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# THE USE OF CHICKPEAS (CICER ARIETINUM) IN POULTRY DIETS: A REVIEW

# FOLOSIREA NĂUTULUI (CICER ARIETINUM) ÎN HRANA PĂSĂRILOR: TRECERE ÎN REVISTĂ

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*Chickpeas can be used as a high energy and protein feed in poultry diets to support growth and egg production. In common with other grain legumes, chickpeas can also contain anti-nutritional factors such as trypsin and chymotrypsin inhibitors that can impair the utilization of the nutrients by poultry. Heat treatment is an effective method to increase the amount of protein available for intestinal digestibility. This review evaluates chickpeas in regard to their nutrient composition, anti-nutritional factors content, and their impact on poultry performance. The possible reasons and implications of these results are discussed.*
**Keywords**: chickpeas, broilers, layers, performance, egg quality

## Introduction

Intensive poultry production is based on diets high in cereal grains and a protein supplement, with soybean meal (SBM) being the most common. However, the need to lessen the impact of imported and therefore high SBM prices on poultry producers has led to research on local protein sources, such as chickpeas, as poultry feeds. The chickpea (*Cicer arietinum* L.) is one of the world's most important grain legumes (FAO, 1993), because it is a valuable source of protein, minerals and vitamins, and occupy a very important place in human nutrition. Most of the world's chickpea production and consumption (>70%) is in India, but this crop is of importance in many other countries in Asia, Africa, Europe, and the Americas. In Mediterranean countries, it is cultivated principally as a legume crop, since it is well adapted to semi-arid conditions, with some irrigated varieties yielding as much as 3.5 t/ha of seed in autumn seeding. Although most chickpeas are produced for human consumption, they provide the poultry industry with an alternative protein and energy feedstuff. The objective of this review is to summarize available data on nutrient composition of chickpeas and examine available data on their nutritive value to poultry.

## Nutrient composition of chickpeas

The chemical composition of chickpeas is in Tables 1 and 2. The crude protein (CP) content of chickpeas, which ranges from 124 to 306 g/kg, is highly dependant on the cultivation system (Christodoulou et al., 2006ab).

Table 1

Chemical and mineral composition of raw chickpeas (Chavan et al., 1989)

| **Chemical composition** | **(g/kg, as fed basis)** | **Mineral composition** | **(mg/kg, as fed basis)** |
|---|---|---|---|
| Crude protein | 124 – 306 | Ash | 20.4 – 46.7 |
| Total carbohydrates | 506 – 709 | Calcium | 930 – 2590 |
| Starch | 372 – 508 | Phosphorus | 2440 – 4580 |
| Total sugars | 48 – 93 | Magnesium | 917 – 1680 |
| Crude fiber | 12 – 135 | Iron | 30 – 106 |
| Cellulose | 71 – 97 | Copper | 6 – 21 |
| Hemicellulose | 35 – 87 | Zinc | 15 – 42 |
| Pectic substances | 15 – 38 | Sodium | 98 – 1501 |
| Lignin | 22 – 59 | Potassium | 6923 – 10284 |
| Crude fat | 31 – 74 | | |

The sulfur amino acids are the first limiting, followed by valine, threonine and tryptophan. Chickpeas contain 506 to 709 g/kg of total carbohydrates, with starch, total sugars and crude fiber being the major components .The total lipid content in chickpeas ranges from 31 to 74 g/kg (Chavan et al., 1989). Triglycerides are the major components of neutral lipids, whereas lecithin is the major component of polar lipids. Among the fatty acids, unsaturated fatty acids constitute 671.3 g/kg (oleic acid 218.4 g/kg, linoleic acid 432.9 g/kg, and linolenic acid 20.0 g/kg), while saturated fatty acids make up 104.2 g/kg (palmitic acid 92.2 g/kg and stearic acid 12.0 g/kg). Chickpeas are also a good source of dietary minerals, such as calcium, phosphorus, magnesium, iron, and potassium (Chavan et al., 1989).

