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Original article

Performance, carcass quality and cost benefit of pigs fed graded levels of dried brewers' grains

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ABSTRACT

Twelve Large White weaner pigs with average live weight of 7.55 kg (range 7.00-7.90 kg) were used to evaluate the performance, carcass quality and cost benefit of pigs fed graded levels of dried brewers' grains (DBG). The diets contained 0, 25, 35 and 45% DBG in treatments T1, T2, T3 and T4 respectively. The experiment was in a completely randomized design (CRD) with each treatment being replicated three times. Fortnightly live weight, daily feed intake, feed cost and final carcass quality of pigs were recorded. Results showed that pigs fed T3 had significantly ($P<0.05$) higher live weight gain than other treatments during all the stages. However, pigs on T4 had significantly ($P<0.05$) higher feed intake (1.32 kg) than those on other treatments during the weaner stage. At the grower stage pigs fed on T3 had weight gain and feed conversion ratio (FCR) similar to the control diet. Back fat (1st rib) thickness, dressing out percentage and carcass length in T3 diet was significantly ($P<0.05$) reduced. There was also a reduction of feed cost with increased inclusion of DBG; with diet T3 having the highest gross margin and T2 had the lowest. It is concluded that in growing pigs the inclusion of 35% DBG in pig diets gives highest economic return without affecting performance.

1. Introduction

The use of agro industrial by- products such as wheat bran and dried brewers grains appears to be an available option for most resettled farmers in Zimbabwe in light of the marginal yearly price increase of commercial concentrates since the implementation of the land reform programme in 2000 and the subsequent adoption of the multiple currency system in 2009. In Zimbabwe oilseed cakes or meals from soya bean, cotton and sunflower are mainly used as a protein source in commercial concentrates (Mutambara, 2013). However, these cakes have increasingly become expensive and/or unavailable due to drought induced low farm output. For example, the total production of soya beans in 2004/5 agricultural season was 40,000 tonnes against a national requirement of 200,000 tonnes (Mpepereki, 2006).

Dried brewers grain (DBG) is a solid waste from the brewery industries. Chibuku Breweries a subsidiary of Delta Beverages is one of the successful agro processing companies in the country. The Brewing Company has manufacturing plants in major cities and towns in Zimbabwe; therefore providing a ready source of cheap brewer's waste that can serve as an alternative protein source. According to Nguyen Thanh Phi Long (1996) brewer's grains are quite high in protein (27-33% DM); though also high in fibre can be a potential cheap and affordable alternative source of proteins in monogastric diets, especially amongst smallholder farmers who have access to them. Apart from curbing environmental pollution the use of DBG also increases the options of protein sources farmers can use in pig production systems. Although brewers' grains are available and cheap, it is difficult to dry them to low moisture content for easy storage and use, especially during the wet season. There is wide variability in the proximate composition of DBG depending on the brewery that produced it (Rijal et al., 2009). Brewers grain has long been used for pig production as cited by several researchers such as Leick et al., (2006), Amaefule et al., (2006), Amaefule et al., (2009), Aguilera-Soto et al., (2009) and Albuquerque et al., (2012). The inclusion rates recommended when using DBG ranges from 20 to 50% (diet DM) in growing pigs. According to Chenost and Mayer (1977), it is crucial to integrate animal production into allied processing industries to ensure that animals play a complimentary rather than a competitive role with men in meeting feed requirements. The objective of the study was to determine the performance, cost benefit and carcass quality of pigs fed graded levels of dried brewer's grains.

2. Materials and methods

2.1. Study site

The study was carried out at Chinhoyi University Farm in Mashonaland West Province in Zimbabwe (17o21'N, 30o10'E) located 6km south of Chinhoyi along the Harare – Chirundu highway. The vegetation mainly comprises of tree savanna or bush clump with tall perennial grasses such as Hyparrhenia filipendula on red clay soils. Associated woody species include Brachystegia spiciformis, Julbernadia globiflora and Acacia species. The farm lies on an altitude of 1200m. Rainfall is confined to summer (November to March) and is moderately high (750-1000mm). The mean annual temperature ranges from 20o to 30oC.

