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New feeds from brewery by-products

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Abstract

Technological procedure for fractionation of dehydrated feed from combined brewery by-products (brewer's spent grains + protein sludge from press liquor + brewer's yeast) was tested. The following fraction yields were obtained from the initially dehydrated feed: 40% decellulosed fraction – passing material, 60% coarse fraction – flowing material. Decellulosed fractions dry matter contain 390 g/kg crude protein, 190 g/kg total amino acids, 102 g/kg crude fat. Decellulosed fraction is of extremely fine granulation (950 g/kg particles below 0,5 mm), and has markedly higher bulk density than spent grains ground (385 : 210 kg/m^3). Supplement of 100 g new feed plus 1 g L'lysine HCl was successfully used instead of 81 g soybean meal plus 20 g corn ground in broiler feeding. It was concluded that new feed from brewery by-products, supplemented by the lacking amount of lysine was an ideal source of nutritive matters for broilers. This decellulosing procedure is very promising one with regard to the improvement of the nutritive and commercial value of brewery by-products.

Keywords: brewer's by-products, fractionation, passing material, flowing material, chemical composition, bulk density, nutritive value

Introduction

In the process of brewing and packaging beer, the generation of by-products and waste products is unavoidable. Technological advances and improved microbiological control over the past 25 years have enabled the brewer to reduce product losses and produce valuable by-products from materials that were previously considered waste products. The most common brewery by-products are brewer's spent grain, brewer's yeast, sludge and spent hops. All of these products contain more then 20% protein (brewer's spent grains 28-30%, brewer's yeast 40-45% and protein sludge from press liquor 50-60%) and are generally sold as protein supplements for animal feeds. This very attractive spectrum of by-products attracts the attention of technologists [2, 4, 5, 11, 12, 13, 15, 16, 17, 20, 21, 24] and nutritionists [3, 7, 8, 10, 14, 25] who investigate the technological and nutritive aspects of combined by-products. The above authors reported the positive results on production technology and nutritive value of combined brewery by-products.

Brewer's spent grains, which comprises about 85% of the total amount of brewery by-products, reduces the nutritive value of combined by-products, as it contains, according to some authors [4, 9, 14, 18] enormously high amount of ballast matters: 150-170 g/kg crude fiber and over 80 g/kg incrusting lignin. Stiles end Hebert [30] found out that brewer's spent grains contained about 67% protein, lipid and extractive component and about 33% ligno-cellulosic matters. These authors found out that ligno-cellulosic component rendered an independent part in spent grains that could be successfully separated by the effective decellulosing procedure. The following decellulosing procedures are of interest: centrifugal filtration – wet procedure [30] and mechanical separation – dry procedure [4, 5, 12]. A number of procedures for production of protein concentrates for human and animal feeding were patented from the domain of spent grains mechanical separation [22]. Lopez et al. [18] found that the biological value of spent grains protein from decellulosed fraction – passing material – was markedly higher than that from coarse fraction – flowing material (69,6 : 32,3). This drastic difference could be correlated to experimental findings of some other authors [5, 26, 28] who found out that 18-20 % of spent grains crude protein was strongly bound to its ligno-cellulosic complex, and it is well known that such proteins are only partially digestible in the monograstic digestive tracts of animals.

This experiment is the continuation of our former investigations [4, 5, 16] and the aim is to determine the technological and nutritive effects of mechanical separation of dehydrated feed from combined brewery by-products.

Materials and methods

Characteristics of combined brewery by-products

Combined feed was made on the base of real quantity ratio of by-products in brewery **(Table 1)**. Wet spent grains from strainer was pressed in industrial press, spent grain press liquor was fractionated in industrial decanter-centrifuge and brewer's yeast was condensed and termolysed. The mixture prepared in this way was homogenized and dehydrated in industrial rotary drier with indirect heating.

Table 1. Composition of new feed produced of combined brewery by-products

BY PRODUCTS	DRY MATER CONTENT (%)	SHARE OF BY-PRODUCTS (%)	
		On wet basis	In dry mater
Pressed spent grains	30,5	82,0	85,0
Sludge from decanter	26,0	11,0	10,0
Brewer's yeast	22,0	7,0	5,0

Characteristics of the technological procedure for decellulosing

Decellulosing (fractionation) of initial dehydrated feed was carried out in a semi-industrial centrifugal separator. Mechanical separation was performed on the basis of particle size and particle specific gravity. The separator characteristics: centrifugal fixed sieve with rotor for mass transport and dispersing; capacity of 400-500 kg/h depending on sieve holes diameter; number of rotor revolutions of 1435 min^{-1} ; installed energy 2,2 kW; sieve area of 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.

