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EFFECT OF PROCESSING ON NUTRITIONAL CONTENT AND PROTEIN DIGESTIBILITY OF COWPEA GRAIN IN BROILERS

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ABSTRACT

Dietary protein in broiler feeds comes mainly from soybean meal and to a lesser extent from animal protein. Nowadays, animal protein is not recommended as a broiler feed ingredient because it is associated with zoonotic diseases such as salmonellosis and soybean is very scarce in Zimbabwe due to low productivity. This shortage is causing an increase in the cost of soybean and making broiler production less viable. Shortage of soybean is forcing animal nutritionists to search for potential alternative sources of protein. Cowpea is the best alternative since it is locally available, cheap and drought tolerant. Cowpea use in broiler feed manufacture is limited because it contains some anti-nutritional factors which reduce protein digestibility and broiler growth performance. The objectives of this paper are to determine the effectiveness of dehulling, roasting and boiling cowpea on nutrient and anti-nutrient content, protein digestibility and broiler performance. The purpose of this review paper is to develop cost effective broiler diets from cowpea. Protein digestibility was measured by using ecxreta analysis through subtracting protein in excreta from protein in feed ingested and broiler weight gains were measured by subtracting final bird weight from previous bird weight. Feed conversion ratio was calculated from dividing weight of total feed eaten by weight gained by the birds.

Contribution/Originality: Traditional methods of processing cowpea such as dehulling, roasting and boiling partially remove anti-nutritional factors when used singly to process cowpea. A combination of either dehulling and roasting or dehulling and boiling need to be explored in order to come up with a processing technique which entirely removes anti-nutrients in cowpea to improve nutrient content and protein digestibility.

1. INTRODUCTION

Poultry production in Zimbabwe has been growing tremendously over the past two decades [1]. It is claimed that 18 million and 90.8 million broiler chicks were sold in Zimbabwe during year 2009 and 2019, respectively [1]. This growth is attributed to high demand for poultry meat due to changes in eating habits, population growth, urbanisation and increase in disposable incomes [1].

Poultry production is being negatively affected by the scarcity of soybean meal which is the major supplier of dietary protein to broiler feeds [2]. The shortage of soybean meal is causing a high demand and increase of prices for this commodity making poultry production unviable [3].

Researchers are searching for other potential alternative sources of vegetable protein to soybean meal [2, 4, 5]. Cowpea is a suitable alternative since it is locally grown, drought tolerant, cheap and has comparable amino acids to soybean meal [6]. Cowpea, like any other grain legume has low methionine and cysteine which should be supplemented with exogenous crystalline forms of these amino acids [4].

The use of cowpea grain in broiler diets is limited by the presence of anti-nutritional factors such as condensed tannins, lectins, non-starch polysaccharides (NSP) and enzyme inhibitors [2, 7, 8]. Anti-nutritional factors reduce protein digestibility of cowpea grains by broilers [9]. Tannins binds to proteins making them indigestible to digestive enzymes whilst enzyme inhibitors prevents the release of trypsin and chymotrypsin from the pancrease resulting in no digestion of proteins [4, 10]. Enzyme inhibitors also cause secretion of endogenous proteins from the pancrease into the intestinal lumen [4]. Avian species have no enzymes which can digest NSPs [6].

Dehulling, roasting and boiling are domestic processing techniques that were used by earlier researchers to reduce or eliminate anti-nutritional factors from cowpea grain [4, 10]. Using a single processing technique is reported to leave some residual anti-nutritional factors in cowpea grain since dehulling only removes tannins and NSPs which are located on the seed coats but do not remove lectins and protease inhibitors [4, 10]. Heat processing methods only removes trypsin and chymotrypsin inhibitors which are located in the seed cotyledons but are not effective in eliminating tannins and NSPs [7].

AS a result, there is need to combine dehulling with either roasting or boiling in order to efficiently remove anti-nutritional factors in cowpea grains in order to improve its nutritional value and increase protein digestibility by broiler chickens.

2. DEHULLING

2.1. Anti-Nutrients Content

Dehulling refers to the removal of the seed coat of grain legumes Bariu [11]. Belal, et al. [12] and Koivunen [4] claimed that dehulling removes tannins and non-starch polysaccharides which are contained in the seed hulls of cowpea grains. Belal, et al. [12] reported that dehulling reduced tannin contents of raw cowpea (0.76%) by 98 percentage points to 0.02%. However, in another experiment by the same researcher dehulling reduced tannin level in raw cowpea by 85% [13]. In another experiment by Anjos, et al. [7] dehulling reduced tannin content in raw cowpea from 1.54 mg/ 100g to 0.22 mg / 100g. However, dehulling cannot meaningfully remove trypsin inhibitors, chymotrypsin inhibitors and lectins from cowpea grains because they are located in the cotyledons [11].

