, 16-19].

The major limitation to the use of this combined by-product in poultry rations is its high fiber content (about 130 g/kg dry feed), resulting in lower digestibility of the rations for poultry. However, upon removing the lignocellulosic component by mechanical means, a dry by-product of higher nutritive value may be obtained. Several works were published and offer promising solutions to that end [20, 21, 22, 23]. As the continuation of this research work, the objective of the present study was to use previously defined technological procedure for the production of new feed from dried brewery by-products, with high protein and low fiber content, and to increase the nutritive value of the new feed in feeding formulations for laying hens.

Materials and methods

Preparation and characteristics of brewery by-products

Examined mixture from brewery by-products (calculated on dry matter basis) was of the following composition: brewer's spent grains 85%, sludge from press liquor 10% and brewer's yeast 5%. (Fig 1) Liquor fraction, obtained after pressing wet spent grains in industrial press, was fractionated in industrial decanter centrifuge; brewer's yeast was condensed in decanter centrifuge and subjected to thermolysis. Mixture prepared in this way was then homogenized and dehydrated in industrial rotary tube dryer with indirect heating.

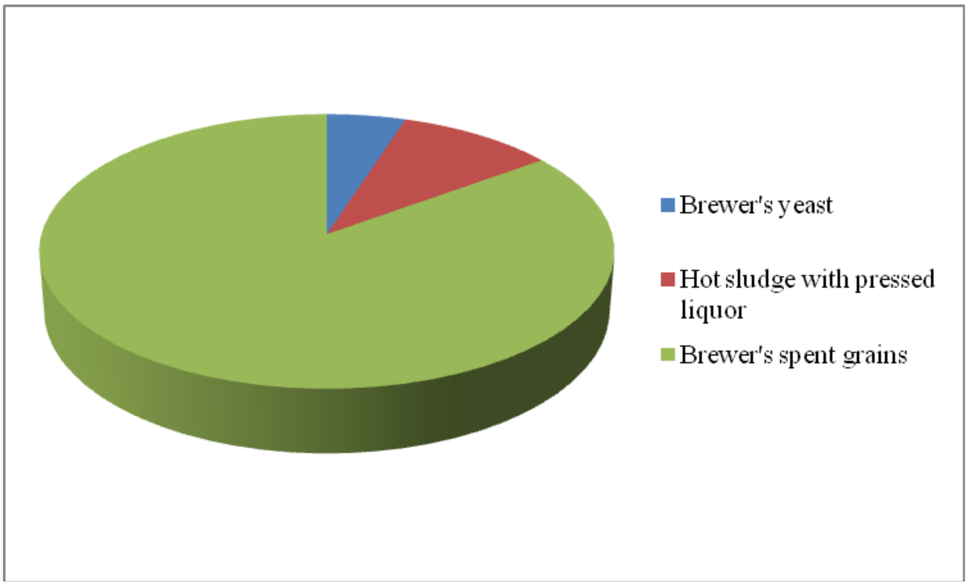

Figure 1. Composition of brewer's by-products

Characteristics of the applied technological process.

Sieving (fractionation) of dehydrated feed was performed in semi-industrial centrifugal separator based on the size and specific gravity of the particles. Characteristics of the used separator: centrifugal fixed sieve with a rotor for mass transport and dispersing; capacity from 400-500 kg/h depending on the sieve holes diameter; number of rotor revolutions 1435/min.; installed power 2.2 kW, sieve area 0.6 m^2; sieving area of 0.19 m^2

with sieve holes diameter of 1.5 mm. Three thousand kilograms of initial dehydrated feed was fractionated.

Applied analytical methods

Chemical composition: Macronutrient content was determined by AOAC method [24]. Amino acids were analyzed on amino acid analyzer – Biotronik model LC 5001. The samples were previously treated with 6 N HCl for 23 hours at 110°C; cystine and methionine were oxidized by performic acid for 15 hours at 2°C; tryptophane was determined by spectrophotometric method.

Statistics: Data from biological trials were processed by analysis of the variance (ANOVA) and the differences between groups were tested for significance, by STATISTICA 8.0 program [25].

Experimental setup

Ninety Isa-Brown layers, 22 week old, were divided into two treatment groups of 30 birds each and one control group with 30 hens. The birds were housed in cages. Feed and water were provided *ad libitum* and the feeding trial lasted 8 weeks.

