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Method for obtaining gluten-free high protein animal feeds

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Abstract. *The purpose of the study is to select suitable flour according to its mineral composition to obtain gluten-free high protein animal feed. The research found that whole grain rice flour, millet, chickpea, corn, chalk and primex additive are suitable for gluten-free feed and have good technological parameters. The animal feed is with high protein and fats. They are with low carbohydrates composition and used for dogs and birds. The new products are without GMO, artificial colors and flavors. They are with Fe, Zn, Ca.*

Keywords: rice flour, gluten-free, high protein, animal feed, millet, chickpea, corn, chalk, primex

Introduction

Recently, the demand for gluten-free products has increased due to heightened awareness of gluten intolerance in animals. (Andon and Anderson, 2008). Animals with gluten intolerance need gluten-free feeds. In order to produce such feeds, it is necessary to study the gluten-free flours and to put them in the appropriate proportions (Borisova, 2015).

Celiac disease, an autoimmune disorder of the small intestine, results in malabsorption of key nutrients, leading to deficiencies in iron, folic acid, calcium, and fat-soluble vitamins (Borisova, 2016). Key symptoms associated with this disease include anemia, mouth ulcers, diarrhea, constipation, abdominal pain, bloating, fatigue, osteoporosis, infertility, cancer, anxiety, and depression. (Koinov and Radkov, 1981). Research indicates that celiac disease affects about 1% of the global population (Mc Afee et al., 2010).Throughout their lives, patients with this disease have an intolerance to the prolamine fraction of wheat (gliadins), rye (chakras) and barley (chordines) (Genadiev et al.,1968; FAO/WHO,1991; Stabler and Allen, 2004; Lim et al., 2009; Toldrá and Reig, 2011). Celiac disease has become a global concern with its prevalence increasing due to enhanced diagnostic procedures (Vangelov, 1999; Torbica et al., 2010). Omega-6 fatty acids have a high value due to the high content of linoleic acid in cereals at the expense of shorter and medium-chain fatty acids that are missing (Kozmina, 1971; Ordinance №8, 2002; REG.EU, 2006). Granulation facilitates transport and the storage of feed mixtures, support taste qualities and increase digestability (Koleva, 2012).

The purpose of the study is to select suitable flour according to its mineral composition to obtain gluten-free high protein animal feed. The research found that whole grain rice flour, millet, chickpea, corn, chalk and Primex additive are suitable for gluten-free feed and have good technological parameters.

The animal feed is high in protein and fats. They are with low carbohydrates composition. The new products are without GMO, artificial colors and flavors. They are with Fe, Zn, Ca. This product is used for dogs and birds.

The feeds can contain from 50 ÷ 55% dry fodder of animal origin (meat and fish flour), from 30 ÷ 35% grain raw materials (wheat, corn, oats and barley). Especially the influence on the quality of biscuits and their digestibility shows the bulk and the homogeneity of the bulk compound feed. The author recommends shredding the components

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to be carried out in a hammer crusher with sieve openings Ø=1.5 ÷ 2.0 mm. Another main factor influencing the quality of biscuits is the consistency of the dough. The quality of feeds depends mostly on moisture, temperature, duration of mixing and presence of chemical raising agents (Peiretti and Maineri, 2011). Granulation facilitates transport and the storage of feed mixtures, improves taste qualities and increases digestibility. A number of other authors point out the needs of dependent dog nutrients according to their age and physiological condition (Laguerre et al., 2007; Kotsev, 2012). The values are close to those mentioned above (Koleva, 2012). Digestibility of protein and fat is greater in the old than in the young dogs.

Material and methods

Analytical methods used
Organoleptic assessment
The following standards are applied:

- BDS Bulgarian state standard 15612-83, Organoleptic evaluation of the raw materials - appearance, color, taste, aroma.
- The feeds developed were organoleptically evaluated on the 9th Bald Hedonic Scale.
- BDS Bulgarian state standard 1671-89, Determination of total protein content- Kendal's method.
- BDS Bulgarian state standard 1671-89, Determination of total fat content- Soxtec device.
- BDS ISO 2171: 1999, Determination of total ash content.
- BDS ISO 5498: 1999, Determination of total fiber content.
- Macro- and trace elements are determined on an atomic emission photometer - AES-ICP "Varian-Liberty II".

Preparation of feed

In dry feeding methods, feed preparation mainly involves grinding cereals. The hard shell of the grain is broken down during this process, making the nutrients more readily available for digestion. Grinding usually comes in three degrees: coarse (with continuous particle sizes of 1.8-2.6 mm), medium (particle sizes of 1.0-1.7 mm), and fine (particle sizes of 0.2-0.9 mm). A medium grind is generally recommended for dogs because finely ground feed tends to be dusty and much of it gets wasted. Additionally, finely ground feed moves quickly through a dog's digestive tract, resulting in less efficient nutrient absorption.

