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Review

Implementation of triticale in nutrition of non-ruminant animals

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Cognition of chemical composition and nutritive values of triticale grain as well as the effect of its application in non-ruminant animal nutrition were pointed out in this paper. There is a high level of proteins in the grain of triticale (2 to 3% more than wheat and 4% more than rye), with very beneficial amino acid composition, and is the reason for its usage in domestic animals nutrition. Nowadays, people are of the opinion that triticale is one of potential plant species with the brightest perspective in the production of food for domestic animals. Considering the increased production of triticale, some detail researching of its nutritional value is necessary due to the required evaluation of the role and significance in domestic animal nutrition based on triticale. Due to intensive plant breeding programs, there are new varieties of triticale in the market, distinctive by the higher yield and wide range of desired traits. As a result of this, triticale is becoming very attractive and is occupying larger portions of arable land. These review will show if there are some advantages of triticale compared to other cereals and how large the frame of these advantages is, as well as how it will affect the further spreading of triticale on arable land.

Key words: Triticale, chemical composition, nutritive capacity, nutrition.

INTRODUCTION

Triticale is one of the new and successful species of cereals, developed by crossing durum wheat with rye in order to join positive characteristics of both parents. Regarding the yield, triticale potential, grown under optimal conditions, is approximately similar to wheat potential, and was much higher than wheat potential under unfavorable growing conditions (Brown and Graham, 1978). Triticale accumulate more nitrogen than wheat in heading period and grain physiological maturation, and this indicates that triticale is a much appropriate

culture for growing grain on nitrogen poor soils. High ability of nitrogen accumulation leads to decreased requirements for nitrogen fertilizers. It is very important as a result of environment protection. Triticale is an important species due to its value on soils with marginal characteristics as dry or acid soils, and is also less demanded regarding the various preparations which take place in agronomy. Triticale is well known by its high tolerance, with regards to acid soils, and by its high productive results on sandy soils as well. However, similar advantages were obtained with regard to the aridity. Triticale is suitable for planting in areas where corn did not grow and in the areas with moderate climate as well. It could be said that triticale is distinctive by 'very good' to 'excellent' tolerance with regards to the most

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important pathogens and small grains pests. Those traits are the heredity of parental species. Early stature, drought and aridity resistance, lower steam, high and stabile grain yield are just some of the triticale varieties characteristics derived from wheat, as the second parent (Milovanovic et al., 2006). New triticale varieties mostly reached the yield of the leading wheat cultivars, while they surpassed rye varieties, barley and oat (Milovanovic and Perisic, 2002; Milovanovic et al., 1998; 2005a). The stable yield of triticale is greatly caused by its high adaptability in local agro-ecological conditions.

According to the data in the literature, there are significant variations of triticale chemical composition and nutritive value, as a result of the huge number of hybrids with very different characteristics (Milovanovic et al., 2005b). Regarding chemical composition, triticale is very similar to wheat, except the reduced sugar which is higher than wheat and more closer to the level colloquial for rye (Varughese et al., 1996).

Nowadays, triticale is the most implemented as feed in non-ruminant animals nutrition, especially in pigs and poultry nutrition (Djekic et al., 2009a), as well as it being recently used more for silage (Coffey and Gerrits, 2009). Numerous researches in animal nutrition indicate a successful partial replacement of corn, wheat or barley by triticale without negative implications on domestic animals' efficiency.

BASIC INFORMATION ABOUT TRITICALE AS FEED

Triticale is a very suitable feed for all animal kinds because it is a resource of high amount of energy. A very important parameter of the economical relevancy is protein yield per unit of the arable surface. Pointed characteristics are important for the purpose of the biological value and technological products quality, as well as for human and domestic animals nutrition. Nutritive value of grain and consequently the quality of the product depends on the protein content in the grain. Proteins with higher content of essential amino acids (lysine, tryptophan, cisteine + methionine, threonine, leucine, isoleucine, histidine, valine and phenylalanine) have higher nutritive value, where the lysine content is the most important, as the first spars amino acid in cereals. There is a higher percentage of protein and lysine in triticale when compared to the parental species, as well as the lower energetic value when compared to wheat and maize (Mosse et al., 1988; Barneveld and Cooper, 2002).

