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Original scientific paper

The impact of triticale diet on production characteristics and meat quality in pigs

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A b s t r a c t: Triticale (Triticosecale) is a hybrid crop which inherited the excellent grain quality and high yield potential of wheat (Triticum spp.) and the good tolerance to biotic and abiotic stresses factors of rye (Secale cereale). As an energy crop, triticale has now been used for human food and livestock feed for many years. The main agronomic goal has been to improve the properties of triticale grains over those of wheat, corn, rye, barley, etc., making triticale an attractive option for increasing global food production. This paper discussesthe advantages of using triticale as a pig feed.

Keywords: *triticale characteristic, pig feed, meat quality, carcass quality.*

Introduction

Triticale (*Triticosecale*) is the only cereal crop successfully developed by man within the last 140 years. This crop species developed from crosses between wheat (*Triticum spp.*) and rye (*Secale cereale*). Triticale has high grain yield potential and quality that a rise from its wheat ancestry, plus broard adaptability, and ability to tolerate low soil fertility, drought and extremes of soil pH, all derived from rye (*Glamoclija,* 2012). Because of these characteristics, triticale is a well-established livestock feed ingredient that is widely available for use and readily accessible by most feed mills (*Glamoclija et al.,* 2017a). Triticale can be used in livestock diets like other cereals as a whole grain, or for fodder production like hay, silage, straw or chaff, and it compares favorably with respect to quantity and quality attributes. The grain is primarily used for feeding pigs, but it can be also used for poultry, and for ruminant animals such as cattle and sheep. As forage, the crop is grazed by cattle and sheep, or harvested for silage or hay for those animals. Triticale also produces an abundant amount of straw, which can be used for many animal species (*Van Barneveld,* 2002). Early interest in triticale as a feed grain was generated because of its higher protein concentration and better amino acid balance as compared to other feed grains.

The production characteristics of pigs and quality of the pork produced from the animals are influenced by numerous genetic and non-genetic factors, including dietary factors. The strains of pigs referred to as PIC (*Pig Improvement Company,* www.pic.com) swine have been developed for optimal, lean production, excellent growth rate and feed efficiency, and low backfat levels (*Turyk et al.,* 2011). Because of its agronomic attributes and dietary quality, triticale has the potential for broad application in animal feeds and has attracted international interest for its application as a major ingredient of swine feed. Triticale can be used as a substitute for corn or barley in the diets of growing-finishing pigs, without compromising muscle quality or palatability (*Jaikaran et al.,* 1998).

Nutrient composition of triticale

Triticale is primarily included in livestock diets as an energy source (*Glamoclija et al*., 2017b). It is characterized by moderate protein and high gross energy content because of its high contents of starch and other carbohydrates (*Widodo et al.*, 2015). Early on, interest in triticale as a feed grain was generated because of its higher protein concentration and better amino acid balance as compared to other feed grains such as maize and wheat (Table 1, Table 2) (*Boros,* 2002, *Glamoclija et al.,* 2017a).

The proximate chemical composition of triticale grains is, in general, intermediate between the two parent species of wheat and rye (Table 3) (*Myer and Lozano del Rio,*2004).

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Table 1. Comparative composition of triticale, maize and wheat grain (on an as-fed basis) (adapted from *Boros,* 2002; *Glamoclija et al.,* 2017a)

Item	Triticale	Maize	Wheat
Crude protein (%)	12.0	8.5	11.5
Lysine (%)	0.40	0.24	0.34
Crude fiber (%)	2.8	2.2	2.4
Acid detergent fiber (%)	3.8	2.8	3.5
Neutral detergent fiber (%)	12.7	9.6	11.0
Crude fat (%)	1.8	3.8	1.8
Calcium (%)	0.05	0.02	0.05
Phosphorus (%)	0.33	0.25	0.33
Metabolizable energy in pigs (kcal/kg)	3200	3350	3350

Table 2. Comparative chemical composition and energy value of triticale and other common grains for feeding animals in Europe (adapted from *Boros,* 2002; *Glamoclija et al.,* 2017a)