Laying hens were fed with three diets: standard (control) diet K containing cereals and mineral- vitamin premix; and modified (trial) diets in which:

- 5.1% soybean meal + 5% corn was replaced by 10% non-conventional feed from brewery by-products + 0.10% L-lysine HCl (A1)
- 8.1% soybean meal + 2% corn was replaced by 10% non-conventional feed from brewery by-products + 0.10% L-lysine HCl. (A2)

Table 1. Composition of control and trial feed for layers

Components	Share of component in mash (%)		
	Control diet	**A1**	**A2**
Corn	66.5	61.5	64.5
Soybean meal	18.0	13.9	9.9
Brewery by-product decellulosed mixture	-	10.0	10.0
Fish meal	3.0	3.0	3.0
Dehydrated alfalfa meal	3.0	3.0	3.0
Dicalcium phosphate	1.5	1.5	1.5
Limestone	6.7	6.7	6.7
Iodized salt	0.3	0.3	0.3
Premix	1.0	1.0	1.0
L-lysine	-	0.1	0.1
Metabolizable energy, ME J/kg	11, 480	11, 939	11, 900

Metabolizable energy of the control and experimental diets were estimated based on the chemical composition and specific equations.

Results and discussion

Results of sieving (fractionation) of the combined mixture are shown in Table 2. The following fraction yield was obtained in the centrifugal separator: 40% passing material – decellulosed fraction with 390 g crude protein/kg dry matter and 60% flowing material – coarse fraction with 262 g crude protein/kg dry matter. In passing material 49.7% crude protein, 50.3% crude fat and only 29.9% crude fibre of initial feed were separated. Taking into account the obtained yield and the composition of decellulosed fraction, it can be concluded that significant amount of fine particles from protein sludge and yeast, and insignificant amount of spent grains cellulose particles went into passing material.

Table 2. Nutritive value of non-conventional feed

	Initial feed from dryer	**Passing material (Brewery by-product decellulosed mixture)**	**Flowing material**
Fraction yield (%)	100	40	60
Crude protein	314 g/kg	390 g/kg	262 g/kg
Total aminoacids	152 g/kg	190 g/kg	128 g/kg
Crude fat	81 g/kg	102 g/kg	65 g/kg
Crude fibre	143 g/kg	107 g/kg	167 g/kg
ME (metabolizable energy)	10,420 J/kg	12,000 J/kg	-

A similar decellulosed fraction, but of poorer quality (33-35% crude protein), obtained by mechanical separation of spent grains was previously reported by other authors [18, 19, 23]. Key issue related to the mechanical separation of brewer's spent grains is the low yield of decellulosed fraction. This observation is based on the experimental data showing that about 50.3% crude protein from the initial feed was distributed into the flowing material and that still high level of crude protein (262 g/kg dry matter) remained in coarse fraction. In the past, some authors, however, obtained high yield (52%) of decellulosed and defatted fraction of exceptional quality (60-66% crude protein in dry matter) by centrifugal filtration (wet procedure) [22, 26, 27].

Nevertheless, mechanical separation of spent grains is the promising solution for the following reasons:

- Equipment for mechanical separation is simple and cheap;
- Process of mechanical separation is cost-effective;

There are technical and technological possibilities for upgrading process of mechanical separation of the brewery spent grains.

Brewery by-product decellulosed mixture is a concentrated source of nutritive matters (Tables 1), containing: 390 g crude protein/kg dry matter, 190 g total essential amino acids/kg dry matter, 102 g crude fat/kg dry matter, 12,000 KJ metabolizable energy for poultry kg/dry matter. It is important to point out that decellulosed feed dry matter, compared to spent grains dry matter, contains higher amount of crude protein by 44% (390:270 g/kg) and lower amount of crude fibre by 54% (107:165 g/kg).

Dry matter from brewery by-product decellulosed mixture contains considerably higher levels of essential amino acids (Table 3) than dry matter from conventional spent grains. Bibliographic data show that lysine is the first limiting amino acid in brewery by-products [16, 17, 21, 28]. On the other hand, brewery by-product decellulosed mixture proteins compared to soybean meal proteins contain considerably higher levels of methionine, tyrosine and valine. According to the reported data it can be concluded that proteins from non-conventional feed and soybean meal are mutually complementary.

