Original scientific paper
Journal of Central European Agriculture, 2019, 20(3), p.788-795
DOI: /10.5513/JCEA01/20.3.2426

Nutritional usability of thermal treated white and brown bread in broiler feed

Hranidbena vrijednost termički dorađenog bijelog i crnog kruha u hranidbi brojlera

Tajana KRIČKA, Zlatko JANJEČIĆ, Nikola BILANDŽIJA, Dalibor BEDEKOVIĆ (✉), Neven VOĆA, Ana MATIN, Vanja JURIŠIĆ, Mateja GRUBOR

University of Zagreb Faculty of Agriculture, Svetosimunska 25, 10000 Zagreb, Croatia

✉ Corresponding author: dbedekovic@agr.hr

ABSTRACT

Growing consumer demand for safe and affordable food as well as the need for a sustainable food supply will force the producers to explore methods for production output increasing. The poultry industry has an important role in the provision of a sustainable food supply, especially because chickens have a high feed conversion efficiency compared to other birds or livestock and, chicken meat is a low greenhouse gas emission food compared to other sources of dietary protein and has accessible source of protein with a low-fat content. The most important aspect of broiler production is feeding, and it represents about 70% of total costs. In order to facilitate the broilers, feed mixture production, it is tending to replace corn component, with a new, cheaper but high-quality component. As an alternative, it is possible to use the old bread, which would enable its remediation. Its use in broiler feeding is possible only after thermal treatment. Following this work will include the possibilities of using 5 and 10% of the old white and brown bread share in broilers feed mixture after thermal processing by extrusion. Feeding with both types of old extruded bread proved to be satisfying and did not affect broilers performance so generally dried bread can be used in chicken feed by as a partial replacement for maize component. Although both breads have proved good feeding quality, slightly better results were obtained in feeding with 10% share of brown bread.

Keywords: broilers performance, extruding, feeding, nutritional value, old bread

SAŽETAK

Rastuća potražnja potrošača za sigurnom i pristupačnom hranom, kao i potreba za održivom opskrbom hranom prisilit će proizvođače da istraže načine povećanja proizvodnje. Peradarska industrija ima važnu ulogu u osiguravanju održive opskrbe hranom, posebno zato što pilići imaju visoku učinkovitost konverzije hrane u odnosu na druge ptice ili stoku, a pileće meso je hrana niske emisije stakleničkih plinova u usporedbi s drugim izvorima prehrambenih proteina i ima pristupačan izvor proteina s niskim udjelom masti Najvažniji aspekt proizvodnje brojlera je hranidba, koja predstavlja oko 70% ukupnih troškova. Kako bi se olakšala proizvodnja krmnih smjesa za piliće, teži se zamjeni komponentu kukuruza novom, jeftinijom ali kvalitetnijom komponentom. Kao zamjensku komponentu, moguće je koristiti stari kruh čime bi se istovremeno omogućila njegova sanacija. Njegova uporaba u hranidbi brojlera moguća je samo nakon termičke dorade. Temeljem navedenog, ovaj rada obuhvaća mogućnosti korištenja 5 i 10% udjela starog bijelog i crnog kruha, u krmnoj smjesi za brojlere, nakon termičke dorade ekstruzijom. Hranidba s oba tipa starog ekstrudiranog kruha pokazala se zadovoljavajućom i nije utjecala na prirast brojlera pa se općenito, sušeni kruh može koristiti u hranidbi pilića kao djelomična zamjena za kukuruznu komponentu. Iako su se obje vrste kruha pokazale kvalitetne prilikom hranjenja, nešto bolji rezultati dobiveni su u hranidbi s 10% udjela starog crnog kruha.