2.2. Nutrient Content

Adegunwa, et al. [14] reported that dehulling increased the crude protein (CP) of cowpea from 21.27% CP in raw cowpea to 23.11% CP in dehulled cowpea. CP is a measure of the amount of protein in a feed determined as the amount of nitrogen multiplied by 6.25 Bariu [11]. Adegunwa, et al. [14] findings are in agreement with Balail [13] results which stated that dehulling improved the nutritional content of cowpea from 29.18% CP, 6.22% crude fibre (CF) and 93.63% dry matter in raw cowpea to 31.80% CP, 4% CF and 94.33% dry matter (DM) in dehulled cowpea, respectively. Bariu [11] defined CF as a measure of the amount of indigestible cellulose, pentosans and lignin in feeds and DM to the material remaining after removal of water from a feed. These results confirm assertions by Akanji, et al. [6] and Zapletal, et al. [8] that dehulling removes tannins and non - starch polysaccharides in grain legumes and consequently improves their nutritional compositions.

2.3. Growth Performance of Broilers

Akanji, et al. [6] reported that feeding broilers with diets containing 20% dehulled cowpea significantly (P<0.05) reduced growth performance indices (feed intake, body weight gain, feed conversion efficiency (FCE) and protein efficiency ratio (PER)). Nalle [10] defined feed conversion ratio (FCR) as the ratio of the weight of feed eaten to weight gained by the animal or ratio of inputs to outputs whilst FCE refers to the ratio of outputs to inputs. PER is defined as a measure of the nutritive value of protein sources [11]. Broilers fed diets containing dehulled cowpea had average feed intake, body weight gain, FCE, PER and mortality of 0.244 kg / week, 0.117 kg / wk, 0.48 / wk, 1.918 / wk and 10 %, respectively as compared to 0.297 kg / wk feed intake, 0.186 kg / wk weight gain, 0.626 / wk FCE, 2.717 / wk PER and 5% mortality for birds fed control diets [5]. However, Belal, et al. [12] obtained different results from those of Akanji, et al. [6] by claiming that feeding diets containing 15% dehulled cowpea grains had no significant ($P>0.05$) effect on feed intake, body weight gain, FCR and PER in broiler chickens. This contradiction may be attributed to the assumption that the cowpea variety used by Akanji, et al. [6] had a high content of protease inhibitors and lectins which negatively affected protein digestibility and utilisation by broilers [11, 15].

2.4. Protein Digestibility

Tshovhote, et al. [16] reported that dehulling cowpea grains improved cowpea digestibility of Indigenous variety, Agrinawa variety and Glenda variety to 79%, 77% and 76% respectively. Improvement in digestibility of proteins in cowpea after dehulling may be due to removal of tannins and non-starch polysaccharides which are known to reduce protein digestibility since they binds to proteins and make them indigestible to digestive enzymes [17].

3. ROASTING

3.1. Anti-nutrients content

Roasting refers to the process of exposing grain legumes to dry heat in order to eliminate anti-nutritional factors Anjos, et al. [7]. Anjos, et al. [7] reported that roasting at a temperature of 120°C for 30 minutes reduced trypsin inhibitors in cowpeas from 6700 trypsin inhibitor units (TIU) per gramme in raw cowpea to less than 2000 TIU/g. Anjos, et al. [9] claimed that roasting reduced phytic acid from 1.2% in raw cowpea to 0.86% in roasted cowpea but increased tannin content from 0.86% in raw cowpea to 1.2% in roasted cowpea. These results are supported by results obtained by Adegunwa, et al. [14] who reported that roasting cowpea (Variety IT88D-867-II) increased the tannin content from 0.64 milligrams / 100 grams to 1.14 mg / 100g when compared to 0.19 mg / 100g produced by boiling.

Roasting is a less effective method of removing anti-nutritional substances especially tannins and non – starch polysaccharides from grain legumes [14, 15]. These authors' findings were supported by Bariu [11] who claimed that roasting inactivated 54 – 82% of the protease inhibitors while extrusion and autoclaving at 100°C for more than 15 minutes inactivated 78 – 98% and 85% - 100%, respectively. This superiority of either extrusion or autoclaving over roasting may be attributed to the fact that extrusion and autoclaving disintegrated the cell wall of grain legumes and made protease inhibitors more susceptible to heat destruction [15].