Characteristics of broiler diets

The composition of the basal (complete) diet is as follows: 63,5% corn ground, 25,0% soybean meal, 6,0% fish meal, 2,0% feed grade fat, 3,5% mineral-vitamin premix; the composition of the trial diets as follows: 61,5% corn ground, 6,9% soybean meal, 10,0% decellulosed feed from brewery, 6,0% fish meal, 2,0% feed grade fat, 3,5% mineral-vitamin premix, 0,10% L'lysine HCl. Both diets were isoproteinaceous and isoleucine. Therefore, the following substitutions were done in the trial diet: 81 g soybean meal plus 20 g corn ground was substituted with 100 g brewery dehydrated feed plus 1g L'lysine HCl. Two hundred broilers of Hybro provenience were included in the trial and they were kept in pens on floor.

Analytical methods

Chemical composition (moisture, crude protein, crude fat, crude fiber and ash) was determined by AOAC methods [1] and physical properties by DIN 1060, 51057, 4193 [6]. Amino acids were analyzed on BIOTRONIK-type LC 5001 amino analyzer; the samples were previously hydrolyzed with 6N HCl for 23 h at 110^{0}C [19] ; cystine and methionine were oxidized by performic acid [19, 27] at 20^{0}C for 15 h. Tryptophane was determined spectrophotometrically.

Statistical methods: Data for body weight, daily weight gain, feed conversion ratio were statistically processed by analysis of the variance and the differences between groups were tested for significance.

Results and discussion

Decellulosing (fractionation) of brewery by-products

The following fraction yields were 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. Passing material which we named "new feed" is the main result of decellulosing (fractionation) of combined brewery by-products and it contain 49,7% crude protein, 50,3% crude fat and only 29,9% crude fiber (**Table 2**).

Table 2. Decellulosing (fractionation) results for dehydrated feeds of combined brewery by-products

Items	Initial feed from dryer	Sieve holes diameter ∅1,5 mm	
		Passing material	Flowing material
Fractions yield (%)	100,0	40,0	60,0
Dry matter composition (%)			
Crude protein	31,4	39,0	26,2
Crude fat	8,1	10,2	6,5
Crude fiber	14,3	10,7	16,7

On the basis of the yield obtained and the new feed composition it was concluded that a considerable amount of fine particles from protein sludge and yeast and smaller amount of decellulosed particles from spent grains got into the passing material. Ishiwaki [12] and Delic [4, 5] have shown that the similar yield but poorer quality of decellulosed fraction (33-35% crude protein) was obtained by means of the mechanical separation of spent grains.

Therefore, the main problem of spent grains mechanical separation is low yield of new feed. This observation is based on experimental data showing that 50,3% crude protein from initial feed was distributed into flowing material and that still high level of crude protein remained in coarse fraction (262 g/kg dry matter).

Mechanical separation of spent grains, however, is perspective for the following reasons: (1) the equipment for mechanical separation is simple and cheap; (2) mechanical separation is very economic, it requires minimum energy consumption; (3) there are technical and technological possibilities for improving the mechanical separation of brewery spent grains. Stiles and Hebert [30], 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).

New feed characteristics

New feed is a concentrated source of nutritive matters (**Tables 2 and 3**). It contains 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 J metabolizable energy for poultry/kg dry matter. It is important to point out that new feed dry matter, compared to pressed spent grains dry matter, contains an amount of crude protein higher by 44% (390:270 g/kg) and an amount of crude fiber lower by 54% (107:165 g/kg).

New feed dry matter contains considerably higher levels of essential amino acids (**Table 3**) than conventional spent grains dry matter: total amino acids (190,2:120,6 g/kg), lysine (15,0:9,6 g/kg), methionine (7,8:5,0 g/kg), cystine (5,9:3,2 g/kg), threonine (14,9:9,6 g/kg), tryptophane (5,9:2,9 g/kg), arginine (18,0:11,0 g/kg), histidine (6,9:5,7 g/kg), isoleucine (23,5:11,8 g/kg), leucine (33,1:21,0 g/kg), phenylalanine (20,3:16,1 g/kg), tyrosine (17,0:9,6 g/kg), valine (21,9:16,1 g/kg).

Table 3. Amino acid composition of new feed produced of combined brewery by-products

Amino acids in dry mater	In new feed (%)	In crude protein (%)
Lysine	1,50	3,80
Methionine	0,78	2,05
Cystine	0,59	1,50
Threonine	1,49	1,48
Tryptophane	0,59	1,48
Arginine	1,80	4,60
Histidine	0,69	1,76
Isoleucine	2,35	5,94
Leucine	3,31	8,37
Phenylalanine	2,03	5,10
Tyrosine	1,70	4,30
Valine	2,19	5,54
Glycine	1,39	-
Serine	1,55	-
Aspartic acid	1,92	-
Gltamic acid	6,60	-
Proline	2,57	-
Alanine	1,82	-

New feed proteins, however, in comparison to soybean meal proteins contain lower levels of lysine (36,0:62,0 g/kg), arginine (46,0:78,0 g/kg) and histidine (17,6:26,0 g/kg).