Ključne riječi: proizvodni pokazatelji brojleri, ekstrudiranje, hranidba, hranidbena vrijednost, stari kruh

INTRODUCTION

According to current global predictions, poultry meat by 2025 will achieve the highest production and consumption level, over beef, veal, pork and sheep (OECD/FAO, 2016). This can be related to the fact that chicken meat is an affordable and accessible source of protein with a low-fat content (King et al., 2017a). By the year 2050 global population is expected to reach 9 billion, and based on recent trends above mentioned as well as increased income growth among poorer populations, will lead to increase in animal protein demand (King et al., 2017b). Due to this, the poultry industry has an important role in the provision of a sustainable food supply, especially because chickens have a high feed conversion efficiency compared to other birds or livestock (Food and Agriculture Organization, 2010) and, chicken meat is a low greenhouse gas emission food compared to other sources of dietary protein (Caro et al., 2017).

Growing consumer demand for safe and affordable food as well as the need for a sustainable food supply will force the producers to explore methods for production output increasing. The most important aspect of broiler production is feeding, and it represents about 70% of total costs. Considering the mentioned there is a need for costly maize partial replacement by some other energy source which is available at a cheaper rate.

Therefore, for the broiler feed industry economy it is very important to find an ingredient, if possible locally produced, which can partially replace corn component without negatively affecting performance of the broilers (Al-Tulaihan et al., 2004). During the search for maize alternative source it was noticed that bakery waste was abundantly available as a cheaper component than maize (Yadav et al., 2014). Already in 1965, Damron et al. (1965) state that the dried <bakery product at 10% can be included in broiler feed without a negative effect on their performance. Also, Dabron et al. (1999) and Al-Tulaihan et al. (2004) state that a by-product of bakery industry (bread waste), is rich in energy and vitamins, low in fiber and can be used to replace maize in the broiler diet which also automatically reduce feed cost.

Food waste was used for many years as animal feed. However, its nutrient components are chemically unstable and the waste putrefactive degradation can begin within a few hours after the waste is discarded (Chung, 2001). If the waste is not properly preserved or processed, spoilage and pathogenic microorganisms may appear (Jo, 2001). The waste processing must eliminate any pathogens prior to feeding (Kwak and Kang, 2006). Processing methods of waste food before feeding must include drying to less than 14% moisture (Westendorf et al., 1998; Nam et al., 2000). Critical disadvantages of waste food drying are high fuel cost, considerable nutrient loss and depressed animal performance (Westendorf et al., 1998; Nam et al., 2000; Chung, 2001).

Extrusion is a thermal process which could increase nutrient digestibility of old bread and can ensure the use of old bread in broiler feed. Increase in nutrient digestibility during extrusion could occur through physical disruption of cell walls as well as cleavage of nonstarch polysaccharides into smaller fragments, thus significantly reducing their antinutritive effect. (Meng et al., 2005; Oryschak et al., 2010). Extrusion also increase digestibility of particular nutrients in bread through altering their protein structure, chemical characteristics or function (Camire, 1991). Extrusion can significantly disrupt cellular structures within a grain as well as gelatinize the starch components, but the increase in energy yield must be significant if the processing costs tend to be justified (Van Barneveld et al., 2005).

Based on the above, aim of this paper is to evaluate the use of thermally processed by extruding old white and brown wheat bread levels (5% and 10%) in broilers feed and to propose a technology for unused old wheat bread remediation for chicken feeding purposes.

MATERIALS AND METHODS

In the study, 600 one-day male broilers (Cobb 500) were used. Chickens were classified into twenty groups of 30 individuals in each group by random selection. Three groups with four repetitions were formatted: the P-0 group without adding of old bread to the feed (four groups), the P-5 group with 5% of white old bread added to the feed mixture (four groups), and the P-10 group with 10% of the white old bread added to the feed mixture (four groups), and also the P-5 group with 5% of brown old bread added to the feed mixture (four groups), and the P-10 group with 10% of the brown old bread added to the feed mixture by replacing the maize component (four groups). The old bread was thermally treated by extruding.

Chicken were fed ad libitum and the nutrition treatment was divided into two phases. In the first phase at the age of chickens from 1 to 21 days, the chickens consumed the initial feed mixture (starter), and in the second stage from 22 to 42 day, the final feed mixture (finisher).