The nutritive value of proteins depends on the essential amino acids content (Kurkiev et al., 1975). Content of lysine in triticale could be the parameter of overall protein quality. Regarding the content of lysine, triticale is much better than wheat. There is a significant variability regarding the proteins and lysine content of triticale, compared with wheat, which indicates the ability for

further protein quality improvement of triticale, with continuous selection based on yield and grain quality. The content of lysine of some triticale lines is similar or equal to Opaque-2 maize (Halse, 1974). In accordance with the research of Cmeleva and Cikida (1988), there is much higher content of lysine in the hexaploide triticale, when compared to octoploid, while octoploid triticale has less alkyl resorcinol. Researching the triticale variety (Beagle 82), Hale et al. (1985) found that it contains 0.48% lysine. Mayer et al. (1990) found the different contents of lysine (0.48, 0.43 and 0.41%) in researching different triticale varieties.

The nutritive value of triticale for the non-ruminant animals can be decreased as a result of the presence of alkyl resorcinol type phenol, which shows a lot of contradicted results for various experiments (Milovanovic et al., 2001). According to the same authors, triticale exceeds rye and wheat in the carotenoid content, but has less content of crude fiber than rye. Trypsin inhibitors (also known as ingredients of soybean) have an important role in reducing the nutritional value and utilization of proteins. Activity of trypsin inhibitors in triticale is higher when compared to wheat, as well as a similar comparison to rye. Function of these inhibitors can be ceased as a result of the thermal processing (98°C). Some varieties of triticale are in advantage when compared to wheat.

According to the data in literature, there are significant variations of triticale chemical composition and nutritive value, as a result of a huge number of hybrids with very different characteristics. The variations of the different genotypes of triticale winter varieties, as an average for two years, were between the range of 13.44 and 16.42% (Milovanovic, 1993). During the research of the different varieties of winter triticale genotypes, through a four-year period, the average content of protein was 14.32 to 16.29%, while this content amounted from 13.57 to 13.70% in winter wheat varieties (Milanovic, 1995). The allegation of the same authors is that the spring triticale varieties had more proteins when compared to winter varieties. The content of lysine inside the protein of triticale varies in the range of 2.2 to 3.4%, while this amount for wheat varies in the range of 1.7 to 2.1%. Russian triticale varieties contain an average of 14.0% moisture, 12.8% protein, 68.6% carbohydrate and 1.5% fat, while their proteins contain an average of 5 to 10% albumin, 6 to 7% globulin and 30 to 37% prolamin (Muhametov et al., 1996).

In terms of the technological quality of grain for human consumption, triticale still lags behind wheat (less content and a lower quality of gluten), and is mainly used for animal nutrition (Çiftci et al., 2003). Leeson and Summers (1997) emphasize that different varieties of triticale contain 11 to 20% crude protein, while the structure of amino acids, as well as the level of energy are similar to wheat. According to Milovanovic et al. (2001), protein content of triticale varies from 12 to 50%, with forms of

triticale, in which the content of proteins does not exceed the level in wheat. Such cases are found mainly in hexaploid lines and especially in lines improved for increased productivity as well as the plumpness of grain.