	Chemical composition (g kg^{-1}dry matter)						
Item	Maize	Wheat	Triticale	Rye	Oats	Sorghum	Millet
Crude protein	106	130	140	116	120	120	128
Crude fat	47	23	22	22	55	35	38
Cellulose	24	27	27	27	112	29	95
NFE[a]							
Starch	700	680	620	640	440	700	590
Sugar	20	31	55	50	18	15	10
Mineral mater	15	18	20	22	33	20	43
Calcium	0.4	0.8	0.9	0.9	1.2	0.4	0.5
Phosphorus	3.1	4.0	3.6	3.2	3.8	3.3	3.4
Digestible energy in pigs (MJkg^{-1} dry matter)	16.4	16	15.8	15.7	13.2	15.8	13.6

[a] NFE-Nitrogen free extract

Table 3. Proximate chemical composition of triticale, wheat and rye (% on dry basis) (*Myer and Lozano del Rio,*2004)

Cereal	Protein	Starch	Crude fibre	Ether extract	Free sugars	Ash
Spring triticale	10.3–15.6	57–65	3.1–4.5	1.5–2.4	3.7–5.2	1.4–2.0
Winter triticale	10.2–13.5	53–63	2.3–3.0	1.1–1.9	4.3–7.6	1.8–2.9
Spring wheat	9.3–16.8	61–66	2.8–3.9	1.9–2.2	2.6–3.0	1.3–2.0
Winter wheat	11.0–12.8	58–62	3.0–3.1	1.6–1.7	2.6–3.3	1.7–1.8
Spring rye	13.0–14.3	54.5	2.6	1.8	5.0	2.1

Pig production characteristics

Triticale is often the preferred feed grain for pigs in many countries worldwide. Triticale can be included without restriction as a high value, consistent quality cereal grain in least-cost formulations for growing pigs. It canbe used in either ground or pelleted form (*Myer and Barnett,*2000; *Van Barneveld,* 2002; *Salmon et al.,* 2004; *Sullivan et al.,* 2007; *Woyengo et al.,* 2014).

Even though triticale grain contains more proteinthan maize or grain sorghum, diets should be formulated to meet the essential amino acid (especially lysine) requirements of the pig rather than the crude protein requirements. If diets containing triticale were formulated on the basis of crude protein alone, lysine levels could be in adequate and pig performance would suffer (*Van Barneveld and Cooper,*2002). The crude protein concentration of triticale-based diets is usually higher than that of comparable maize-based diets when both diets contain equal levels of lysine (*Myer,*2002).

Typical pig diets formulated with triticale are given in Table 4 (*Myer and Lozano del Río,* 2004).

There are several advantages in feeding pigs triticale. Triticale is superior to barley in digestible energy levels for pigs and protein composition. Triticale digestible energy in pig diets is equivalent to wheat, and in young pig diets it is equivalent to corn, but triticale is cheaper than wheat or corn. Digestibility of dry matter and amino acids in the ileum of pigs fed triticale was generally higher than for barley (*Van Barneveld,* 2002). The superior protein quality and high yield potential of triticale grain has maintained international interest in using the crop as a pig feed (*GRAIN,* 2004). Generally, reports show that using triticale as a pig feed has been very successful. Producers have been able to replace other cereals, (e.g. wheat, corn, barley or millet) with triticale without losing productivity

Table 4. Examples of typical pig diets using triticale grain (*Myer and Lozano del Río,* 2004)

	Grower (20–50 kg)	**Finisher I (50–80 kg)**	**Finisher II (80–110 kg)**
Base feed constituents			
Ground triticale (%)	74.25	82.75	90.00
44% soybean meal (%)[a]	22.5	15.0	8.0
Base feed mix[b]			
Dicalcium phosphate (%)[c]	1.25	0.75	0.625
Limestone ground (%)	1.000	1.000	0.875
Salt (%)	0.50	0.25	0.25
Vitamin-trace mineral premix (%)[d]	0.50	0.25	0.25
Total	*100*	*100*	*100*
Calculated composition (as-fed basis)			
Crude protein (%)	18.8	16.5	14.4
Lysine (%)	0.96	0.77	0.60
Calcium (%)	0.75	0.62	0.55
Phosphorus (%)	0.64	0.53	0.48
Metabolizable energy (kcalkg^{-1})	3150	3170	3200

Legend: [a]Can replace ten parts of 44 percent soybean meal with nine parts of 48 percent soybean meal and one part of triticale.