Table 1 shows the old white and brown extruded bread chemical analysis.

Table 1. Chemical analysis of raw material

Parameter	White bread	Brown bread
Moisture (%)	10.31	8.65
Crude ash (%)	1.9	2.03
Crude protein (%)	10.87	11.13
Crude fat (%)	0.67	0.96
Crude fiber (%)	0.37	0.44
Calcium (%)	0.6	0.7
Phosphorus (%)	0.19	0.19
Sodium (%)	0.97	0.26

Table 2 and 3 shows the recipe mixtures used for feeding and the chemical analysis of used feed mixtures.

During this nutrition exercise old white and brown extruded bread and the used mixtures were analyzed in order to determine moisture content (HRN ISO 6496:2001), ash (HRN ISO 5984:2004), crude proteins (HRN EN ISO 5983-2:2010), fat (HRN ISO 6492:2001, modified by guidelines of the ANKOM XT 15 extraction system), crude fiber (HRN EN ISO 6865:2001 modified by guidelines from FOSS Fiber Cap manual), calcium (RU-5.4.2-11, 1st edition), phosphorous (HRN ISO 6491:2001), sodium (HRN ISO 7485:2001) and metabolic energy by calculation. Metabolizable energy (ME) is calculated as apparent metabolisable energy corrected to zero N-retention (AMEn) according to Jansen (1998).

The chickens body mass, feed conversion, mortality and slaughter indicators was monitored.

At the end of investigation ten chickens from each experimental unit (total 120) were slaughtered by mechanical stunning, followed by bleeding (the carotid artery and the external jugular vein were cut) near the occipital bone and the atlas. After bleeding, birds were placed in a scalding tank with an average temperature of 60 °C for a maximum period of 2 minutes, and then immediately defeathered. Carcasses were eviscerated on stainless steel tables, and their giblets and abdominal fat were collected. Carcasses were individually packed in plastic bags, and chilled in a chilling room at 5 °C for 24 hours. After this period, carcasses were weighed and cut up in commercial parts: breast, drumstick, thighs, feet, back, neck, and wings. Carcass weight (CW) considered whole slaughtered birds, with neck and feet, and no head, abdominal fat or giblets. Carcass yield (CY) corresponded to the ratio between carcass weight after chilling (CW) and body weight at slaughter (BWs), and was calculated according to the following formula:

$$CY\ (\%) = CW/BWs*100.$$

RESULTS AND DISCUSSION

The old extruded bread proved to be a quality and healthy raw material source for chicken feed mixture preparing. Chemical analyzes have been found to contain about 11% proteins, about 0.4% fibers, and about 0.7-1% fat.

Tables 4 and 5 shows the chicken's production indicators results in the period from 1 to 21 day and from 22 to 42 day.

In first 21 days during the adding of both types extruded old breads to the mixture, the body weight

Table 2. Starter mixture recipe (SMR) with extruded breads component and used feed mixtures chemical analysis

	Control group	White bread		Brown bread	
Ingredient (%)	SMR1 (0%)	SMR2 (5%)	SMR3 (10%)	SMR2 (5%)	SMR3 (10%)
Maize	54.9	50.3	45.95	50.3	45.95
Pelleted bread	0	5	10	5	10
Soybean meal	37	36.5	36	36.5	36
Monocalcium phosphate	1.5	1.5	1.55	1.5	1.55
Oil	2.8	2.9	2.8	2.9	2.8
Limestone	1.8	1.8	1.75	1.8	1.75
Salt	0.35	0.35	0.3	0.35	0.3
VAM PT1	0.5	0.5	0.5	0.5	0.5
DL Methionine	0.15	0.15	0.15	0.15	0.15
Binder	1	1	1	1	1
			Chemical analysis		
Moisture (%)	10.15	10.09	10.06	10.01	9.89
Crude ash (%)	6.2	6.21	6.22	6.21	6.23
Crude protein (%)	21.48	21.41	21.37	21.43	21.4
Crude fat (%)	5.43	5.39	5.16	5.4	5.18
Crude fiber (%)	1.97	1.9	1.83	1.9	1.83
Calcium (%)	1.02	1.02	1	1.02	1
Phosphorus (%)	0.71	0.69	0.69	0.69	0.69
Sodium (%)	0.18	0.19	0.18	0.19	0.18
ME (metabolic energy)	12.24	12.19	12.1	12.19	12.1

