THE POTENTIAL OF NATIVE RAW MATERIALS IN THE ANIMAL NUTRITION AND ITS EFFECTS ON THE PRODUCTION QUALITY: A review

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Abstract. Cereal and legume grains are major sources of proteins for humans and form the basis of livestock feeds. However, individually these crops cannot supply the full complement of essential amino acids, lipids and fatty acids, minerals and vitamins. Legume grains can fix nitrogen from the atmosphere, fertilizing the soil for other plants tolerant of infertile soils and capable of pioneering change in barren and poor quality soils. Legume seeds contains from 25 to 48 % crude protein in dry matter, cereals from 10 to 15 %, which depends on the species, genotype and climatic conditions.

The composition of the cereal and legume seeds and especially the protein content makes them highly suitable for livestock diets. However, the presence of diverse compounds in cereal and legume grains, commonly referred to as anti-nutritional factors, that both decrease nutritive value of grains and, if taken in larger amounts, cause health problems that may be fatal for both human and the animals. Different strategies (processing methods, enzymes) have been used to reduce or eliminate the anti-nutritional factors contents and enhance the feed value of the grain.

Review was carried out on the nutritional value of cereal and legume grain and the potential of native raw materials in the animal nutrition and its effects on the production quality.

Keywords: native raw materials, cereal grains, legumes, animal nutrition

Introduction

One of the fundamental tasks of modern agriculture is to ensure sufficient food supplies. Cereal grains and legume grains are an important nutritive component both in developed and in developing countries. There is needed to look for locally available and cheap sources of feed ingredients particularly those that do not attract competition between humans and livestock. As standards of human nutrition improve in all countries, there is a corresponding increase in demand for animal products such as milk, butter, eggs, and meat. This demand can only be met by using animal feeds with a high protein content. Plant protein sources are good sources of dietary fiber, low fat content, particularly saturated fats and deficient in one or more of the essential amino acids, to achieve a balanced amino acids intake, a variety of plant protein sources need to be complemented with each other in the diet (Dousa1 et al., 2011)

The nutritive value of different cereal and legume species is very variable and large differences have also been observed coming from cultivars belonging to the same species. Many interpreting factors, such as protein content, essential amino acid composition and availability, protein digestibility and others are involved in such a highly variability. In addition, cereals as well as legumes may contain large amounts of antinutritional factors which can have serious effects under particular circumstances (e.e. tannins in a low-protein diet or phytates in a metal-deficient diet). Some legume species also contain chemicals of a different nature (i. e. lathyrogens, cyanogenetic glycosides, and others) which may be extremely toxic when ingested in significant amounts. The plant breeder attempting to develop higher-yielding, disease-resistant and nutritionally-improved crop varieties should be aware of such a complex of factors and alert to the possible production or increase of undesirable products or deleterious changes in chemical composition. Available data, although rather limited, indicate valuable breeding approaches to the improvement of nutritive value of cereal and legume grains for humans. (Bozzini, Silano, 1978; Alijošius et al., 2016))

Therefore the objectives of this paper were to review the the nutritional value of cereal and legume grain and the potential of native raw materials in the animal nutrition and its effects on the production quality.

Chemical composition of legume grains

Legume grains are characterised by high energy density allowed to the high protein, starch and/or fat concentrations, as more than sufficient is their calcium concentration. Chemical composition of legume grains is influenced by species (Cutrignelli et al., 2011).

Legume seeds are an abundant source of proteins and, among them, lupin is one of the richest 324–381 g/kg dry matter (Kohajdova et al., 2011). Another grain legumes has less proteins than lupins, for example faba beans - 301 g/kg dry matter and peas - 246 g/kg dry matter. Jezierny et al. (2007) reported similar amount of crude protein in different grain legumes - lupins 387 g/kg dry matter, faba beans 308 g/kg dry matter and peas 249 g/kg dry matter. In comparison to soybean meal, faba beans and peas contain between 45 to 55% and lupins (*L. albus*) even up to 70% of its crude protein content.