The goal of feed preparation is to enhance its biological value, improve taste and dietary properties, and increase the content of proteins, B-vitamins, enzymes, and organic acids. Protein-rich cereals are used in appropriate proportions. The feeds are fermented in a warm room with temperature ranging from 24-27°C. Research has shown that high-quality, gluten-free animal feeds with good technological parameters can be obtained using whole grain rice flour, millet, chickpeas, corn, chalk, and primex.

For 1 kg of flour or a flour mixture, 15-20 g of fresh baker's yeast should be diluted in 1.5-2 liters of warm water (35-40°C). This yeast mixture should then be thoroughly combined with the flour. The fermentation process takes approximately 6 hours. For successful fermentation, it is essential to stir the mixture every 1-2 hours as the yeast cells multiply in the presence of air. The fermented feed is then mixed with a dry flour mixture at a ratio of 1:5 to achieve a crumbly wet slurry.

Wet and compound feeding methods require a significant amount of labor and time for feed preparation. However, these methods allow the utilization of cheap, widely available local feeds. The continuous particle size for this type of feed should be between 1.8-2.6 mm. As mentioned earlier, research has shown that gluten-free animal feeds with good technological parameters can be obtained from a variety of grains and other ingredients.

Results and discussions

The experiment was conducted in a laboratory at the Institute of Mountain Animal Husbandry and Agriculture in Troyan city in 2022 year. Mixes of whole grain rice flour, millet, chickpea, corn, chalk and primex were used. The mixes are three options. These flours should be tempered at room temperature and stored in a dry, cool place. From all the raw materials, the right quantities should be dispensed according to the gluten-free, high-protein animal feed formula. Mix the dough by the single-phase method. According to Koleva (2012) the digestibility of protein and fat is greater in old than in young dogs.

Table 1 shows physicochemical analysis on the flours. In terms of moisture, protein and carbohydrates, whole grain rice flour has the highest content (10.50%; 16.12%; 44.94%), and chickpea flour has the lowest content (0.75%; 4.40%; 14.80%), respectively. In terms of fats corn flour has the highest content (51.40%), and chickpea flour has the lowest content, respectively (1.20%). The walnut flour is rich in fats and proteins. The whole grain rice flour is rich in proteins. The high-protein, gluten-free

flours are appropriate for animal feed. According to Toldrá and Reig (2011), whole grain rice flour is rich in proteins. Chickpea flour is also protein-rich. This plant species prefers well-cultivated soils. According to research by Koinov and Radkov (1981), "white technology" increases the compactness of the surface soil layer due to the chemical composition and technological qualities of both disturbed and promising chickpea varieties.

Table 1. Physicochemical analysis on the flours (%)(n=10)

Type of analysis	Whole grain rice flour	Corn flour	Chickpea flour
Moisture % (x±sx)	10.50±0.02	11.25±0.01	0.75±0.02
Protein % (x±sx)	16.12±0.01	13.05±0.02	4.40±0.02
Acidity ◦H (x±sx)	3.12±0.01	1.70±0.01	2.80±0.01
Fat % (x±sx)	4.04±0.01	51.40±0.02	1.20±0.02
Carbohydrates % (x±sx)	44.94±0.02	24.96±0.02	14.80±0.02
Ash % (x±sx)	1.12±0.01	0.80±0.01	1.00±0.01
Fiber % (x±sx)	13.12±0.01	10.12±0.01	3.42±0.01
Energy value кcal/ 100 g product	219	214	214

p<0.005

In terms of Ca, whole grain rice flour has the highest content, and chickpea flour has the lowest content, respectively. In terms of K, walnut rice flour has the highest content, and chickpea flour has the lowest content, respectively. In terms of Mg, whole grain rice flour has the highest content, and chickpea flour has the lowest content, respectively. In terms of Na, whole grain rice flour has the highest content, and chickpea flour has the lowest content, respectively (Table 2).

According to Toldrá and Reig (2011), the whole grain rice flour is rich in Na, Ca and K.

Table 2. Microelements in the flours (mg/kg)(n=10)

Microelements	Whole grain rice flour	Corn flour	Chickpea flour
Ca mg/kg (x±sx)	2310.50±0.02	511.25±0.01	76.75±0.02
K mg/kg (x±sx)	2916.12±0.01	513.05±0.02	84.40±0.02
Mg mg/kg (x±sx)	1934.04±0.01	651.40±0.02	91.20±0.02
Na mg/kg (x±sx)	1144.94±0.02	724.96±0.02	74.80±0.02

p<0.005

In terms of Fe, corn flour has the highest content, and chickpea flour has the lowest content, respectively. In terms of Mn, walnut rice flour has the highest content, and chickpea flour has the lowest content, respectively. In terms of Zn, whole grain rice flour has the highest content, and corn flour has the lowest content, respectively (Table 3). The results are presented in tables.