Vitamin and trace mineral premix provided the following nutrients per kg of diet: vitamin A, 40,000 IU; vitamin D_3, 8,000 IU; vitamin E, 10 IU; vitamin K_3, 4 mg; vitamin B_1, 4 mg; vitamin B_2, 12 mg; vitamin B_6, 6 mg; vitamin B_{12}, 0.02 mg; niacin, 60 mg; pantothenicacid, 20 mg; folicacid, 2 mg; biotin, 0.02 mg; Fe, 30 mg; Zn, 25 mg; Mn, 20 mg; Cu, 5 mg; Se, 0.1 mg.

Table 3. Finisher mixture recipe (FMR) with extruded breads component and used feed mixtures chemical analysis

	Control group	White bread		Brown bread	
Ingredient (%)	SMR1 (0%)	SMR2 (5%)	SMR3 (10%)	SMR2 (5%)	SMR3 (10%)
Maize	64	59.1	54.18	59.1	54.18
Pelleted bread	0	5	10	5	10
Soybean meal	28.5	28.2	28	28.2	28
Monocalcium phosphate	1.6	1.65	1.7	1.65	1.7
Oil	2.2	2.4	2.5	2.4	2.5
Limestone	1.8	1.75	1.75	1.75	1.75
Salt	0.35	0.33	0.3	0.33	0.3
VAM PT1	0.5	0.5	0.5	0.5	0.5
DL Methionine	0.05	0.07	0.07	0.07	0.07
Binder	1	1	1	1	1
			Chemical analysis		
Moisture (%)	10.33	10.26	10.19	10.18	10.03
Crude ash (%)	5.85	5.87	5.94	5.88	5.96
Crude protein (%)	18.31	18.32	18.37	18.33	18.39
Crude fat (%)	5.03	5.08	5.03	5.09	5.05
Crude fiber (%)	1.89	1.81	1.74	1.82	1.74
Calcium (%)	1.02	1	1.01	1	1.01
Phosphorus (%)	0.7	0.69	0.69	0.69	0.69
Sodium (%)	0.17	0.18	0.18	0.18	0.18
ME (metabolic energy)	12.43	12.4	12.34	12.4	12.34

Vitamin and trace mineral premix provided the following nutrients per kg of diet: vitamin A, 40,000 IU; vitamin D_3, 8,000 IU; vitamin E, 10 IU; vitamin K_3, 4 mg; vitamin B_1, 4 mg; vitamin B_2, 12 mg; vitamin B_6, 6 mg; vitamin B_{12}, 0.02 mg; niacin, 60 mg; pantothenicacid, 20 mg; folicacid, 2 mg; biotin, 0.02 mg; Fe, 30 mg; Zn, 25 mg; Mn, 20 mg; Cu, 5 mg; Se, 0.1 mg.

Table 4. Chickens production indicators results in the period from 1 to 21 day for used extruded breads

	Control group	White bread		Brown bread	
Production indicators	0%	5%	10%	5%	10%
Body mass (g), 1st day	40.95[a] ± 2.88	41.31[a] ± 2.49	40.84[a] ± 2.71	40.95[a] ± 1.67	40.98[a] ± 2.07
Body mass (g), day 21	818.71[c] ± 89.36	836.61[b] ± 59.58	864.33[a] ± 82.82	809.54[c] ± 75.58	849.59[b] ± 82.52
Number of chickens, day 1	120	120	120	120	120
Number of chickens, day 21	120	118	119	120	120
Mortality (%)	0	1.67	0.83	0	0
Conversion (kg/kg)	1.6	1.59	1.5	1.75	1.59

[a, b, c] Mean values within a column having different superscripts are significantly different by least significant difference test (P<0.05).