Grain legumes contain considerably less protein than SBM. Grain legume is as good a source of lysine as soybean meal, but methionine amount is lower in grain legume than in soy bean meal (Steenfeldt et al., 2003). The protein of faba beans and peas contains similar or even higher proportions of lysine (70 and 80 g/kg crude protein, respectively), when compared to protein from soybean meal (69 g/kg crude protein) or lupins (51 to 54 g/kg crude protein).

Martinez-Villaluenga et al. (2009), stated that lupin is a good source of nutrients, not only proteins but also lipids, dietary fibre, minerals, and vitamins.

The lipids content of lupin may range from 1 to 17 %, with a high variation in fatty acid composition. The dominating fatty acids are oleic and linoleic acid (Fuleky, 2009) Siddiq et al. (2010) reported that beans contain 1.27–3.62 % fat, 2.86–5.00 % ash and 56.53– 61.56 % carbohydrates. Compared to pea and faba bean, lupin contains a minute amount of starch but a relatively high amount of fat (Wiseman, Cole, 1988; Petterson, 2000). However, because of the thick hull layer and poor starch content the energy value of lupin is lower compared to the energy values of peas and faba beans (Petterson, 2000).

Stupelienė A. (2010) analyzed of full-scale chemical composition of different varieties of peas grown in Lithuania, and reported that the highest amount of crude ash (3.00% DM), crude fat (2.50% DM), starch (53.84% DM) and the lowest crude protein (23.20% DM) content was determined in the pea variety of "Neosypajusčijsia". "Rainiai" had the highest amount of crude protein (25.80% DM), but the lowest sugar content – 1.28% DM. Analyzed pea varieties also had the different content of crude fiber (difference between minimal and maximal value is 0.55%). The highest amount of NDF, ADF and ADL was determined in the variety of "Neosypajusčijsia" and compounded 13.0%, 10.2% and 0.8% DM, respectively in comparison with others varieties of pea. While in "Sobel" the amount of these fiber fractions and cellulose was correspondingly less 0.4–0.9% DM, 0.7–1.1% DM, 0.1–0.3% DM and 0.8– 1.1% DM respectively, in comparison with others varieties of pea, but has the highest amount of hemicellulose – 3.0% DM. The highest amount of cellulose was in "IP-5" (9.7% DM).

Brand et al. (2004) reported, that calcium concentration ranges on legume grains is between 1.0 g/kg (faba beans) and 1.9 g/kg (lupins). No extreme differences in trace mineral concentrations occurred except for the manganese concentration of yellow lupins, which containes approximately 10 times more manganese than the other legume grains.

One of the limitations to an increased use of grain legumes as feed is the presence of diverse compounds in their grain, commonly referred to as anti-nutritional factors, that both decrease nutritive value of grain legumes and, if taken in larger amounts, cause health problems that may be fatal for both human and the animals (Mikić et al., 2009). In faba beans energy value is dependent on the content of vicine, convicine and tannins (Crépon et al., 2010). The presence and amount of anti-nutritional factors in grain legumes has more effect on their use for monogastrics than on that for ruminants.

In order to reduce the quantities of anti-nutrients in legume seeds, various thermal and hydrothermal processes are used, such as dry heating, steam heating or cooking, autoclaving or mechanical heating (e.g. removing a seed coat). There have been attempts to use some of the industrial methods which combine thermal and mechanical actions such as microionization, extrusion, flaking and pelleting (Akande, Fabiyi, 2010; Van der Poel, 1990; Almeida Calderón et al., 1991; Fŕias et al.,1995, Bau et al., 1997; Wang, 1997)

Chemical composition of cereal grains

Cereals are cultivated throughout the world, including Lithuania. Grain chemical composition, nutritive value and energy content, due to genetic and environmental factors is different and depends on various factors such as sowing time (Kong et al., 2014) genotype, climate conditions (Janusauskaite et al., 2013), environment (Akçura et al., 2011), fertilisation, soil conditions (Manès et al., 2012). Cereals are important sources of protein but have low quality due to limitations in the amounts of essential amino acids, notably lysine. (Evers and Millar, 2002; Shewry, 2007)

Proteins are important both as nutrients and by virtue of the fact that the class includes enzymes which, although making a small contribution to grain weight, can have a marked effect on grain quality and hence price. Other chemical components exerting significant nutritional influence, are phytates and tannins. The walls of endosperm cells comprise a complex mixture of polysaccharides including cellulose, arabinoxylans, and β-glucans, as well as proteins and esterified phenolic acids (Evers et al., 1999). The major components of the grain are starch (~70–80%) and proteins (~10– 15%) along with non-starch polysaccharides (NSP) derived from the cell walls accounting for about 3–8% approximately (Anjum et al., 2008).