2.2. Experimental design

Twelve male Large White weaner pigs 45 days old with initial live weight ranging from 7.00 to 7.90 kg (average 7.55 kg) were used in a completely randomized design. Experimental units (pigs) were randomly allocated to four dietary treatments (T1, T2, T3 and T4) containing 0% DBG, 25% DBG, 35% DBG and 45% DBG as presented in Tables 1 and 2. Experimental diets and dried brewers grains were analyzed for proximate composition according to the method of A.O.A.C (1990). Each treatment was replicated three times. The brewer's grains (sorghum and maize) used in the study were obtained from Chibuku Brewery and sun dried on polyvinyl chloride plastics.

2.3. Housing and management of pigs

The pigs were housed individually in 2m x 2m pens with concrete floors and roofed with asbestos sheets. The pigs were ear-notched for easy identification thus 1, 2, 3 and 4 to coincide with treatments T1, T2, T3 and T4 respectively. Each pen had a fixed concreted trough for feed and water. Water was provided ad libitum. The pigs were fed dry mash twice a day at 09,00hrs and 14,00hrs. The pigs were dewormed with a commercial antihelmintic and given an antibiotic injection to ensure good health before exposure to treatment diets. Left over feed was recorded every day before new feed was offered.

Table 1
Percentage composition of the experimental diets of graded levels of dried brewers' grains.

Feedstuff	T1 (control)	T2 (25%)	T3 (35%)	T4 (45%)
White maize	50	40	33	25
Soya Bean Cake	25	15	15	15
Bone meal	6.40	6.40	6.40	6.40
Dried Brewers Grains	0	25	35	45
Wheat Bran	18	13	10	8
Vitamin Premix	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30
Total (%)	100	100	100	100
Calculated,				
CP (%)	17.65	17.25	17.80	18.30
ME(MJ/Kg)	11.46	11.68	11.41	11.10
CF (%)	4.36	8.81	9.71	10.61
Lysine	0.58	0.73	0.77	0.80
Methionine (%)	0.26	0.29	0.30	0.31
Ca (%)	1.43	1.43	1.43	1.43
Avail P (%)	0.58	0.58	0.58	0.58

Table 2
Proximate composition of DBG and diets of graded levels of DBG (%DM basis).

Composition (%)	T1	T2	T3	T4	DBG
Dry Matter	91	92	91.60	91.30	89.50
Crude Protein	20.92	22.70	20.45	21.68	22.50
Ether Extract	6.11	4.60	6.15	5.65	6.25
Crude Fibre	5.00	8.90	9.80	10.63	20.80
Ash	7.81	8.45	8.30	8.10	4.80
Nitrogen Free Extract	51.20	47.40	46.83	45.34	35.07

2.4. Growth performance

Data were collected for two growth stages namely weaner and grower, although, there was no change in diets. The pigs were also not relocated. The weaner and grower stages lasted 42 days each. Growth performance was evaluated at the weaner and grower stages. Pigs were weighed at the start of the experiment and subsequently every 14 days. Weight gain was calculated as final live weight minus initial live weight. Feed intake was obtained as the difference between the quantity offered and quantity refused. Feed conversion ratio (FCR) was calculated using the equation, FCR = Feed intake / weight gain.

2.5. Cost benefit analysis

Cost-benefit and carcass quality were assessed at the end of the experiment. The cost per kg of the diet was calculated by multiplying the percentage composition of feedstuffs with the price per kg of each feedstuff and summing up. Total feed cost (TFC) was calculated using the equation, TFC = Total feed intake x cost per kg feed. Total feed cost was assumed to constitute 70% of the cost of production. Thus the cost of production = (10 x feed cost) / (7 x total weight gain). The cost benefit was calculated as price per kg pork minus cost of producing 1 kg of pork.

2.6. Carcass evaluation

Prior to slaughter the pigs were deprived of feed overnight but with free access to water. The hot carcass weight was obtained immediately after slaughter. The carcasses were hanged and refrigerated at 3-5oC for 24 hours allowing for further evaluation of carcass length and back fat. Back fat thickness was measured using a Vernier caliper at the 1st and 4th ribs. The carcass length was measured from the anterior edge of the first rib to the anterior edge of aitch bone.

2.7. Data analysis

Data on growth, feed consumption, live weight and carcass quality were statistically analyzed through one way Analyses of Variance using the GLM procedures of SAS (2000) at 95% confidence interval while test for significant differences among treatment means were done using the Tukey test (Steel and Torrie, 1980).

3. Results

3.1. Daily feed consumption

Mean daily feed consumption (kg) by pigs is presented in Table 3. The feed consumption increased by fortnight and differed significantly (P<0.05) among the different treatments. However, feed consumption in the final week (2.27 kg) did not differ significantly (P> 0.05) among the treatments.