Table 5. Chickens production indicators results in the period from 22 to 42 day for used extruded breads

	Control group	White bread		Brown bread	
Production indicators	0%	5%	10%	5%	10%
Body mass (g), day 42	2444.01[a,b] ± 242.48	2486.23[a] ± 190.7	2431.76[b] ± 210.58	2457.29[a] ± 284.73	2515.46[b] ± 211.68
Number of chickens, day 21	120	118	119	120	120
Number of chickens, day 42	114	114	118	118	118
Mortality (%)	5	3.39	0.84	1.67	1.67
Conversion (kg/kg)	1.98	1.94	2.01	1.92	1.88

[a, b, c] Mean values within a column having different superscripts are significantly different by least significant difference test (P<0.05).

of the chickens was increased in the proportion way of increasing the share of the added old extruded bread (Table 4). Also proportional to the increase in the share of the added old white extruded bread the broilers mortality is decreased, while in the experiment with brown extruded bread mortality wasn't observed. After 21 days the best conversion for both experiments was achieved by a group fed with 10% of the old extruded bread.

At the end of the feeding period (day 42), although statistically insignificantly, broilers fed with white extruded bread, shows the best conversion in a group fed with 5 % of extruded old bread, while broilers fed with brown extruded bread, shows the best conversion in a group fed with 10% of extruded old bread (Table 5).

Proportional to the increase in the share of the added old white extruded bread the broilers mortality is decreased, while in the experiment with brown extruded bread mortality was equal in all groups.

Table 6 show statistical values of main chicken body part yield for both experiments.

The slaughter indicators of broilers fed with white extruded old breads, no significant differences were observed, although little better broilers performances were observed in group fed with 5% white extruded old bread was observed (Table 6). Taking into account the slaughter indicators of broilers fed with brown extruded old bread, show a significant difference in the increase in

Table 6. Statistical values of main chicken body part yield in broilers groups fed with 0, 5 and 10% of old white and brown extruded bread

	Control group	White bread		Brown bread	
Bread percentage	0%	5%	10%	5%	10%
Live chickens body mass (g)	2,566[b] ±146.57	2,614.5[a] ± 124.78	2,551[b] ± 138.93	2,579.25[b] ± 135.52	2,649.5[a] ± 161.43
Carcass weight (g)	1,955[b] ± 167.64	2,027.35[a] ± 94.93	1,956.9[b] ± 98.15	1,964.35[b] ± 112.63	1,971.7[b] ± 114.74
Carcass yield (%)	76.2[a] ± 1.24	77.18[a] ± 1.51	76.44[a] ± 1.43	76.11[a] ± 0.06	74.47[a] ± 0.06
Wings (g)	200.1[a] ± 11.55	208.45[a] ± 17.4	205.2[a] ± 10.15	199.35[a] ± 10.73	200.95[a] ± 16.62
Drumstick (g)	241.85[a] ± 18.47	249.8[a] ± 18.16	244.6[a] ± 17.46	241.3[a] ± 18.89	244[a] ± 19.81
Thigh (g)	298.85[b] ± 25.7	232.1[b] ± 20.39	311.05[a] ± 27.77	313.15[a] ± 22.54	308.5[a] ± 16.9
Chest (g)	658.35[a] ± 66.21	642.15[a] ± 45.19	603.7[b] ± 58.12	666.7[a] ± 50.9	672.05[a] ± 48.9
File (g)	497[a] ± 51.55	493.65[a] ± 29.59	459.45[b] ± 45.53	502.85[a] ± 45.83	491.05[a] ± 45.65
Back (g)	442.75[b] ± 39.76	433.1[b] ± 25.54	420.7[b] ± 28.3	493.25[a] ± 42.43	496.7[a] ± 44.9
Abdominal fat (g)	34[a] ± 5.03	37.1[a] ± 8.58	34.85[a] ± 6.38	32.4[a] ± 16.65	35.2[a] ± 13.79
Stomach (g)	45.8[a] ± 5.33	37.2[b] ± 9.52	48.15[a] ± 4.81	46.6[a] ± 3.98	46.25[a] ± 2.6
Liver (g)	36.4[a] ± 12.41	37.2[a] ± 9.52	36.05[a] ± 8.31	35.1[a] ± 9.19	34.45[a] ± 6.95