3.2. Nutrient Content

Roasting improves the nutritional content of cowpea grains Anjos, et al. [7]. Anjos, et al. [7] reported that roasting raw cowpea grains at 120°C for 30 minutes improved the nutrient content in untreated cowpea from 87.9% DM, 29.6% CP, 15.5% Ether Extracts (EE) and 6.4% crude fibre to 90.3% DM, 30.6% CP, 20.8% EE and 4.0% CF in roasted cowpea, respectively. Bariu [11] described EE as part of organic material which is soluble in ether and chiefly consists of lipids. This improvement in nutrient content may be due to the fact that dry heat destroyed some of the non – starch polysaccharides resulting in a reduction in crude fibre [10]. Heat also destroyed heat-labile protease inhibitors and lectins which limit the bioavailability of nutrients [3, 11]. However, essential amino acids which are reported to be already very low in grain legumes, as well as vitamins and minerals were decreased by roasting in cowpea and this may be attributed to volatilisation since they are very sensitive to high temperatures [11].

3.3. Growth Performance of Broilers

Kur, et al. [18] claimed that feeding diets containing 15% roasted cowpea had no effect on overall feed intake and body weight gain in broiler chickens but affected ($P<0.05$) FCR (2.40 kg feed / kg weight gain vs. 2.60 kg feed / kg weight gain for birds fed roasted cowpea diet vs birds fed control diet, respectively). Anjos, et al. [9] obtained different results claiming that roasting cowpea grain reduced body weight gain and increased FCR (0.054 kg and 2.657 kg feed / kg weight gain) at day 9 of age as compared to 0.087 kg weight gain and 1.78 FCR of birds fed the control diet. Inferior results obtained by Anjos, et al. [9] may be attributed either to the fact that he might have roasted cowpea at high temperature for an extended period of time resulting in a reaction between free amino groups with reducing sugars (Maillard reaction) which reduces protein digestibility or he might have used a cowpea variety with a high content of anti-nutrients which reduce protein digestibility [17].

3.4. Protein Digestibility

Anjos, et al. [7] claimed that roasting improved digestibility of cowpea in a feeding trial with cecectomised roosters. Roasting increased digestibility of protein in raw cowpea from an average of 71% to 77% [7]. This improvement in protein digestibility can be attributed to a reduction in heat-labile protease inhibitors brought about by exposure of cowpea grains to dry heat [8]. These results are supported by research findings by Belal, et al. [12] who reported that roasting improved digestibility of cowpea protein from 66.1% to 69.2%. Digestibility of grain legumes' proteins depends on legume variety, duration of heating and processing temperature Belal, et al. [12]. Belal, et al. [12] reported that cowpea varieties with high anti-nutrient contents have low protein digestibility while a long duration of heating decreases anti-nutrients and increases digestibility of proteins in cowpea. However, high temperatures tend to aggregate proteins and reduce their accessibility by digestive enzymes [8].

4. BOILING

4.1. Anti-Nutrients Content

Boiling of grain legumes refers to the process of cooking grain legumes in water at a temperature of 100°C or more for a certain period of time Bariu [11]. Adegunwa, et al. [14] claimed that boiling cowpea variety IT88D-867-II significantly ($P<0.05$) reduced the level of tannins in raw cowpea from 0.64 mg / 100g to 0.19 mg / 100g. These findings were also supported by Ommena, et al. [17] who reported that boiling reduced ($P<0.05$) the amount of phytates, total phenols, tannins and trypsin inhibitors from 0.053%, 0.886%, 0.344% and 19.81% in raw cowpea to 0.051%, 0.819%, 0.306% and 0.33%, respectively. In some researches carried out using other grain legumes, boiling reduced ($P<0.05$) the amount of phytates, tannins and trypsin inhibitors from 33.46 g / kg DM, 1.41 g / kg DM and 33.59 trypsin inhibitor units / mg in raw velvet beans (*Mucuna utilis*) seeds to 29.81 g / kg, 0.99 g / kg and 17.77 TIU / mg, respectively [19]. The above findings confirm the claims by Tuleun, et al. [20] that trypsin inhibitors and chymotrypsin inhibitors are very sensitive to high temperatures and their reduction were inversely related to the duration of heating and temperature.