The major components of barley (Hordeum vulgare L.) are starch, dietary fibre, and crude protein, constituting: 60, 20, and 12% of dry matter, respectively (Oscarsson et al., 1996). Barley contents of crude fat and minerals or ash are low levels approximately 3–4% for fat, and 2–3% for ash of total grain weight (Andersson et al. 2008). The lowest results of crude fat of barley were reported by Kliseviciute et al. (2016). Menkovska et al. (2014) analysed grains of wheat and found of crude protein and crude fat as 12.24 and 1.53% respectively. Anjum et al., 2014 reported that crude protein in wheat different varieties ranged from 9.32 to 14.83% and the difference was significant ($P<0.05$). Grains contained crude fat, total ash and nitrogen-free extract contents varied from 2.60 to 3.76%, 1.61 to 1.82% and 78.72 to 84.24% in different wheat varieties.Triticale has at higher forage quality than wheat and rye (Koch and Paisley, 2002; Mut et al., 2006). The biological value of triticale protein has been shown to be greater than wheat protein (Heger, Eggum, 1991). Triticale protein content between 7.34% and 10.25%, raw ash content between 5.21% and 7.19%, NDF content between 51.24% and 60.00%, ADF content between 33.93% and 39.47% DM (Kaplan et al., 2014).

Considerable differences in chemical composition of different winter wheat, rye and triticale varieties grown in Lithuania were determined (Alijošius et al., 2016). The highest content of crude protein was determined in the winter triticale varieties 'SW Talentro' and 'SU Agendus' – 12.51% DM and 11.89% DM, recpectively, but the highest mean amount of crude protein between three types of grains is characterized by wheat varieties (11.71% DM). The highest crude fat and crude fiber values were determined in wheat varieties – mean amount was 1.39% DM and 1.80% DM, recpectively (dominant variety 'Mariboss'). Whereas the lowest content of crude fat was in triticale varieties and varied from 1.01% DM ('SW Talentro') to 1.37% DM ('Sequenz'). The lowest crude fiber content was in rye varieties reaching from 0.80% DM ('Matador') to 1.36% DM ('SU Stakkato'). The results of our study have indicated that chemical composition (crude protein, essential amino acids, NFE, NDF) of different varieties of triticale are more similar to chemical constituens of wheat varieties, than to that of rye (Alijošius et al., 2016).

In addition, rye (*Secale cereale L.*) has some nutritional benefits over wheat, since its content of minerals, lysine and dietary fibre is higher. Rye Among different cereals of commercial importance, rye has the highest content of DF, ranging from 18-22% (Andersson et al., 2009). Oats are generally lower in energy and have more fiber content than other grains. Thus, their value as a source of energy in high-grain diets will be limited.

Phenolic acids are characterized by biological activity. They stimulate bile production and excretion, strengthen walls of blood vessels, have antiinflammatory properties. Furthermore, they have a strong antioxidant, antibacterial and fungicidal activity. So far such a detailed analysis of phenolic acids in cereals grown in Lithuania has not been performed. The amounts of vanillin acid in barley grains under our examination varied from 238 6.16 mg/kg to 9.03 mg/kg average 7.67 mg/kg. The average of p-coumaric acid in examined barley – 33.51 mg/kg (from 21.56 mg/kg to 43.75 mg/kg). In barley grains, ferulic acid is prevailing among phenolic acids. Its amount in examined barley ranged from 289.83 mg/kg to 638.05 mg/kg (average 418.90 mg/kg). The amount of sinapin acids in barley under investigation varied from 13.66 mg/kg to 63.29 mg/kg; amount of p-hydroxybenzencarboxylic acid varied from 1.40 mg/kg to 3.04 mg/kg (average 2.11 mg/kg) (Kliševičiūtė, 2014). A.Yoshida et al. (2010) determined the amount of ferulic acid in barley under their investigation to be 4.3–34.2 mg/100g DM; sinapic acid – 0.057– 0.445mg/100g DM. The amount of phenolic acids is influenced by biotic and abiotic factors, e. g., causative agents of diseases, UV rays, low temperature, low Fe, P, and N concentrations, usage of herbicides, etc.