Table 3
Mean feed consumption (kg) of Large White pigs fed diets containing graded levels of DBG.

Treatments	**Fortnightly Feed Consumption**					
	2	4	6	8	10	12
T1	0.71^{b}	1.04^{b}	1.32^{b}	1.72^{c}	2.10^{d}	2.27
T2	0.67^{a}	1.00^{a}	1.31^{a}	1.64^{a}	1.99^{a}	2.27
T3	0.67^{a}	1.10^{d}	1.31^{a}	1.71^{b}	2.05^{b}	2.27
T4	0.75^{c}	1.05^{c}	1.32^{b}	1.72^{c}	2.08^{c}	2.27
Grand mean	0.70	1.02	1.32	1.70	2.06	2.27
P-Value	<.001	<.001	0.034	<.001	<.001	1.00
CV%	1.9	0.5	0.2	0.1	0.2	0.1
LSD	0.0249	0.0099	0.0060	0.0029	0.0076	0.0049

Means within columns with different superscripts are significantly different (P<0.05).

3.2. Performance of large white pigs during the weaner stage

The performance of pigs fed different levels of DBG at the weaner stage is presented in Table 5. The final weight and daily feed intake was significantly (P<0.05) reduced among pigs fed 25% dried brewers grains. Pigs fed T3 had significantly higher (P<0.05) live weight (22.76 kg) and daily weight gain (0.37 kg), however, they had a significantly (P<0.05) low FCR of 3.58 followed by the control (3.80), T4 (3.90) and finally T2 (3.95).

Table 4
Performance of weaner Large White Pigs fed graded levels of DBG.

Parameter	**T1**	**T2**	**T3**	**T4**	**P-Value**	**CV%**	**LSD**
Initial live weight (kg/pig)	7.60	7.40	7.40	7.80	0.179	3.0	0.431
Final live weight (kg/pig)	22.19^{c}	21.33^{a}	22.76^{d}	22.02^{b}	<.001	0.2	0.082
Daily weight gain (kg)	0.35^{b}	0.33^{a}	0.37^{c}	0.34^{ab}	<.001	1.8	0.012
Daily feed intake (kg)	1.32^{b}	1.31^{a}	1.31^{a}	1.32^{b}	0.034	0.2	0.006
FCR	3.80^{b}	3.95^{c}	3.58^{a}	3.90^{bc}	<.001	1.9	0.133

Means in a row with different superscripts are significantly different (P<0.05).

3.3. Performance of Large White pigs during the grower stage

The performance of pigs fed different levels of DBG diets at the grower stage is presented in Table 5. Daily feed intake did not significantly differ (P>0.05) between the pigs fed the control and DBG diets.

Table 5
Performance of grower Large White pigs fed graded levels of DBG.

Parameter	T1	T2	T3	T4	P-Value	CV%	LSD
Initial live weight (kg/pig)	22.19^{c}	21.33^{a}	22.76^{d}	22.02^{b}	<.001	0.2	0.082
Final live weight (kg/pig)	49.35^{c}	44.84^{a}	49.92^{c}	46.25^{b}	<.001	0.8	0.707
Daily weight gain(kg)	0.65^{c}	0.56^{a}	0.65^{c}	0.58^{b}	<.001	1.4	0.0162
Daily feed intake(kg)	2.27	2.27	2.27	2.27	1.00	0.0	0.004
FCR	3.51^{a}	4.06^{c}	3.51^{a}	3.94^{b}	<.001	1.7	0.1182

Means in arrow with different superscripts are significantly different (P<0.05).

3.4. Cost –benefit

Cost –benefit analysis of feeding dried brewers grain is shown in Table 6. In general there was a reduction in feed cost with increasing levels of DBG. As expected the control diet gave the highest total feed cost, feed cost per kg weight gain and total cost of production than the DBG diets due to the higher cost per kg of maize which was US$0.25 against US$0.04 for DBG. T3 diet gave the highest gross margin US $1.79 showing that it is more economical and beneficial to include DBG at 35% of the diet.

Table 6
Cost –benefit of feeding graded levels of dried brewer's grains to Large White pigs.