Table 3. Amino acid composition of brewery by-product decellulosed mixture produced from combined brewery by-products

Amino acids in dry mater	Brewery by-product decellulosed mixture (g/kg)	Conventional spent grain (g/kg)
Total aminoacids	190.2	120.6
Lysine	15.0	9.6
Methionine	7.8	5.0
Cystine	5.9	2.9
Threonine	14.9	9.6
Tryptophane	5.9	2.9
Arginine	18.0	11.0
Histidine	6.9	5.7
Isoleucine	23.5	11.7
Leucine	33.1	21.0
Phenylalanine	20.3	16.1
Tyrosine	17.0	9.6
Valine	21.6	16.1

Coarse fraction - flowing material with 26.2 % crude protein in dry matter is consisted of coarse particles of spent grains with protein sludge and yeast, and can be a good source of nutritive matters for ruminants.

The use of non-conventional protein feed in the nutrition of laying hens

Results of the use of combined brewery by-products (non-conventional feed) on the productive and reproductive performance of laying hens are given in Table 3.

Table 3. Results of productive and reproductive performance of layers

Egg quality parameters	K	A1	A2
Egg production	58.6^{a}	61.8^{b}	62.5^{b}
Egg weight	57.3^{a}	57.4^{a}	58.0^{a}
Haught units	73.4^{a}	76.6^{b}	77.0^{b}
Egg fertility	83.5^{a}	87.7^{b}	88.7^{b}
Egg hatchability	75.5^{a}	78.5^{ab}	80.2^{b}

^{a,b}Means in the same row with different superscripts are significantly ($p<0.05$) different

The birds fed in A1 and A2 group, showed significantly higher ($p<0.05$) egg production, but there was no significant differences among treatments in egg weight results. Replacement of soybean meal and corn gave good results in increasing of egg fertility and hatchability of fertilized eggs as well as increasing of Haught units ($p<0.05$).

These positive effects of combined brewery by-products on productive and reproductive performance of layers may be brought in the logical-causative connection with the following facts from the literature: proteins from the combined brewery by-products, when supplemented with the lysine, have similar amino acid pattern as the proteins from soybean meal [16, 17, 18]; combined brewery by-products have higher energy density for poultry than soybean meal; brewery by-products contain high amount of linoleic acid (40-50 g/kg), the essential nutrient for breeding flocks [2, 19, 28, 31, 32]; brewery by-products contain still unidentified matters that show beneficial effect on reproductive performance of breeding poultry [16, 20, 29, 30]. High content of linoleic acid is probably responsible for increasing fertility and hatchability of fertilized eggs.

Literature data and own research results with combined brewery by-products showed better overall effects on productive and reproductive performance of layers, comparing with soybean meal. Combined brewery by-products improved layers performance as follows: egg production by 5.5-8.4%, egg weight by 1.3-3.1 g/egg, egg quality (using a Haugh Unit gauge) by 4.4-11.8 units, egg fertility by 5.0-8.6%, hatchability of fertile eggs by 3.2-14%, while fatty liver syndrome was significantly reduced or completely prevented. In our trial, brewery by-product decellulosed mixture improved egg production by 8.4 %, and hatchability of fertile eggs by 6.3% .

A number of experiments proved that the combined supplement of spent grains and yeast improved productive and reproductive performances of breeding hens and turkeys: it increases egg production and egg mass, improves interior egg quality, increases percentage of fertilized eggs and also increases percentage of hatchability of fertilized eggs and prevents the syndrome of fat liver [20, 31, 32].

According to previous studies of some authors [31, 32], it is important to highlight that higher levels of inclusion of linoleic acid significantly influenced hatchability by modifying the fatty acid composition of fertile eggs.

Based on the above data it can be concluded that combined brewery by-products should be used for feeding of breeding layers.

Conclusion

Non-conventional protein feed (brewery by-product decellulosed mixture) was produced from brewery by-products (brewer's spent grain with hot sludge and protein sludge from press liquor plus brewer's yeast). Brewery by-product decellulosed mixture was produced by fractionation (sieving) of dried brewery by-products. The results obtained in this study indicate that the tested production procedure enables effective and economic production of new protein feed. Established process parameters make a good basis for designing mechanical – technological lines for industrial production of new feed in the breweries. Also, new protein feed made from brewery by-products has been shown to have better effect on productive and reproductive performance of laying hens compared to soybean meal. On the base of obtained results, brewery by-product decellulosed mixture is a good source of protein for laying hens.

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