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The Effect of Extruding on the Quality of the Enriched Corn Meal

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Abstract

The chemico-nutritive and microbiological characteristics of enriched corn meal which has been produced by dry milling and corn de-germinating procedure and extruded enriched corn meal have been shown in this work.

The presented results show that extruding procedure increased the nutritive value of enriched corn meal in comparison with non-treated meal, especially starch content, as well as the microbiology improvement of extrudate.

Keywords: enriched corn meal, extruding

Introduction

Enriched corn meal represents a by-product of the miller's processing of corn, which contains parts of endosperm, shell and germ. This feed till now was not enough used by the feed industry in our country, and because of that, from one side, it is necessary to favour its use by obtaining the insight into its nutritional value, and from the other side, having in mind the even more growing thermal processing in the domain of animal feed production, it could be expected that the extrusion of the enriched corn meal results in increasing of its nutritive value, what is a prerequisite for its better valorization.

Thermal treatment of cereals is used for the improvement of their nutritive, hygienic, physico-chemical and other characteristics. It improves the nutritive value of some nutrients, enhances sensory characteristics (for example, increases of "sweetness" in corn treatment), ensures the microbiological correctness of the product and lowers the concentrations of the present thermolabile anti-nutrients (for example, phytic acid in processing of corn).

Extrusion process is accompanied by the changes of the carbohydrate complex of corn meal, namely by the reduction of the molecular weight of starch effected by the degradation of starch into dextrins [1]. These changes provoke increasing of *in vitro* and *in vivo* digestibility of starch with respect of the fact that the starch gelation generates the increased accessibility of starch-degrading enzymes, and simultaneously leads to inactivation of inhibitors of the α-amylase [2, 3].

The extruding of corn meal is accompanied with the diminishing of the reducing sugars content, probably due to the Maillard reaction, one of the undesirable reactions in food chemistry, which consider interaction between sugars and proteins, primarily with the amino acid residues of lysine [4]. As the retention time during extrusion process is very short (less

than 30 s) the degree of preservation of the valuable cereal components is relatively high [5]. At the same time, thermal treatment assures increased oil digestibility of extrudates, although it is followed by the increased susceptibility to the lipid oxidation due to the increase of surface contact with air [6].

Thermal treatment is also used for the improvement of the microbiology of extrudate with respect to the untreated material, as follows from the papers of Kelley and Walker [7, 8] who indicated impressive reduction of bacteria counts, but not to the consistent sterilization of feeds by application of dry extrusion.

This work presents only the preliminary results indicating nutritive value of the enriched corn meal which has been produced by classical dry milling and corn de-germinating procedure according to Bühler technology and extruded enriched corn meal – new feeds that could be more often used in feed production concerning their chemico-nutritive characteristic.

Materials and methods

The enriched corn meal from the mill "Tisa" – "Mirotin", Vrbas, with the moisture content of max 14%, was used for dry extrusion. This meal was moistened up to 20%, and thereafter extruded. The dry extruding procedure was performed with a "Metal-Matic", model 11-1000 extruder (Beočin). The capacity of this extruder was 1000 kg/h of the extruded feed. The installed electro motor power for the extruder was 75 kW, and that of the dosing screw – 1.5 kW. The extrusion was performed at the temperature of 105 °C.

The basic chemical composition (moisture, crude proteins, crude fiber, crude fat and mineral matters) of the enriched corn meal and extruded enriched corn meal were determined according to the official A.O.A.C. methods [9].

Starch content, as well as reducing sugars content, were analyzed according to valid Yugoslav rule book for control of quality of wheat, milling and bakery products, pastry and flash-frozen pastry [10], and calcium, phosphorus, iron, copper, sodium contents and bulk density were determined according to the Rule book of methods of sampling and of methods for performing physical, chemical and microbiological analyses of feeds [11].

The determination of the total tocopherols was performed using the method of BASF, which is presented in "Estimation of Vitamins and Carotenoids in Premixes and Feed", under the number MAE/EC 1 [12].

Microbiological investigations included analyses as follows: determination of total number of aerobic mesophilic bacteria, total number of moulds, total number of sulphite-reducing clostridia, presence of *Salmonella* spp., coagulase-positive staphylococci, *Escherichia coli* and *Proteus* spp. All of analyses were carried out according to the Rule book of methods of sampling and of methods for performing physical, chemical and microbiological analyses of feeds [11].

Results and discussion

Chemico-nutritive profile of the enriched corn meal and extruded enriched corn meal is presented in **Table 1**.