The research in the different countries showed that the grain of triticale has similar nutritional value to wheat and is superior in relation to barley, if it is not contaminated by the ergot or by the fusarium. Comparing some of the KG winter varieties of triticale that are recently approved (Favorit) with standard, besides the desirable properties of nutritive value, there is an achievement of significantly higher productivity (Milovanovic et al., 2006). The author emphasizes that the variety, known by the name "Favorit", has a high yielding and yield stability, as well as a high grain protein content and high nutritional value. Grain of this variety is mostly used as a component for preparation of concentrated mixtures for animal nutrition, due to high content of amino acids (lysine, methionine and tryptophan) and protein. In the description of the Southern Georgia Regional Commission (SGRC) triticale variety, known by the name "Knjaz", Milovanovic et al. (1998, 2007) emphasize that its average content of crude protein in dry matter (DM) amounted to 14.1%, which is 1.2% more when compared to the standard (KG 20). Protein content in the grain of triticale SGRC varieties often vary in the range of 14 to 17%, while the lysine content exceeds the commercial varieties of wheat for 10 to 30% (Milovanovic et al., 2001, 2007b). In the dry matter of grain, the average content of ash is 1.82%, for the SGRC variety known as "Rubin", considering the same authors claims. Perisic et al. (2008) did a research on the winter variety of triticale titled "General". When this was compared to older cultivars that were widespread in production, the main traits of "General" variety were higher and more stable in grain yield. During the period that lasted for two years, grain yield of the "General" variety (6.782 kg/ha) was statistically higher than the KG standard (5.770 kg/ha). Protein content in the grain of the "General" variety was averagely 14.6% and the content of ash was 1.72%. The authors conclude that due to the high content of protein (14 to 17%) and the high essential amino acids content in grain, the variety "General" represents an important ingredient of concentrated food mixtures for animals, wherein it could be used for a partial or complete replacement for the other feed (corn, barley and oats). The chemical composition of two cultivars of triticale, "KG 20" and "Favorit", were presented by Djekic et al. (2009b). Research was carried out in the period of 2007 to 2008 in the SGRC in Kragujevac. The content of protein in dry matter was averagely 12.24% for the "KG 20" variety of triticale, while this content was 12.55% in the "Favorit" cultivar of triticale. The average content of ash in dry matter was 1.34 and 1.37%, in the cultivars of triticale known as "KG 20" and "Favorit", respectively. The average dry matter content in both observed triticale cultivars was about 11.35%. Statistically, significant influences of the variety on the

content of protein, ash or dry matter were not detected ($p > 0.05$).

The results of the micro experiments of different winter varieties of triticale and perspective genotypes from Small Grains Research Centre, Kragujevac, during the period of 2003 to 2008 are presented in Table 1.

The data in Table 1 showed that newer winter varieties of triticale and perspective genotypes had lower protein content in grain than trusted varieties ("KG 20"), with the exception of some varieties such as "Favorit", "Vojvoda", "Tr 102/6", "Tr 71/5-2" and "Tr 110/3-2". When compared to wheat ("Pobeda" variety), there was a lower content of protein in the grain of the mentioned varieties of triticale, except in the cultivar "Favorit" (13.87% DM). Considering the average values of protein content in grain, in comparisons with the tested varieties of triticale and perspective genotypes versus trusted variety "KG 20", there were no significant differences ($P > 0.05$). Values of the protein content from this period of investigation are significantly lower than the values from previous researches (Milovanovic et al., 1998, 2001, 2007a, 2007b; Perisic et al., 2008). This is so, as a result of late sowing (October 29 to December 6), as well as other conditions during the year and because of the decreasing tendency of the protein content due to the continual pressure of triticale selection for increasing yield and better plumpness of grain.

According to the results gathered from the micro experiments accomplished in the Small Grains Research Centre in the city of Kragujevac, during the five year examination of spring triticale varieties and perspective genotypes, the content of protein in triticale ranged from 13.074 to 14.694% DM (Table 2). However, the examined spring triticale varieties and perspective genotypes, except the genotype "Tr 9/10-2", had higher average protein content when compared to trusted varieties ("Vojvoda" - 13.076%). Consequently, there was no statistically significant difference for the average protein content in comparison with the tested spring triticale varieties and perspective genotypes versus trusted cultivars. Thus, there was a statistically significant difference for the average protein content in the grain of "Knjaz" triticale variety compared to the trusted varieties ($P < 0.05$), which indicated that spring triticale genotypes do have a higher protein content when compared to winter genotypes.