[b]A complete mineral-vitamin premix or a complete mineral premix and separate vitamin premix canbe used instead of the suggested base mix. Follow manufacturer guidelines.

[c]Defluorinated phosphate or mono-dicalcium phosphate, if available, can be substituted for dicalcium phosphate. However, if a substitution is made, the diets need to be reformulated since these products contain different calcium and phosphorus levels than does dicalcium phosphate.

[d]Amounts shown are typical for many commercial products. Follow manufacturer guidelines.

Table 5. Feeding and carcass production results for market hogs in the 27–110 kg class, comparing corn, barley and triticale (*Jaikaran et al.,* 1998)

	Corn	Barley	Triticale	Barley/Triticale
Feeding results				
Daily feed intake (kg) (F)	2.50	2.53	2.50	2.66
Daily gain (kg) (G)	88.5	91.5	89.9	93.5
Feed efficiency (kg) (F/G)	2.85	2.87	2.81	2.86
Carcass production results				
Shipping weight (kg)	109.7^{ab}	109.1^{b}	110.7^{ab}	112.4^{a}
Shrink (%)	4.86	5.45	5.22	4.66
Dressing (%)	79.5^{a}	78.2^{b}	78.6^{ab}	79.0^{ab}
Backfat (mm)	19.7^{ab}	17.5^{b}	17.9^{b}	20.7^{a}
Estimated lean yield (%)	59.4^{ab}	60.2	60.2^{a}	58.7^{b}
Carcass cutout lean yield (%)	55.6^{ab}	56.6^{ab}	56.9^{a}	55.0^{b}

*Values with different superscript letters in a row are significantly different (p<0.05)

Table 6. Meat and carcass quality of market hogs fed on corn, barley or triticale (*Robertson et al.,* 1998)

	Corn	Barley	Triticale	Barley/ triticale
Final live weight and carcass data				
Shipping weight (kg)	109.7^{ab}	109.1^{a}	110.7^{ab}	112.4^{a}
Final live weight at abattoir (kg)	105.1	104.3	104.7	105.5
Warm carcass weight (kg)	87.8^{b}	86.2^{a}	86.8^{ab}	87.5^{ab}
Rib eye area (12^{th} rib) (cm^2)	35.70	36.46	37.90	35.35
Total cut out yield (g kg^{-1})	556.3	565.6	568.9	550.2
Meat quality (longissimus thoracis)				
pH 45 min	6.27	6.25	6.31	6.31
pH 48 h	5.55	5.53	5.59	5.57
Lightness (L*)	48.6^{a}	50.6^{b}	50.8^{b}	50.1^{ab}
Chroma (Cab*)	9.3	8.7	8.2	8.6
Drip loss ($mgkg^{-1}$)	29.1^{a}	38.7^{b}	28.3^{a}	30.7^{a}
Maximum shear value (kg)	4.85	4.77	5.00	4.88
Moisture ($mgkg^{-1}$)	747.9^{ab}	748.4^{ab}	749.0^{b}	744.9^{a}
Intra-muscular fat ($mgkg^{-1}$)	17.9	19.1	18.2	21.1
Total protein (mgg^{-1})	220.6	218.8	219.6	221.1
Boiled chop overall tenderness	5.39^{a}	6.18^{b}	5.55^{ab}	5.45^{a}

Values with different superscript letters in a row are significantly different (p<0.05)

Table 7. Comparison of carcass characteristics of pigs fed barley or triticale based diets (*Turyk et al.,* 2011)

Specification	Barley	Triticale	SEM*	Significance§
Body weight at slaughter(kg)	105.17	110.83	1.41	p<0.01
Cold carcass weight(kg)	83.70	87.00	1.32	p<0.05
Cold dressing(%)	79.62	78.45	1.87	NS
Meatiness(%)	57.47	58.40	0.47	p<0.05
Carcass length(cm)	80.17	81.00	0.39	NS
Backfat thickness(cm)				
Over the shoulder	3.12	3.30	0.20	NS
Mid back	2.00	1.90	0.24	NS
Over loin I	1.72	1.65	0.15	NS
Over loin II	1.10	0.93	0.11	p<0.05
Over loin III	2.00	1.92	0.17	NS
Average offive measurements	1.97	1.86	0.19	NS
Loin eye area (cm^2)	42.93	45.85	0.88	p<0.01
Weight of suet(kg)	1.20	0.94	0.09	p<0.01