[a, b, c] Mean values within a column having different superscripts are significantly different by least significant difference test ($P<0.05$).

their final weight by increasing the share of bread in the feed, and significant differences have been observed in thigh and back mass. Similar results of body weight were obtained from Al-Tulaihan et al. (2004), Catalá-Gregori et al. (2009) as well as Ayanrinde et al. (2014).

CONCLUSION

The use of old bread regarding to the broilers performance, with previous thermal processing by extrusion, allows replacement of the maize component. The research has shown that the use of old bread does not have a negative impact on broilers mortality and there are no significant changes in slaughter indicators, which makes feed with share of 5 and 10% old bread recommendable. A slightly better broiler performances was observed in feeding with brown extruded bread and that with share of 10% extruded old bread.

REFERENCE

Al-Tulaihan, A. A., Najib, H., Al-Eid, S. M. (2004) The nutritional evaluation of locally produced dried bakery waste (DBW) in the broiler diets. Pakistan Journal of Nutrition, 3 (5), 294-299.

Ayanrinde, O. J., Owosibo, A. O., Adeyemo, A. A., Omer, M. A. M., Farah, O. M., Ali, S. M., Mishra, A. (2014) Performance characteristics of broilers fed bread waste-based diets. International Journal of Modern Plant and Animal Sciences, 2 (1), 1-11.

Camire, M. E. (1991) Protein functionality modification by extrusion cooking. Journal of the American Oil Chemists' Society, 68 (3), 200–205.

Caro, D., Davis, S. J., Bastianoni, S., Caldeira, K. (2017). Greenhouse gas emissions due to meat production in the last fifty years. In: Ahmed, M., Stockle, C. O., eds. Quantification of climate variability, adaptation and mitigation for agricultural sustainability. Cham: Springer International Publishing, 27–37.

Catalá-Gregori, P., García, V., Madrid, J., Orengo, J., Hernández, F. (2009) Inclusion of dried bakery product in high fat broiler diets: effect on pellet quality, performance, nutrient digestibility and organ weights. Asian-Australasian Journal Journal of Animal Sciences, 22 (5), 686-693.

Chung, J. C. (2001) Strategy for active recycling of food waste. Journal of Korea Solid Wastes Engineering Society, 18 (8), 22–29.

Dabron, B. L., Waidroup, P. W., Harms, R. H. (1999) True metabolizable energy of dried bakery product for use in broiler diet. Poultry Science, 69 (1), 72-75. DOI: https://dx.doi.org/10.3382/ps.0690072

Damron, B. L., Waldroup, P. W., Harms, R. H. (1965) Evaluation of dried bakery products used in broiler diets. Poultry Science, 44, 1122–1126. DOI: https://dx.doi.org/10.3382/ps.0441122

Food and Agriculture Organization (2010) Agribusiness Handbook: Poultry meat and Eggs. Rome: Investment Centre Division, Food and Agriculture Organziation.

HRN EN ISO 5983-2:2010 (2010) Animal feeding stuffs - Determination of nitrogen content and calculation of crude protein content - Part 2: Block digestion and steam distillation method (ISO 5983-2:2009; EN ISO 5983-2:2009). Zagreb: Croatian Standards Institute.

HRN EN ISO 6865:2001 (2001) Animal feeding stuffs - Determination of crude fibre content - Method with intermediate filtration (ISO 6865:2000; EN ISO 6865:2000). Zagreb: Croatian Standards Institute.

HRN ISO 5984:2004 (2004) Animal feeding stuffs - Determination of crude ash (ISO 5984:2002). Zagreb: Croatian Standards Institute.