Based on the results obtained from the previously accomplished experiments, as well as the wide range of data from the commercial production and statistical data, it could be concluded that better results in the improvement of small grains could be achieved by the application of contemporary technology. New and promising varieties and lines of triticale have larger grain, better fullness of grain, grain weight and starch content in grain, while the content of protein and lysine was less compared to older cultivars (Myer et al., 1996; Milosevic et al., 2001). Selection of triticale based on these traits leads to a

Table 1. Average values and variability of crude protein content in "KG" varieties of winter triticale and perspective genotypes, in the micro experiment of Kragujevac city during the period of 2003 to 2008.

Cultivar/genotype	\bar{x}	S	S_x	t_{exp}
KG 20	12.597	1.297	0.748	-
Presto	12.593	1.373	0.793	0.449
Tr 350/3	12.330	1.036	0.598	0.278
Favorit	13.870	1.063	0.614	-1.315
Tr 102/6	12.957	2.844	1.642	-0.200
Triumph	11.970	1.341	0.774	0.582
Tr 64/1	12.177	2.140	1.235	0.291
Zarko	12.083	2.243	1.295	0.343
Tr 339/4-3	12.253	2.021	1.167	0.248
Tr 71/5-2	12.937	0.958	0.553	-0.365
Vojvoda	12.750	1.316	0.760	-0.144
Tr 207/1	11.230	1.480	0.854	1.203
Tr 55/3	11.280	0.400	0.231	1.681
Tr 110/3-2	12.695	0.215	0.124	-0.130
Pobeda	13.463	1.798	1.038	-0.677

Table 2. Average values and variability of crude protein content in "KG" varieties of spring triticale and perspective genotypes, in the micro experiment of Kragujevac city during the period of 2003 to 2008.

Cultivar/genotype	\bar{x}	S	S_x	t_{exp}
Vojvoda	13.076	0.735	0.328	-
Soko	13.098	0.752	0.336	-0.553
Delija	13.282	0.259	0.116	-0.591
Tr 15/7	13.314	0.481	0.215	-0.606
Knjaz	14.694	1.094	0.489	-2.745
Tr 5/10	13.280	1.568	0.701	-0.263
Tr 49/7-1	13.600	4.438	1.985	-0.260
Tr 15/7-3	13.134	0.835	0.373	-0.117
Tr 9/10-2	13.074	0.806	0.361	0.004
KG 20	14.154	0.768	0.343	-2.268
Zlatar	13.306	0.843	0.377	-0.460

reduced total content of crude protein in grain and an increase in the content of lysine (Mosse et al., 1988). By using modern methods, breeding of small grains will offer the market new genotypes with higher genetic potential for yield. Due to a series of advantages in the technology of production and because of the increased protein content in grain, triticale takes a more important place in the production of grain for animal nutrition.

APPLICATION OF TRITICALE IN NUTRITION OF PIGS

Triticale is mostly used as an animal feed. Numerous

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 (Adeola and Young, 1985; Adeola et al., 1986; Myer et al., 1986; Huenke and Honeyman, 2001; Honeyman et al., 2001).

Some researches have gave the same or even better performance characteristics of pigs at slaughter, when corn was replaced by triticale in mixtures for pigs (Hale et al., 1985), while the other studies have shown a decreased performance (Brand et al., 1995; Myer et al., 1989). In the possibility research of using triticale in pig