β-glucan is one of the major cell wall carbohydrate which is isolated from cereal grains, notably oats and barley (Skendi et al., 2003). The total level of beta-glucan in oats (1.8 to 7.9%) (Saastamoinen, 2004), rye (1.3 to 3.1%) (Demirbas, 2005), and wheat (0.4 to 1.4%) (Lazaridou, 2007) β-glucans concentrations of the different barley varieties ranging from 3.9 to 4.9% (Zhang, 2001), but β-glucan concentration can go up to 8-10% (Izydorczyk, 2000).

Kliševičiūte V. (2014) determined that concentration of trace element Cu in barley species under examination was – 1.92 mg/kg DM, trace element Mn – 8.46 mg/kg DM, trace element Zn – 16.95 mg/kg DM, trace element Fe – 35.70 mg/kg DM, trace element Se – 0.12 mg/kg DM. Trace elements concentrations in triticale species: copper – 3.43 mg/kg DM, manganese – 15.00 mg/kg DM, zinc – 18.89 mg/kg DM, iron – 30.22 233 mg/kg DM, selenium – 0.08 mg/kg DM. Concentrations of trace elements in wheat species: copper – 0.86 mg/kg DM, manganese – 16.75 mg/kg DM, zinc – 15.66 mg/kg DM, iron – 32.91 mg/kg DM, selenium – 0.10 mg/kg DM. Also concentration of β-glucanes in different species of wheat ranges between 2.12% and 3.65%; in triticale species – between 0.33% and 0.57%; in wheat species – from 0.37 % and 0.67%. The amount of pentosanes in different species of barley range between 5.07% and 7.84%; in triticale species – between 4.58% and 7.52%; in wheat species between 5.15% and 6.37%.

Uses of legume grains

Grain legumes, such as soybean (*Glycine max (L.) Merr.),* pea (*Pisum sativum L.*), faba bean (*Vicia faba L.*), lupins (*Lupinus spp.*), common vetch (*Vicia sativa L.*) and grass pea (*Lathyrus sativus L.*), represent one of the most quality and least expensive solutions for a long-term demand for plant protein in animal husbandry (Mikić et al., 2009). Annual legumes are one of the most important crops on a global scale. In animal feeding, they can be used as green forage, forage dry matter, forage meal, silage, haylage, immature grain, mature grain and straw, while some species may be used for grazing too (Mikić et al., 2006).

Legume grains as a silage can be effectivly used in ruminant nutrition. Silage produced from a mixture of whole-crop cereals and whole-crop pulse legumes is likely to have a higher nutritive value compared with silage produced from a cereal-only whole-crop due to a higher concentration of crude protein (Lunnan, 1989) and higher degradability of nutrients in the rumen (Mustafa et al., 2000; Salawu et al., 2001). Such silages are also suggested to balance the supply of protein and energy for rumen microbes (Adesogan et al., 2004). So silage for ruminants nutrition, can be produced from faba bean (Pursiainen & Tuori 2008, Borreani et al. 2009, Pakarinen et al. 2011), white lupin (Fraser et al. 2005a, Pakarinen et al. 2011), narrow-leafed lupin (Fraser et al. 2005b) and yellow lupin (Serrano 1989), whole-crop pea (Pursiainen & Tuori 2008, Borreani et al. 2009), Field pea can be ensiled as a single crop (Salawu et al., 2002) or in mixture with the whole-crop plants, for example wheat, barley and oats (Mustafa, Seguin, 2004; Pursiainen, Tuori, 2008). In other research, Mariotti et al. (2012) reported that results are often improved by mixing a cereal grains with legumes for example - durum wheats and faba beans.