On the basis of the data reported, it can be concluded that lysine is the first limiting amino acid in brewery by-products as has been already shown by many other workers [10, 12, 18, 29]. Arginine could potentially be the second limiting amino acid under the condition that 6,5% crude protein from soybean meal is substituted with the same level of crude protein from new feed in poultry diet. On the other hand, new feed proteins compared to soybean meal proteins contain considerably higher levels of methionine (20,5:15,0 g/kg), tyrosine (43,0:32,5 g/kg) and valine (55,0:47,0 g/kg). Consequently to the data reported it can be concluded that proteins from new feed and soybean meal are mutually complementary.

New feed has considerably higher bulk density **(Table 4)** than initial feed from dryer (385:275 kg/m^3), but this bulk density is relatively low in relation to other conventional feeds for animal feeding. The new feed has exceptionally fine granulation (95% particles below 0,5mm), that causes the forming of dust and consequently marked losses of fine particles at handling and mash preparing in feed mills. Both physical disadvantages of new feed, however, could be successfully overcome by pelleting.

Table 4. Physical characteristics of new feed combined of brewery by-products

Characteristics	Initial feed from dryer	New feed
Bulk density (g/cm^3)	275	385
Specific gravity (g/cm^3)	1095	1170
Module of particle fineness	4,4	2,4
Module of particle uniformity	1:7:2	0:6:4
Particle size (%)		
2,0 – 3,0 mm	15,0	-
1,0 – 2,0 mm	37,0	-
0,5 – 1,0 mm	10,0	5,0
0,25-0,5 mm	28,0	87,0
below 0,25 mm	10,0	8,0

New feed nutritive value in broiler feeding

Experimental data obtained indicate that a supplement of 100g of new feed plus 1 g L'lysine HCl successfully substituted 81g soybean meal plus 20g corn ground in basal diet for broilers indicating that the new feed has high nutritive value. Moreover, this non-conventional feed supplemented with lacking level of lysine showed somewhat better biological effect than soybean meal: broilers weight gain was higher by 3,6% and feed conversion ratio was better by 4,6% (**Table 5**). The data obtained in trial with broilers are in complete agreement with findings published by other researchers [11, 17, 23]. Namely, the following data were demonstrated: (1) new feed have better nutritive value than conventional spent grains especially in poultry feeding; (2) properly dosed lysine supplement markedly increase the nutritive value of new feed.

Table 5. Nutritive value of new feed of combined brewery by-products in broiler feeding

Performances	Basal diet	Trial diet
Number of broilers in group	100	100
Days of trial feeding	40	40
Initial body weight of bird (g)	39,8	39,6
Final weight gain of bird (g)	1 490[a]	1 545[b]
Daily weight gain (g)	36,6[a]	37,6[b]
Feed conversion ratio (kg/kg)	1,96[a]	1,87[b]

[a,b] means within the same row followed by different letters are significantly different ($p<0.05$)

Incorporation of brewery by-products into poultry diets

It is estimated that decellulosed feed should be directed to poultry feeding, primarily for breeding flocks. This estimation is based on the following data: (1) Combined brewery proteins, when supplemented with lacking amount of lysine, have similar amino acid patterns to soybean meal proteins [2, 4, 5, 10, 11, 14]; (2) Individual and combined as well as specially decellulosed brewery by-products have considerably higher energy density for poultry than soybean meal [4, 5, 10, 18]; (3) Decellulosed brewery by-products contain an exceptionally high amount of linoleic acid (40-50 g/kg), the essential component for commercial and breeding flocks [4, 5, 10, 11]; (4) Combined brewery by-products contain still unidentified biogenic matters that show beneficial effect on reproductive performances of breeding poultry [4, 5, 10, 11]; (5) A great number of experiments proved [2, 3, 4, 5, 7, 8, 11, 14] 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.

Coarse fraction characteristics

Flowing material with 26,2% crude protein in dry matter has similar composition to conventional spent grains. This feed consists of coarser particles of spent grains with admixtures of protein sludge and yeast. Coarse fraction of spent grains is a good source of nutritive matters for ruminants [3, 10, 11, 17, 25, 31].

Conclusion

The new feed was produced from combined dry brewery by-products (brewer's spent grain with hot sludge and protein sludge from press liquor plus brewer's yeast) by means of fractionation (sieving). The production procedure tested enables effective and rational production.

The new feed (calculated on dry matter) contains: 39% crude protein, 10,2% crude fat and 10,7% crude fiber. Proteins in this new feed, compared to soybean proteins, contain lower concentrations of lysine and arginine and higher concentrations of methionine, tyrosine and valine. Pursuant with the data reported it can be concluded that proteins from new feed and soybean meal are mutually complementary.

New feed compared to soybean meal, has better influence on broiler production: body weight gain was higher by 3,6% and feed conversion ratio was better by 4,6%. Based on these data it can be concluded that new feed of brewery by-products should be directed primarily to poultry feeding.

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