nutrition (Kovcin and 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. Also, the content of trypsin inhibitor and himotripsin inhibitor in older varieties of triticale is very high, which adversely affects the possibility of triticale usage in the nutrition of pigs. For the fattening of pigs, Alle and Hines (1972) used the following rations: 1. Triticale; 2. Triticale + 0.1 % L-lysine; 3. Triticale + soybean meal; 4. Sorghum + soybean meal; 5. Wheat + soybean meal. The same authors found that the lowest growth was observed when the meal was based only on triticale ($P < 0.05$) as a result of the small amount and low usage rate of lysine. The analysis of carcass sides points at significant differences among the treatments considering the thickness of back bacon, length of sides, surface of cross section of loins and proportion of meat. Golushko and Marusich (1996) determined the significant increase in digestibility of protein and energy, regarding the nutrition of growing pigs. The influence of the triticale level in the nutrition of weaned piglets was researched by Erickson et al. (1979). The mentioned authors researched the different shares of triticale in the total amount of grains, or more precisely 0, 20, 40, 60, 80 and 100%, in nutrition of weaned piglets. According to the obtained results, they concluded that the increasing amount of triticale in the nutrition of weaned piglets, over 60%, led to reduced growth, while the feed consumption increased. However, if synthetic lysine is included in mixtures, there is the possibility of further increasing the amount of triticale up to 100%, and whereby the decreasing of piglets growth is stopped, the feed consumption is increased due to the high content of crude fiber. Considering the starting phases of pigs fattening, the triticale and corn have similar nutritional properties, but during the final phase of fattening, there are some advantages of corn (Mayer and Barnett, 1996). In addition, efficient replacement for corn and triticale can also be used as a substitute for soybeans flour in mixtures for nutrition of pigs. Mayer and Barnett (2008) emphasize that the content of lysine in mixtures for pig fattening is more important than the protein content, because through a research of mixtures with or without triticale, the same level of protein were identified by higher growth and yield of meat, when pigs consumed the mixtures. Sullivan et al. (2007) researched three groups of piglets fed during summer and winter months. In the first group, pigs were fed by standard mixture, without inclusion of triticale, while the amount of triticale in the second and third mixture was 40 and 80%. The authors concluded that the feed consumption was higher during the summer months, compared to winter months, and they found out that the second group of piglets achieved the lowest feed conversion ratio. Investigations of triticale's usage in pig nutrition, carried out in Canada

(Robertson et al., 1999), point at the possibility of efficiency substitution of corn and barley, by the grain of triticale in mixtures for nutrition of pigs within the body weight range of 25 and 100 kg.

TRITICALE APPLICATION IN POULTRY NUTRITION

Triticale is already used widely for the nutrition of poultry (broilers and hens) across the world. The quality of poultry products can be modified or improved by the addition of triticale as feed in rations for animal nutrition, and this is a considerable reason for the scientific interest about the usage of triticale in food for livestock, despite the fact that the published data in the fields of productivity of poultry, as well as the information about eggs and meat quality, are insufficient when compared to those about the positive effects of this species of small grains on ruminants and pigs.

In the research of broiler production, one of the subjects was the determination of the effect of broilers nutrition by the mixtures with different share of triticale, on production results, as well as on the qualitative and quantitative properties of broiler meat. A lot of scientists across the world engaged in a research that showed the effect of the nutritional value of triticale on properties of productivity of heavy strains of poultry (Ruiz et al., 1987; Johnson and Eason, 1988; Al-Athari and Guenter, 1989; Vieira et al., 1995), while there were no such research in Serbia.

Barneveld and Cooper (2002) investigated six varieties of triticale in mixtures for broiler fattening. Feed consumption was between 1.75 and 2.24 kg per 1 kg of the chicken's body weight. The authors emphasized that the contents of protein, lysine and methionine were higher when compared to the grain of wheat and corn, while the digestibility was similar among the mentioned grains. Savage et al. (1987) emphasized that the usage of triticale in the nutrition of chickens led to the improvement of the physical and sensory properties of boiled meat. The usage of triticale in mixtures for broiler fattening, instead of wheat, did not lead to significant changes of chickens' properties in production and meat processing. Vohra et al. (1991), suggest that the usage of triticale in mixtures, for broiler fattening as well as for hens, can be a solution to the problem of adding commercial enzymes in animal food mixtures, and it leads to a decrease of the total costs in food production. 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 and 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%, while the highest feed conversion was accomplished in formulations when the amount of triticale was 15%. Sarver et al. (2006) investigated different formulations, or in other words share, of triticale (T) and wheat (W), in food mixtures for broiler fattening. They found that the highest body weight of chickens was attained, at the end of the experimental period, in cases when chickens consumed formulations W40T60 or W60T40. However, the lowest mortality was in the group where consumed mixture did not contain any triticale. Comparing the triticale and wheat in broiler nutrition, Savage et al. (1987) emphasize that inclusion of triticale in the nutrition of turkey leads to better meat quality compared to other ways of nutrition.