HRN ISO 6491:2001 (2001) Animal feeding stuffs - Determination of phosphorus content - Spectrometric method (ISO 6491:1998). Zagreb: Croatian Standards Institute.

HRN ISO 6492:2001 (2001) Animal feeding stuffs - Determination of fat content (ISO 6492:1999). Zagreb: Croatian Standards Institute.

HRN ISO 6496:2001 (2001) Animal feeding stuffs - Determination of moisture and other volatile matter content (ISO 6496:1999). Zagreb: Croatian Standards Institute.

HRN ISO 7485:2001 (2001) Animal feed - Determination of potassium and sodium content - Method using flame emission spectrometry. Zagreb: Croatian Standards Institute.

Janssen, W. M. M. A. (1989) European table of energy values for poultry feedstuffs. 3rd edition. Beekbergen: Spelderholt Center for Poultry Research and Information Services.

Jo, B. Y. (2001) Use and safety of feed containing food waste. Symposium on Establishment of Food Waste Recycling Policy. 18 October 2001, National Environment Research Institute, Seoul, Korea.

King, T., Osmond-McLeod, M. J., Duffy, L. L. (2017a) Nanotechnology in the food sector and potential applications for the poultry industry. Trends in Food Science & Technology, 72, 62-73.
DOI: https://dx.doi.org/10.1016/j.tifs.2017.11.015

King, T., Cole, M., Farber, J. M., Eisenbrand, G., Zabaras, D., Fox, E. M., Hill, J. P. (2017b) Food safety for food security: Relationship between global megatrends and developments in food safety. Trends in Food Science & Technology, 68, 160–175.
DOI: https://dx.doi.org/10.1016/j.tifs.2017.08.014

Kwak, W. S., Kang, J. S. (2006) Effect of feeding food waste-broiler litter and bakery by-product mixture to pigs. Bioresource Technology, 97 (2), 243-249.
DOI: https://dx.doi.org/10.1016/j.biortech.2005.02.008

Meng, X., Slominski, B. A., Nyachoti, C. M., Campbell, L. D., Guenter, W. (2005) Degradation of cell wall polysaccharides by combinations of carbohydrase enzymes and their effect on nutrient utilization and broiler chicken performance. Poultry Science, 84 (1), 37–47.
DOI: https://dx.doi.org/10.1093/ps/84.1.37

Nam, B. S., Chung, I. B., Kim, Y. H., Moon, H. K., Kim, D. H., Hur, S. M., Bae, I. H., Yang, C. J. (2000) Effect of recycled food waste on the growth performance and carcass characteristics in growing-finishing pigs. Korean Journal of Animal Science, 42 (3), 279–288.

OECD/FAO (2016) OECD-FAO agricultural outlook 2016-2025. Paris: OECD Publishing.

Oryschak, M., Korver, D., Zuidhof, M., Meng, X., Beltranena, E. (2010) Comparative feeding value of extruded and nonextruded wheat and corn distillers dried grains with solubles for broilers. Poultry Science, 89 (10), 2183-2196.
DOI: https://dx.doi.org/10.3382/ps.2010-00758

RU-5.4.2-11 (n.d.) Animal feed- Determination of calcium by complexometric method, internal method.

Van Barneveld, R. J., Hughes, R. J., Choct, M., Tredrea, A. M., Nielsen, S. G. (2005) Extrustion and expansion of cereal grains promotes variable energy yields in pigs, broiler chickens and laying hens. Recent Advances in Animal Nutrition, 15, 47-55.

Westendorf, M. L., Dong, Z. C., Schoknecht, P. A. (1998) Recycled cafeteria food waste as a feed for swine: Nutrient content, digestibility, growth, and meat quality. Journal of animal science, 76 (12), 2976–2983.

Yadav, D. S., Shrivastava, M., Singh, J. P., Mishra, A. K. (2014) Effect of replacement of maize with bakery waste in broiler ration. International Journal of Agricultural Sciences and Veterinary Medicine, 2 (1), 28-33.