Enriched corn meal produced according to the Bühler technology represents a new feed in our country, which is characterized with increased protein and fat levels if it is compared with the corn meal that was produced according to the classical procedure. The increase of the crude proteins content if compared with the corn grain reaches up to 25%. Further essential merit of this feed is increased energetic value determined by its increased

fats content (**Table 1**) owing to the mixing of corn meal and germs. Corn, being the basic energetic component in feed industry and the most frequently used cereal for composing of feed mixtures [13] has an energetic value of 16.2 MJ/kg, and the enriched corn meal has the energetic value of 17.8 MJ/kg.

Table 1. Chemical composition of the enriched corn meal and extruded enriched corn meal

Quality parameter	Enriched corn meal	Extruded enriched corn meal
Moisture (%)	11.85	8.44
Crude proteins (%)	10.79	10.68
Crude fibre (%)	3.60	3.55
Crude fats (%)	7.34	6.64
Mineral matters (%)	2.13	2.00
Starch (%)	51.44	48.68
Total sugars (%)	3.03	6.45
Reducing sugars (%)	2.09	0.90
Calcium (%)	0.17	0.18
Phosphorus (%)	0.48	0.41
Sodium (%)	0.10	0.10
Iron (mg/kg)	60.12	64.36
Copper (mg/kg)	1.24	1.28
Total tocopherols (mg/kg)	103.20	90.43
Bulk density (g/dm^3)	526.11	359.08

Tocopherols also contribute to the nutritive value of the enriched corn meal (**Table 1**), first of all α-tocopherol, as the main constituent of the lipid-soluble vitamin E, but at the same time, the extremely potent antioxidant [14].

Extrusion process considerably lowers moisture content of the moistened enriched corn meal (from about 20% to about 10%) so the extrudate is convenient with respect to its keeping properties, i.e., to its storage (**Table 1**).

According to the literature data that point out to the physico-chemical changes of carbohydrate fraction of corn after the thermal treatment [1] starch content is a little bit lower after the extrusion process if compared with the starch content of the enriched corn meal, that indicates the partial degradation of starch components amylose and amylopectin. Parallel to that, reducing sugars content of the extruded product is also lower than in the enriched corn meal, probably due to the interactions between sugars and proteins, i.e. because of the Maillard reaction.

HT/ST (high temperature – short time) principle of the extrusion cooking explains relative stability of total tocopherols during the extrusion process (**Table 1**) what enables, at least when this antioxidant is considered, greater anti-oxidative potency of the extrudate, and, therefore, the better storage properties connected with the lipid oxidation with respect to the lipid oxidation.

In addition, extruded enriched corn meal is characterized by the diminished bulk density (359.08 g/dm^3 – **Table 1**). Decreasing of the bulk density after the extrusion process or some other thermal treatment has been found by Bekrić [13] and Gjural and co-workers [15], and this is very important during the storage and transportation, as well as for the production of feeds with special requirements (for example, feeds for trouts, pets, etc.).

Granulometric composition of the extruded enriched corn meal (**Table 2**) points out to the milling procedure as a necessary step before the final using of extrudate, especially if it is for feeds production or as the carrier for premix production.

Table 2. Grain size distribution of the enriched corn meal and extruded enriched corn meal

Sieve mash (∅, mm)	Sieve residue (%)	
	Enriched corn meal	Extruded enriched corn meal
4.0	0.00	0.30
2.0	0.50	3.00
1.25	5.00	9.00
1.0	11.85	7.85
0.63	23.85	34.30
0.25	25.75	36.45
0.125	27.55	8.20
0.063	5.00	0.90
Bottom	0.50	0.00

Having in mind the existing data about reduction of microbial contamination after the usage of some thermal treatment [16, 17], as well as after the extrusion [8], give the evidence about the possibility of hygienization, insight into the **Table 3** can serve as a proof of this earlier observed phenomenon.

Table 3. Microbiology of enriched corn meal and extruded enriched corn meal

Quality parameter	Enriched corn meal	Extruded enriched corn meal
Total count of aerobic mesophilic bacteria per 1 g	4.500.000	140.000
Total count of moulds per 1 g	90.000	800
Salmonella spp.	-	-
Coagulase-positive staphylococci	-	-
Escherichia coli	-	-
Proteus spp.	-	-
Sulphite-reducing clostridia	500	400

Conclusion

Enriched corn meal and extruded enriched corn meal are new highly valuable protein energetic feeds in the feed industry.

The extruded enriched corn meal is a feed which has increased nutritive value and improved microbiology if it is compared with a non-thermally processed meal, and it can be recommended for young animals feeding and for production of fish feeds.

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