A lot of studies had been done in order to replace, at least a part of soy bean meal in dairy and beef cattle nutrition, the results showed that soya bean meal can be replaced by seed or meal of faba beans (Moss et al. 2000), peas (Brunschwig, Lamy 2003), white lupins (Froidmont, Bartiaux-Thill 2004), yellow lupin (Marley et al. 2008), or narrow-leafed lupin (Eriksson, 2010; Niwinska, Andrzejewski 2011). Wilkins, Jones (2000) stated, that the choice of legume for the supplement depends on the background silage, as the slow breakdown of lupins makes them more suitable with grass silage, while pea and faba bean are more suitable with maize silage. The aim of Kudlinskienė et al. (2016) research was to determine the influence of extruded lupins' fodder beans and peas on fermentation processes in the rumen of dairy cows. The results of this study shown that extruded soybeans replacement with extruded lupins *(Lupinus spp.)*, faba beans *(Vicia faba)* and peas *(Pisum sativum)* in dairy cows rations, had no negative influence on rumen‘s fermentatative indexes and warranted it‘s optimal activity.

Dovidaitienė et al. (2016) analyzed the influence of extruded rapeseeds (30 %) and faba beans (70 %) mixture on productivity, product quality and composition of dairy cows. The results revealed that cows of the control group gave 7.74 % more milk compared to the cows from the trial group during the whole experiment. Adding extruded soybeans to compound feed for the control group, protein content increased and milk fat content decreased. Milk fat content dropped by 0.26 % for the control group cows and increased by 0.69 % ($P<0.05$) for the trial group cows. Protein content increased by 0.19 % in the control group, and for the trial group the increase was 0.33 % ($P<0.01$). Protein content for the trial group cows at the end of the experiment was 0.15 % higher compared to the control group. Also extruded rapeseeds (30 %) and faba beans (70 %) mixture, had no negative effect on rumen fermentatative indexes and warranted it‘s optimal activity (Dovidaitienė, 2016a).

Reports can be found on the successful use of almost every grain legume species for feeding monogastrics - pigs, broiler hens, laying hens and turkeys. Pea and faba bean are equally suitable for grower and finisher pigs (Smith et al. 2013), and low tannin content provides a valuable increase in the apparent metabolizable energy of the legume (Crépon et al. 2010). Stein et al. (2004) showed that growing-finishing pigs fed diets containing 0, 12, 24, or 36% field peas produced no differences among treatment groups in average daily gain, average daily feed intake, gain per feed, backfat thickness or lean meat percentage, but pigs fed diets containing 12, 24, or 36% field pea had greater ($P<0.05$) loin depths than pigs fed the control diet. The apparent ileal digestibility for methionine, tryptophan, cystine and serine were lower ($P<0.05$).

The aim of Nalle at al. (2010) study was to evaluate the effect of the inclusion of faba beans (*Vicia faba*), white lupins (*Lupinus albus*) and peas (*Pisum sativum*) in two different basal diets on the performance, digestive tract development and carcass characteristics of broilers housed in floor pens over a 35 day grow-out period. They concluded that, when balanced for metabolisable energy and digestible amino acids, dietary inclusion of faba beans, white lupins and peas at 200 g/kg either in wheat-soybean meal or wheat-soybean meal-meat meal basal diets could support a good performance of birds over the 35-day grow-out period. Laudadio et al. (2011) stated that faba bean is acceptable at up to 31% and white lupin was acceptable up to 24% in a mixed feed for broilers (Laudadio & Tufarelli 2011).

Peas and faba beans are also a good source of energy for broilers (Nalle et al., 2011a; Crépon et al., 2010; Masey O'Neill et al., 2012). Supplementing a feed based on yellow lupin (Olkowski et al. 2010) or narrow-leafed lupin (Steenfeldt et al. 2003) with a glycanase mixture resulted in significantly improved performance of broilers.

Fru-Nji et al. (2007) reported, that field pea, in contrast, could be included up to 50% of the feed of laying hens. The low digestibility of the storage galactan in lupin seeds reduces their value in monogastric feeds. Pea was more digestible than faba bean and narrow-leafed lupin in turkey diets (Palander et al. 2006). The standard ileal digestibility of protein from narrow-leafed and yellow lupin was as good as that of soy bean meal, while those of pea and faba bean were significantly lower (Jezierny et al. 2011).