## Biological value, Protein Efficiency Ratio, and Digestibility of chickpeas

A biological evaluation of chickpea protein is essential because chemical analyses do not always reveal how much of a protein is biologically available and utilized (Chavan et al., 1989). Both growth methods (PER, protein efficiency ratio) and nitrogen balance methods (BV, biological value; NPU, net protein utilization; and TD, true digestibility) are recommended for this purpose. The values of BV, PER, TD, and NPU for chickpea proteins are presented in Table 3. Considerable variations exist in these values which indicate that the genetic diversity for protein quality exist in chickpea cultivars. In addition, Newman et al. (1987) found similar

PER values of about 2.8 for three chickpea varieties and protein digestibilities ranging from 0.79 to 0.88, while Carías et al. (1998) found a PER value of 1.58 and a NPU value of 0.598. Thus, chickpea protein quality was described by Friedman (1996) as being equivalent to that of SBM.

Table 2

Chemical composition (g/kg, as fed basis) of raw, heated and extruded chickpeas (Christodoulou et al., 2006ab)

| **Chemical composition** | **(g/kg, as fed basis)** | | |
|---|---|---|---|
| | Chickpeas | Heated chickpeas | Extruded chickpeas |
| Dry matter | 908 | 921 | 923 |
| Crude protein | 209 | 211 | 239 |
| Crude fiber | 38 | 39 | 38 |
| Crude fat | 50 | 51 | 51 |
| Ash | 27 | 27 | 39 |
| Arginine | 17.4 | 17.6 | 20.7 |
| Glycine + serine | 13.3 | 13.4 | 15.9 |
| Histidine | 5.9 | 6.0 | 7.0 |
| Isoleucine | 8.8 | 8.9 | 10.7 |
| Leucine | 16.0 | 16.2 | 19.0 |
| Lysine | 14.9 | 15.0 | 17.8 |
| Methionine | 1.5 | 1.5 | 1.8 |
| Methionine + cystine | 5.2 | 5.2 | 6.2 |
| Phenylalanine | 10.0 | 10.1 | 12.2 |
| Phenylalanine + tyrosine | 16.3 | 16.5 | 19.5 |
| Proline | 5.8 | 5.9 | 6.9 |
| Threonine | 7.3 | 7.4 | 8.9 |
| Tryptophan | 2.7 | 2.7 | 3.2 |
| Valine | 9.7 | 9.8 | 11.3 |

Table 3

Protein quality parameters of raw chickpeas (Chavan et al., 1989)

| **Parameter** | **Range** |
|---|---|
| Biological value | 0.520 – 0.850 |
| Protein efficiency ratio | 1.2 – 2.64 |
| Digestibility coefficient | 0.760 – 0.928 |
| Net protein utilization | 0.870 – 0.920 |

## Improving the nutritional value of chickpeas

Chickpeas, like other legumes, contain a variety of anti-nutritional factors (ANF), such as protease and amylase inhibitors, as well as lectins, polyphenols and oligosaccharides (Table 4), which impair nutrient absorption from the gastrointestinal tract and can result in detrimental effects on animal health and growth (Singh, 1988). It has been reported that some organs may become hypertrophic in monogastrics due to ANF contained in legume seeds. In comparison with other legumes, such as soybeans, peas, and common beans, chickpeas contain relatively small amounts of trypsin inhibitors and chymotrypsin inhibitors, offering thus fewer problems in poultry nutrition. Chavan et al. (1989) reported similar ANF contents for chickpeas and soybeans. However, in order to improve the nutritional value, and to provide effective utilization of chickpeas to a maximal level in poultry diets, it is essential that ANF activity is removed and that a higher protein and energy digestibility is obtained (Van der Poel, 1989).