*SEM – standard error of the mean; § – Student's t-test; NS – non significant

Table 8. Comparison of physical and chemical properties of meat from pigs fed barley or triticale based diets (*Turyk et al.,* 2011)

Specification	Barley	Triticale	SEM*	Significance§
Muscle *longissimus lumborum*				
Dry matter (%)	27.33	27.46	0.41	NS
Crude ash (%)	1.16	1.12	0.02	NS
Crude protein (%)	22.82	23.29	0.18	NS
Crude fat (%	3.45	3.31	0.72	NS
Muscle *semimembranosus*				
Dry matter (%)	25.13	25.12	0.19	NS
Crude ash (%)	1.18	1.17	0.01	NS
Crude protein (%)	22.94	23.08	0.12	NS
Crude fat (%)	1.33	1.06	0.01	NS
Muscle water holding capacity (%)				
longissimus lumborum	20.00	23.93	1.55	p<0.01
semimembranosus	17.60	19.07	1.35	NS
Muscle meat colour (L*)				
longissimus lumborum	48.22	47.30	0.76	NS
semimembranosus	44.02	41.78	0.89	p<0.05
pH45 min	6.34	6.32	0.07	NS
pH24 h	5.82	5.79	0.08	NS

*SEM – standard error of the mean; § – Student's t-test; NS – non significant

Table 9. Growth performance of pigs fed balanced diets containing triticale compared with wheat, barley or sorghum *(Van Berneveld and Cooper,* 2002)

	Gain ($gday^{-1}$)	Feed conversionratio (kg)	Gain ($gday^{-1}$); EBW* basic	Feed conversionratio (kg); EBW basic	Backfat depth at P2 position (mm)
Triticale	681	2.4	415	4.0	10.1
Wheat	677	2.5	400	4.2	10.3
Barley	662	2.7	377	4.7	9.3
Sorghum	653	2.6	369	4.6	10.2

*EBW – Empty body weight

or product quality. Triticale is also more cost-effective than its competitors, as its high lysine content means less protein supplement is required (*Mergoumet al.,* 2009).

Two Canadian studies (*Robertson et al.,* 1998; *Jaikaran et al.,* 1998) compared the grain source of 100% triticale with 100% corn, 100% barley and a 50:50 mix of barley and triticale. The studies compared 25 pig production, carcass and meat quality characteristics. Triticale performed similarly to the corn (control) diet for 24 characteristics, and similarly to the 50:50 barley and triticale mixture in all cases. The conclusion was that triticale could be successfully substituted for corn or barley in the diets of growing-finishing (25–110 kg) pigs. Pig production results during/after feeding with corn, barley, triticale or the mix of barley plus triticale are shown in Tables 5 and 6 (*Robertson et al.,* 1998; *Jaikaran et al.,* 1998; *Myer and Lozano del Rio,* 2004).

Turyk et al. (2011) concluded that the greater body weight of pigs fed triticale diets resulted in significantly ($p<0.05$) greater cold carcass weight at comparable dressing percentages. Pigs fed triticale-based diets had larger loin eye area and smaller suet weight (both $p<0.01$), and tended to have slightly thinner backfat over loin compared with animals on barley-based diets (Table 7). The same authors conducted physical and chemical analyses of meat from pigs fed barley-or triticale-based diets (Table 8).

Van Berneveld and Cooper (2002) (Table 9) concluded that use of triticale in pig diet results in better daily weight gain than diets based on wheat, barley or sorghum.

Conclusion

The general scientific belief is that triticale is an excellent feed choice for pigs. Its use results in few to no feeding problems, and it is a suitable substitutefor other grains. When triticale substitutes other grains, ration costs are lower because less soymeal or other protein meal supplements are needed. Triticale varieties are used in pig diets to supply levels of digestible amino acids and digestible energy equal or better to those in wheat-, barley-, or corn-based diets. Finally, the performance of growing pigs, production characteristics and meat quality parameters are equal or better than when pigs are fed wheat-, barley-, or corn-based diets. Overall, the available scientific knowledge indicates that triticale can be used in pig diets without restriction.

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