4.2. Nutrient Content

Research findings by Ommena, et al. [17] shows that crude protein, ether extracts, crude fibre and ash were significantly ($P<0.05$) reduced by boiling cowpea grain and moisture content was increased from 9.25% in raw cowpea to 15 % in boiled cowpea. Reduction in CP was due to loss of amino acids through leaching Bariu [11]. Increase in moisture content affects storage of boiled cowpea.

Ommena, et al. [17] reported that boiling reduced ($P<0.05$) the amount of vitamins, minerals and essential amino acids in raw cowpea. This may be due to the fact that vitamins and minerals are volatile and may be lost when temperatures are very high [8, 9].

4.3. Growth Performance of Broilers

Osunbitan, et al. [21] reported that incorporating boiled cowpea at 20 % inclusion level in broiler starter diets depressed (P<0.05) feed intake, weight gain and FCR but caused no significant (P>0.05) effect on feed intake, body weight gain and FCR of broilers when added to finisher diets. The reason for poor growth indices during starter phase may be due to the fact that the digestive system of young broilers is not tolerant of residual anti-nutritional factors in boiled cowpea [21]. The results by Osunbitan, et al. [21] are in agreement with the results by Balaiel [19] who reported that broilers fed finisher diets containing 20 % boiled velvet (*Mucuna utilis*) beans produced similar results to broilers fed the corn-soy control diet. Bariu [11] also obtained similar results when he fed broilers with 20% boiled common beans. However, Balaiel [19] results with boiled *Mucuna utilis* reveal that feed intake, daily weight gain and FCR increased in response to an increase in duration of heating with an increase in daily feed intake from 87.53 g / day to 94.62 g /day and daily body weight gain from 34.68 g / day to 39.79 g / day when boiled for 20 minutes and 60 minutes, respectively.

4.4. Protein Digestibility

Boiling was reported to improve the digestibility of proteins of grain legumes [22]. In studies that were conducted with boiled peas (*Pisum sativum*) and chickpeas (*Cicer arietinum*), protein digestibility of peas and chickpeas improved (P<0.05) from an average of 81.7% in unprocessed peas and 81.61% in unprocessed chickpeas to 86.35% and 88.52% in processed peas and chickpeas, respectively [22]. These results were supported by Affrifah, et al. [23] who reported that boiling improved the digestibility of proteins of cowpea grains depending on variety and duration of heating with high digestibility witnessed in cowpea varieties with low levels of anti-nutrients and long duration of heating at high temperatures. These claims were supported by research findings by Ommena, et al. [17] who found that digestibility of proteins was increased from 66.1% in raw cowpea to 78.2% in boiled cowpea.

5. CONCLUSION

Domestic processing techniques (dehulling, roasting and boiling) reduce anti-nutritional factor content, improve nutrient content and digestibility of proteins in cowpea grains [7, 17, 18]. Dehulling reduces the level of tannins and non-starch polysaccharides in cowpea but is not effective in removing trypsin inhibitors, chymotrypsin inhibitors and lectins [4, 18]. Dehulling improves the nutrient content of cowpea grains since seed coat removal removes tannins and non-starch polysaccharides which reduce bioavailability of nutrients [18]. However, the digestibility of proteins after dehulling depends on the level of trypsin and chymotrypsin inhibitors (cowpea variety) with low digestibility witnessed in varieties with high enzyme inhibitors [7]. Incorporation of more than 20% level of dehulled cowpea with high levels of anti-nutrients reduces overall feed intake, weight gain, FCR and PER by broiler chickens [11].

Roasting removes anti-nutrients in cowpea grain, improves nutrient content and protein digestibility of cowpea and growth performance of broilers fed diets containing roasted cowpea [7]. However, roasting at high temperatures aggregates proteins or leads to a reaction between free amino groups with reducing sugars (Maillard reaction) which reduces protein digestibility, lowers bioavailability of proteins and negatively affects growth performance of broiler chickens [11].

Boiling significantly reduces both anti-nutrients and nutrients content on cowpea grains [17]. Soluble tannins and non-starch polysaccharides are lost mostly through leaching in boiling water and enzyme inhibitors are affected by high temperatures [11]. Soluble nutrients are lost through leaching and volatilisation [18]. Protein digestibility in boiled cowpea increases due to efficient removal of anti-nutrients [17, 18].

Overall, a single processing method cannot effectively remove anti-nutritional factors from cowpea grains which means a combination of either dehulling and roasting (dehulling – roasting) or dehulling and boiling (dehulling – boiling) should be investigated in order to come up with a best modified method of processing cowpea grains without lowering its nutrient contents and protein digestibility.

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