Table 4

Anti-nutritional factors and toxic substances of chickpeas (Singh, 1988)

| **Constituent** | **Range** | **Constituent** | **Range** |
|---|---|---|---|
| Protease inhibitors | | Polyphenols (mg/g) | |
| Trypsin (units/mg) | 6.7 – 14.6 | Total phenols | 1.55 – 6.10 |
| Chymotrypsin (units/mg) | 5.7 – 9.4 | Tannins | Traces |
| Amylase inhibitor (units/g) | 0 – 15.0 | Phytolectins (units/g) | 400 |
| Oligosaccharides (g/100 g) | | Cyanogens (Glycosides) | Traces |
| Raffinose | 0.36 – 1.10 | Mycotoxins (ppb) | Traces – 35 |
| Stachyose | 0.82 – 2.10 | | |
| Stachyose + Verbascose | 1.90 – 3.00 | | |

Many ANF in legumes are inactivated by heat treatment, the effectiveness of which depends, among other factors, on initial level, temperature, heating time, particle size, moisture, and probably species and variety. Heat processing includes extrusion, infrared radiation, micronizing, autoclaving, steam processing or flaking. Among the various available processing techniques for heat treatment, extrusion offers very good results in destroying ANF of legumes. Trypsin inhibitor and haemagglutination activity of grain legumes (i.e., phaseolus bean) decreased, after extrusion at 145°C for 16 sec, to 2 to 22% and 2 to 7%, respectively, of that determined in raw beans and trypsin inhibitor activity of grain legumes (i.e., phaseolus bean) decreased, after extrusion at 100°C and 130°C for 10 sec, to 6 and 3% respectively, of that in raw beans. Moreover, ANF of chickpea were inactivated when ground chickpeas (2 mm) were wet extruded at 120°C (i.e., the barrel temperature near the exit) for 20 sec (Christodoulou et al., 2006b). In addition, Saini (1989) reported that trypsin and chymotrypsin inhibitors of grain legumes (soybean) retained 17% and 30% activity, respectively, after dry heating at 120°C for 15 min, and Nestares et al. (1993) reported that the oligosaccharide and polyphenol content of chickpeas decreased, after dry heating at 120°C for 15 min, to 43% and 53% respectively, of that determined in raw chickpeas. According to Márquez et al. (1998), inactivation of 66% of the trypsin inhibitor activity occurred in chickpeas after dry heating at 140°C for 6 h. Furthermore, Monsoor and Yusuf (2002) showed that in vitro digestibility of chickpeas was increased by 9% due to inactivation of protease inhibitors when chickpeas were heated at 100°C in boiling water for 5 min.