Cost	T1	T2	T3	T4
Cost per kg feed (US$)	0.75	0.66	0.64	0.61
Total feed intake (kg)	128.24	124.36	126.15	128.59
Total weight gain (kg)	41.75	37.44	42.52	38.45
Total feed cost (US$)	96.18	82.08	80.74	78.44
Cost per kg weight gain (US$)	2.30	2.19	1.90	2.04
Total cost of production (US$)	3.29	3.13	2.71	2.91
Price per kg pork (US$)	4.50	4.50	4.50	4.50
Gross margin (US$)	1.21	1.37	1.79	1.59

3.4. Carcass quality

The carcass quality of pigs fed different levels of DBG is shown in Table 7. The pigs fed on diet T3 had a significantly (P<0.05) lower dressed weight percentage, carcass length and back fat (1st rib) thickness than those fed all other diets. This suggests that the pigs used much of their energy for tissue accretion rather than fat deposition. The difference in carcass length is likely to have been caused by individual differences amongst the pigs.

Table 7
Carcass quality of Large Whites pigs feed graded levels of dried brewer's grains.

Parameter	T1	T2	T3	T4	P-Value	CV%	LSD
Dressed weight (%)	60.55^{b}	61.43^{c}	59.68^{a}	61.71^{c}	0.001	0.7	0.764
Back fat thickness							
1st rib (cm)	1.85^{c}	1.70^{b}	1.28^{a}	1.95^{d}	<.001	1.5	0.048
4thrib (cm)	1.35^{d}	1.19^{b}	1.29^{c}	0.79^{a}	<.001	1.5	0.032
Carcass length (cm)	86.78^{c}	76.17^{b}	65.06^{a}	76.09^{b}	<.001	0.1	0.095

Means in the same row with different superscripts are significantly different (P<0.05).

4. Discussion

The results agree with those of (Amaefule et al., 2006) who also recorded low feed conversion ratio with 35% DBG at the weaner stage with the highest inclusion level of 40% DBG. The results also tally with the findings of (LuuHuuManh et al., 2000; 2003) who also observed better feed conversion ratio with 30% replacement of fishmeal protein with the brewers waste with maximum inclusion levels of 100% wet brewer's grains. The overall performance of weaner pigs fed DBG could be considered very good considering that the diets had high crude fibre (CF) content though it was not in excess of the 15% level above which feed intake and growth rate are depressed (Kornegay, 1973).

While the crude protein contents were within the range recommended by the National Research Council (1998) the energy contents were lower, suggesting that microbial fermentation in large intestines may have contributed significantly in meeting the energy requirement of pigs (McDonald et al., 1988). The slightly reduced daily weight gain for diet T2 can be attributed to the high dry matter percentage of the diet and this could have interfered with nutrient digestibility.

The similarity in the daily feed intake amongst treatments in the 12th week, thus the finishing period is not only because of the increased body size but also because of the higher feed requirements per unit body weight gain; this is a reflection of fat deposition which is associated with more energy per unit gain, (National Research Council, 2001). Rather, 25% DBG diet significantly ($P<0.05$) reduced final live weight and significantly ($P<0.05$) increased FCR of pigs (4.06) when compared to the control and 35% DBG diets both of which had FCR of 3.51 respectively.

The results of performance of pigs fed 35% DBG compared favourably with those fed the control diet in all the performance parameters considered. This may be due to the similarity of their crude protein contents (Table 2). Those fed control diet and 35% DBG had similar daily weight gain and FCR showing that the 35% DBG diet as good as the control, while the lower weight gain and higher feed conversion ratio for pigs fed 25% DBG and 45% DBG clearly indicate that 35% was the optimum inclusion level, below or above which weight gain and feed conversion ratio (FCR) may be affected. This is supported by Amaefule et al., (2006) and Aguilera-Soto et al., (2009) who reported DBG inclusion level of 35% could be recommended for good average daily gain and feed efficiency with inclusion rates higher than this level tending to have a depressive effect on the two parameters. In the study by Amaefule et al., (2006) with maximum inclusion level of 40% DBG in 18% CP maize- groundnut cake meal diets, FCR was the same for the control and 35% DBG. The performance of the 45% DBG can best be explained by the bulky nature of DBG that depressed feed intake and nutrient digestibility at high inclusion levels (Aguilera-Soto et al., 2009).