Considering the production of eggs for consumption, investigations of various formulations of triticale in rations for hens, were mainly focused on egg quality improvement (quality of the albumen and a decrease of the cholesterol content). A lot of scientists investigated the possibility of using triticale in the production of light strains of poultry or, in other words, in the production of eggs (Maurice et al., 1989; Boros, 2002; McNab and Shannon, 1975; Flores et al., 1994; Fayez et al., 1996). Same authors concluded that there was no difference in productivity, even in the case when nutrition of hens was based only on triticale.

In Oregon, Boldaji et al. (1986) investigated the different formulations of triticale in mixtures for hens. According to the obtained results, they concluded that there were no significant differences in egg production, feed consumption, external and internal egg properties or considering the body weight of hens which consumed triticale when compared to the control group. There was a somewhat lighter color of yolk in the case of the nutrition based on triticale, compared to eggs in the control group. Total feed consumption per one egg was lower when the feeding was based on triticale, compared to hens in the control group, while the quality of eggs was equal. The authors concluded that the usage of triticale in mixtures for nutrition of hens depends on the momentary price of triticale compared to corn, as well as its availability in the market. Considering the research in the nutrition of hens, by Karunaewa and Tham (1984), usage of different percentage of triticale instead of barley did not have a negative influence on the production of eggs, but Leeson and Summers (1987) emphasize that bigger proportions of triticale grains usage leads to negative effects. According to Jokic et al. (2004), triticale can be included in rations for chickens and hens in the amount of 5 to 15%, as well as to about 2% in rations of broilers. A higher amount of triticale could not be recommended due to the deficiency of lysine or alternatively, because the synthetic lysine must be added.

The content of soluble pentosan in triticale is similar to that in wheat and is significantly lower when compared to rye (Petterson, 1988; Pena, 1996). According to Petterson (1988), the content of insoluble pentosanes is

highest at triticale (6.6%) and lowest at wheat (3.9%), while the content at rye is intermediate (4.9%). Additional preparation with pentosan improves the properties of chickens that consumed rye or triticale significantly. This improvement is a result of the cell wall's breakdown in endosperm by enzymes and it leads to complete digestion in the small intestine of chickens. Contrary to the mentioned information, unlike the corn, triticale does not contain pigments with yellow color (Carotenoids and Xanthophylls). Considering the higher market demands for chickens with yellow skin, as well as the brown colored eggshell, in mixtures for broiler and hen nutrition, feedstuff with higher content of pigments should be included, such as corn flour and dehydrated alfalfa (El Boushy and Raterink, 1992).

CONCLUSION

As a result of the nutritional values, which are higher even in comparison with corn, selectors and experts for livestock nutrition have recommended triticale for nutrition of all species of domestic animals, up to date. Also, it can be successfully used as a substitution for wheat, in animal nutrition rations, because requirements for food in the world are increasing, while the arable land used for seeding of wheat decreased, as well as its yields. Triticale has a special characteristic due to the high protein content in grain, as well as the favorable content of important amino acids, when compared to other grains.

It is essential to achieve appropriate amount of proteins in rations of all categories of non-ruminant animals. Supplying excessive amount of protein is neither rational nor economic, while deficit of proteins can lead to decreased consumption, lower food conversion, declining of growth and meat production, as well as an alteration of the quality of meat and eggs. Such symptoms are often in relation, or are jointly manifested, with the deficit of energy and they are a sign of inadequate nutrition of pigs and poultry. Also, the ratio between degradable and non-degradable proteins has to be appropriate, in order to achieve the maximal results in production.

Based on the mentioned facts, it can be concluded that triticale, as a younger species of small grains has found its place in crop production, while the significance in livestock production is a result of this cereal's quality. Thus, the importance of triticale in human nutrition is increasing. However, the entire facts that were formerly mentioned described triticale as one of the plants that have the brightest perspective in the future.

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