According to Toldrá and Reig (2011), whole grain rice flour is rich in zinc (Zn), iron (Fe), and manganese (Mn). Promising varieties of chickpeas are also rich in iron (Fe) and manganese (Mn), as noted by Koinov and Radkov (1981).

Table 3. Trace elements in the flours (mg/kg)(n=10)

Trace elements	Whole grain rice flour	Corn flour	Chickpea flour
Fe mg/kg (x±sx)	5670.50±0.02	6542.51±0.01	567.50±0.02
Mn mg/kg (x±sx)	456.81±0.01	654.99±0.02	346.40±0.02
Zn mg/kg (x±sx)	768.04±0.01	467.90±0.02	456.20±0.02

p<0.005

Table 4 shows physicochemical analysis of the feed. In terms of moisture, protein and carbohydrates mix 1 has the highest content (11.50%; 16.12%; 44.94%), and mix 3 has the lowest content (1.25%; 4.40%; 14.80%), respectively. In terms of fiber, mix 1 has the highest content (16.94%), and mix 3 has the lowest content (10.94%), respectively. The composition of feeds characterized by the use of whole-grain high-protein flours as an additive to rice. This achieves high energy value from protein content, compensating for the carbohydrate component.

Peiretti and Meineri (2011) reported high fiber content in chickpeas.

Table 4. Physicochemical analysis of the feed (%)(n=10)

Type of analysis	Feed mix 1	Feed mix 2	Feed mix 3
Moisture % (x±sx)	11.50±0.02	12.25±0.01	1.25±0.02
Protein % (x±sx)	16.12±0.01	13.05±0.02	4.40±0.02
Acidity ◦H (x±sx)	3.12±0.01	1.70±0.01	2.80±0.01
Fat % (x±sx)	4.04±0.01	51.40±0.02	1.20±0.02
Carbohydrates % (x±sx)	44.94±0.02	24.96±0.02	14.80±0.02
Ash % (x±sx)	1.94±0.02	1.24±0.02	1.54±0.02
Fiber % (x±sx)	16.94±0.02	13.94±0.02	10.94±0.02
Energy value кcal/ 100 g product	219	214	200

p<0.005

Table 5 shows microelements in the feed. Regarding Na, mix 1 has the highest content, and mix 2 has the lowest content. The composition of feeds is characterized by the use of whole-grain high-protein flours as an additive to rice. This achieves high energy value from protein content, compensating for the carbohydrate component. The quality of feeds largely depends on factors such as moisture, temperature, duration of mixing, and the presence of chemical raising agents (Peiretti and Maineri, 2011). Granulation simplifies the transportation and storage of feed mixtures, improves taste, and enhances digestibility. Several other authors, including Kotsev (2012), emphasize the need to adjust the nutrients and energy value in dog food based on the animal‘s age and physiological condition.

Table 5. Microelements in the feeds (mg/kg)(n=10)

Microelements	Feed mix 1	Feed mix 2	Feed mix 3
Ca mg/kg (x±sx)	641.50±0.02	631.25±0.01	101.75±0.02
K mg/kg (x±sx)	3016.12±0.01	1673.05±0.02	1184.40±0.02
Mg mg/kg (x±sx)	2134.04±0.01	1181.40±0.02	1131.20±0.02
Na mg/kg (x±sx)	1234.94±0.02	934.96±0.02	967.80±0.02

p<0.005

In terms of Fe, mix 2 has the highest content, and mix 3 has the lowest content, respectively. In terms of Mn, mix 2 has the highest content, and mix 3, has the lowest content, respectively. In terms of Zn, mix 1 has the highest content, and mix 3 has the lowest content, respectively (Table 6).

Peiretti and Meineri (2011) reported high trace-elements content in the feeds with chickpeas, rice and corn. these cereals are rich in Zn and Fe.

Table 6. Trace elements in the feeds (mg/kg)(n=10)

Trace elements	Feed mix 1	Feed mix 2	Feed mix 3
Fe mg/kg (x±sx)	5670.50±0.02	6542.51±0.01	567.50±0.02
Mn mg/kg (x±sx)	456.81±0.01	654.99±0.02	346.40±0.02
Zn mg/kg (x±sx)	768.04±0.01	467.90±0.02	456.20±0.02

p<0.005

Conclusion

Feeds from rice, corn, and chickpea flours are high in protein and gluten-free. The feeds are high in protein and fats. They are with low carbohydrate composition and are used for dogs and birds. The new products are without GMO, artificial colors and flavors. They are with Fe, Zn, Ca. Composition of animal feeds is characterized by the fact that whole-grain high-protein flours are used as an additive to rice to achieve high energy value based on protein content, at the expense of the carbohydrate component.

Conflict of interest declaration

The authors declare that there is no established conflict of interest in the absence of commercial and financial relationships.

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