In addition, Meffeja et al., (2007), evaluated diets with 0, 20, 30 or 40% of ensiled wet brewer's grains (WBG) and reported that dry matter intake increased linearly; however, DM digestibility was similar in 0, 20 or 30% treatments (mean = 72.1%) and decreasing to 63.4% on 40% treatment. During fermentation of diets some nutrients may be modified. Canibe et al., (2007) reported that some amino acids were deaminated mainly by bacteria during fermentation, then protein quality and pig performance could be affected. Pigs used in the current study did not develop skin disorders such as scabs suggesting that brewer's gains had adequate amounts of zinc. Furthermore though the diets contained lysine and methionine and energy levels below the National Research Council (1998) recommendations they did not show any signs of unthriftiness associated with amino acid deficiencies suggesting that microbial fermentation in the gut may have compensated for the shortfall.

Amaefule et al., (2006) reported similar results, suggesting that there might not be increased financial benefits if DBG exceeded 35% of the diet. LuuHuuManh et al., (2000, 2003) also observed reduced feed cost with increasing levels of wet brewers grains with maximum inclusion levels of 100%, as wet brewers grains were cheaper than the fish meal it replaced. However, this advantage was offset by the poorer performance on the diets with increased wet brewers grain, thus there was little difference between the gross margin over feed cost between the control diet and that with 30% replacement of fish meal protein by wet brewers grains, while with higher levels of wet brewers grain the margin over feed was less than the control diet. The low recommendation of 30% wet brewers grains can be attributed to their bulkiness and slightly low energy content compared to DBG (Wyss, 1997). Therefore, the optimum economic inclusion level of dried brewer's grains in pig diets was 35%, since cost minimization and gross income optimization is observed at this level.

The carcass quality obtained in this study could not be attributed to any factor though the results agree with the findings of Yaakugh et al., (1994) and Pelevina (2007) that dried brewers grains did not affect carcass quality of hybrid pigs. Furthermore, Whitney et al., (2001) conducted a study on growth performance and carcass evaluation where grow-finish pigs were fed diets containing 0, 10, 20 and 30% maize dried brewer's grains. They also arrived at the same conclusion that they were no differences in carcass lean or muscle quality of pork carcass fed increasing levels of dried brewer's grain. However, belly firmness declined linearly and iodine value (degree of unsaturated versus saturated fatty acid in pork fat) increased as increasing levels of brewer's grains were added to grower-finisher diets. However, depending on the market, the effect of feeding dried brewers grains (DBG) on pork fat quality are generally not a concern.

5. Conclusion

Dried brewer's gains are an alternative safe and cheap source of feed that can be incorporated in pig diets. However, though feed costs are reduced with higher inclusion levels this in turn depresses performance. We conclude that the optimum inclusion level of dried brewers' grains in pig diets that increase the economic return of the producer is 35%.

References

Aguilera-Soto, J.I., Ramirez, R.G., Arechiga, C.F., Gutierrez-Banuelos, H., Mendez-Llorente, F., Lopez-Carlos, M.A., Pina-Flores, J.A., Rodriguez-Frausto, H., Rodriguez-Tenorio, D., 2009. Effect of fermentable liquid diets based on wet brewers grains on performance of growing pigs. J. Appl. Anim. Res., 36 (2), 271-274.

Albuquerque, D.M., de, N., Lopes, J.B., Segundo, L.F., de, F., Brandão, T.M., Ribeiro, M.N., Ramos, L., de, S.N., Figueirêdo, A.V., de., 2012. Dehydrated brewery residue for pigs in the growth phase under high temperature conditions. Rev. Bras. Zoot., 41 (7), 1784-1788.

Amaefule, K.U., Onwudike, O.C., Ibe, S.N., Abasiekong, S.F., 2006. Performance, cost benefit, carcass quality and organ characteristics of pigs fed high graded levels of brewers' dried grain diets in the humid tropics. Pakistan J. Nutr., 5 (3), 242-247.

Amaefule, K.U., Onwudike, O.C., Ibe, S.N., Abasiekong, S.F., 2009. Nutrient utilization and digestibility of growing pigs fed diets of different proportions of palm kernel meal and brewers dried grain. Pakistan J. Nutr., 8 (4), 361-367.

A.O.A.C., 1990. Official methods of Analysis. Association of official Analytical Chemists, Washington DC USA.