Thus grain legumes can be used to replace part or all of the imported soya bean meal used in nutrition of broilers and laying hens, pigs and ruminants, at least on an experimental field.

Uses of cereal grains

Barley is easily digestible (due to low gluten contents) and has superior nutritional qualities, high lysine, thiamin and riboflavin concentration (Marwat et al., 2012).

The results of experimental of laying hens feed conversion ratio and body weight at the end of the experiment clearly showed that decreases efficiency of feed utilisation from wheat/barley-based diets (Mathlouthi et al., 2003), Svihus et al. (1997) found that broiler chickens fed to whole barley grew at the same rate,however, feed consumption was higher than that of chicken broilers fed to rolled barley. Kliseviciute et al., (2012) and Bennett et al., (2002), found that using diet barley broilers body weight decreased nearly throughout all growing periods.

Yang et al. (1998) observed that degree of rolling hull-less barley affected milk production and ruminal digestibility. Hironaka et al. (1978) concluded that medium steam-rolled barley resulted in better performance than thin, coarse, or whole barley fed to steers.Weiss et al (1989) evaluated barley-based distillers' grains derived from a mix of 65% barley and 35% corn for dairy cows and found that feeding barley-based distillers' grain up to 130g kg^{-1} of the diet dry matter did not affect milk yield or milk fat percentage.

Rye grain is not recommended for growing chickens (such as broilers and pullets) and turkeys. Including high levels of rye grain in poultry diets typically causes problems for growing chicks. Rye should not compose more than 40% of the diet.

Triticale is a convenient feed for all animals since represents a high source of energy. Because of favorable enzyme composition, triticale grains favorably effect the intestinal tract of monogastric animals (Barneveld, Cooper, 2002; Korver et al., 2004).

Some studies have shown that the no deteriorating effect on productivity of broilers and/or layers when diets grain portion consisted of 100% triticale (Chapman et al., 2005). Karaalp, Ozsoy (2001), also reported that more than 30% triticale in broiler diets has been reduced yield performance and efficiency and hasn't improved in that situation even adding enzyme to triticale.

Similar results were obtained by Osek et al. (2010). Zarghi, Golian (2009) found that the introduction of 40% of triticale into diets did not negatively affect weight gain or final weight of broiler chickens.

According to Korver et al. (2004), the usage of triticale has an advantage because it results to a higher average body weight gain for chickens on a weekly basis, and in conditions of equal feed intake. Hermes, Johanson (2004) assert that if the nutrition of heavy strains is based on the different amounts of triticale in mixtures for broiler fattening, then it does not lead to any negative effect in the productive properties of chickens. The biggest body weight of the investigated chickens was achieved when the amount of triticale in mixtures for broiler fattening was 10%. Sarker et al. (2006) investigated different formulations, or in other words share, of triticale and wheat, in food mixtures for broiler fattening and results is the results of analysis varied and contradictory.

Studies indicate that triticale may partially be a successful replacement for corn, wheat or barley in mixtures for pigs with no negative effects on the performance of those animals (Huenke, Honeyman, 2001; Honeyman et al., 2001). In the possibility research of using triticale in pig nutrition (Kovcin, Stanacev, 2004), based on the review of data in literature, the authors emphasize that it is possible to include the triticale in mixtures for piglet nutrition up to 60% of the total content of cereals. Further increase of triticale content in mixtures for piglets leads to a decline of growth.

Conclusions

Leguminous and cereal grain plant's nutritive value is widely analysed worldwide, including Lithuania. LUHS Veterinary Academy had formulated feeding raw material's nutritive value tables, which data is used for composing combinated feed's formulas for animals, performed analysis was exceptional for determining betaglucans, pentosans, phenolic acids, flavonoids, fatty acids and counting thrombogenicity's index in cereal grains, cultivated in Lithuania. Various feeding experiments with laying hens, broiler chickens, dairy cows, pigs are performed using leguminous and cereal grain's processed differently and cultivated in Lithuania. During these experiments, we evaluate digestive processes dynamics, quality of production, animal's physiological condition. Thorough experiments enable us to more effectively use raw materials cultivated in Lithuania and forecast it's productivity and quality of production.

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