Canibe, O., Hojberg, Badsberg, J.H., Jensen, B.B., 2007. Effect of feeding fermented liquid feed and fermented grain on gastrointestinal ecology and growth performance in piglets. J. Anim. Sci., 85, 2959-2971

Chenost, M., Mayer, L., 1977. Potential contribution and use of agro-industrial by-products in animal feeding. In, New feed resources proceedings of a technical consultation held in Rome, 22-24 November, 1977 1-27.http,//www.fao.org/DOCREP/004/X6503E/X6503EOO.HTM

Kornegay, E.T., 1973. Digestible and metabolizable energy and protein utilization values of brewers' dried by-products for swine. J. Anim. Sci., 37 (2), 479-483

Leick, C.M., Puls, C.L., Ellis, M., Killefer, J., Carr, T.R., Scramlin, S.M., England, M.B., Gaines, A.M., Wolter, B.F., Carr S.N., McKeith, F.K., 2010. Effect of distillers dried grains with solubles and ractopamine (Paylean) on quality and shelf-life of fresh pork and bacon. J.Anim. Sci., 88,2751-2766.

Luu, H.M., Tran, C.B., Nguyen, N.X.D., Bui, P.T.H., 2000. Composition and nutritive value of rice distiller's by-products (hem) for smallholder pig production. Sustainable Livest. Product. Local Feed Res. Proceedings National Seminar –Workshop .UAF, SIDA-SAREC.http,//www. mekarn .org/sarec2000/manh.htm.

Luu, H.M., Tran, C.B., Nguyen, N.X.D., Lindderg, J.E., 2003. Effects of replacement of fish meal with rice distillers waste (hem) on performance and carcass quality of growing pigs. (Editors, Reg Preston and Brian Ogle). Sustainable Livestock Production on Local Feed Resources.Proceedings Final-Seminar-Workshop.UAF, SIDA-SAREC. Http, // www.merkan. org/Saec03/manhcatho03.htm.

McDonald, R.A., Edward, J.F.D., Greenhalgh, J.F.D., Morgan, C.A., 1988. Animal Nutrition (5ed). Pearson Education limited, Edinburgh United Kingdom.

Meffeja, F., Njifutie, N., Manjeli, Y., Tchoumboue, J., Tchakounte, J., 2007. Comparative digestibility of diets containing ensiled brewer's grains, palm kernel cake or cocoa pod husk in growing finishing pigs in Cameroon. Livest. Res. Rur. Dev., 19 (5), 70.

Mpepereki, S., 2006. Soya Production, Talking Farming, (Zimbabwe Broadcasting Television show, 10 January 2006).

Mutambara, J., 2013. A preliminary review of regulatory constraints affecting pig industry in Zimbabwe. *Livestock Research for Rural Development*. Volume 25, Article #43. Retrieved June 18, 2014, from http,//www.lrrd.org/lrrd25/3/muta25043.htm.

National Research Council., 1988. Nutrient Requirements of Swine. 9th Revised edition National Academy Press, Washington, DC.USA.

National Research Council., 2001. Nutrient requirements of dairy cattle. 7th Revised Edition, Subcommittee on Dairy Cattle Nutrition, Committee on Animal Nutrition, Board on Agriculture and Natural Resources, National Research Council, National Academy Press, Washington, DC, USA.

Nguyen Thanh Phi Long., 1996. A study of utilizing of food processing by-products for smallholder farmers in Mekong Delta. Graduate thesis. Agr. College Cantho Univ.

Pelevina, G., 2007. Brewer's grains in feed rations for pigs. Redaktsiya Zhurnala Svinovodstvo 4,18-20.

Rijal, T.B., Nepal, D.B., Sah, R.A., Sharma, M.P., 2009. Economic use of brewers grains in the diets of swine. Nepal J. Sci. Technol., 10(2009) 29-35.

SAS Institute Inc., 2000. SAS Users Guide Statistics. Version 604 edition. Cary, North Carolina, U.S.A.

Steel, R.G., Torrie, J.H., 1980. Principles and Procedures of Statistics. McGraw-Hill Book Company, New York, USA.

Whitney, M.H., Shurson, G.C., Johnston, L.J., Wulf, D., Sharks, B., 2001. Growth performance and carcass quality characteristics of grow-finish pigs fed increasing levels of distillers dried brewers gains with soluble. J. Anim. Scie., 79,108(suppl.1).

Wyss, U., 1997. Ensiling of brewers' grains, high effluent production and good fermentation quality. Agr., 4 (3), 105-108

Yaakugh, I., Tegbe, T.S.B., Olorunju, S.A.S., Aduku, A.O., 1994. Replacement value of brewers dried grain for maize on performance of pigs. J. Sci. Food Agric., 66 (4), 465-471.