Farrell et al. (1999) found a negative effect on body weight (BW), daily feed consumption (DFC) and feed conversion ratio (FCR) of broiler chickens fed diets containing raw chickpeas up to 360 kg/t of concentrate mixture (Table 5), as well as increased relative pancreas weight when compared to other diets. Viveros et al. (2001) studied the nutritional value of raw and autoclaved chickpeas in two experiments with male broiler chickens from 1 to 28 day of age. In the first experiment, broilers received diets with 0, 150, 300 and 450 kg/t raw chickpeas, and in the second experiment diets with 0, 75 and 150 kg/t raw and autoclaved chickpeas. Viveros et al. (2001) reported that increasing the proportion of raw chickpea in the diet negatively influenced BW gain, DFC and FCR, and that feeding autoclaved chickpeas increased BW gain and DFC, and did not change FCR compared with those fed the control diet. The same report suggested that inclusion of 300 kg/t raw chickpeas in the diet of broiler chickens reduced starch digestibility by 3%, protein digestibility by 18% and apparent metabolisable energy by 9% compared with those fed the control diet. Feeding broiler chickens raw chickpeas, at inclusion levels up to 450 kg/t of diet, resulted in increased weights of gizzard, liver and pancreas, and with autoclaved chickpeas at inclusion levels up to 150 kg/t of diet, resulted increased weight of the gizzard, and decreased weight of the liver, compared with those fed the control diet (Viveros et al., 2001). In a recent study, Brenes et al. (2008) studied the nutritional value of raw and extruded chickpeas in an experiment with broiler chickens (Cobb) from 1 to 21 day of age. Increasing chickpea content in the diet did not affect BW gain, DFC and FCR, with no differences occurring between raw and extruded chickpeas, while relative liver weight increased with both raw and extruded chickpeas, and relative pancreas weight increased only with raw chickpeas (Brenes et al., 2008). Christodoulou et al. (2006a) also found that raw chickpeas can partially replace SBM at inclusion levels of 120 kg/t of diet without affecting final BW, DFC and FCR of broiler chickens (Cobb 500) compared to the SBM diet, whilst higher inclusion level (240 kg/t of diet) adversely affected productive performance, suggesting that birds may have been susceptible to the ANF contained in raw chickpeas. Carcass yield traits and internal organs weights of broiler chickens were not affected when raw chickpeas were incorporated at inclusion level of 120 kg/t of diet, but negatively influenced with the higher inclusion level of 240 kg/t of diet (Christodoulou et al., 2006a). In contrast, Garsen et al. (2008) found that partial replacement of SBM with raw chickpeas resulted in similar performance and carcass characteristics of broiler chickens (Ross), when chickpeas were supplemented to their diet in gradually increasing levels up to 480 kg/t with respect to the birds age (i.e., 160 kg/t for 1-14 day of age, 240 kg/t for 15-28 day of age, 480 kg/t for 29-42 day of age). Christodoulou et al. (2006b) showed that partial replacement of SBM with extruded chickpeas (i.e., 200 kg/t of diet) resulted in similar performance of male broiler turkeys (B.U.T. 9). The diets containing higher inclusion levels of extruded chickpeas (i.e., 400, 600 and 800 kg/t of diet) did not affect DFC at the end of the experiment (84 day of age), but negatively influenced final BW and FCR, compared to the control diet. Carcass yield traits were not affected with inclusion of extruded chickpeas in diets of broiler turkeys, at inclusion levels up to 800 kg/t.

Table 5

The effect of chickpeas (CKP) on performance of broilers summarized from several sources

| Feedstuff | CKP level | Poultry | DFC[1] (g/d) | BW gain (g/d) | FCR (g DFC/g BW gain) | Carcass yield (g/100 g BW) | Reference |
|---|---|---|---|---|---|---|---|
| Raw chickpea (g/kg) | 120 | Male broiler chickens | 94.5 | 49.6 | 1.96 | | Farrell et al. (1999) |
| | 180 | | 92.0 | 47.5 | 2.00 | | |
| | 240 | | 95.7 | 53.7 | 1.93 | | |
| | 300 | | 94.8 | 50.6 | 1.90 | | |
| | 360 | | 93.4 | 48.9 | 2.00 | | |
| Raw chickpea (g/kg) | 0 | Male broiler chickens | 40.2 | 30.5 | 1.32 | | Viveros et al. (2001) |
| | 150 | | 39.2 | 26.6 | 1.47 | | |
| | 300 | | 37.2 | 24.4 | 1.53 | | |
| | 450 | | 34.8 | 21.1 | 1.65 | | |
| Raw chickpea (g/kg) | 0 | Male broiler chickens | 47.5 | 31.5 | 1.50 | | Viveros et al. (2001) |
| | 75 | | 46.7 | 29.9 | 1.56 | | |
| | 150 | | 43.0 | 27.7 | 1.55 | | |
| Autoclaved chickpea (g/kg) | 75 | Male broiler chickens | 46.8 | 31.8 | 1.47 | | |
| | 150 | | 45.8 | 28.4 | 1.61 | | |
| Raw chickpea (g/kg) | 0 | Broiler chickens | 101.6 | 49.9 | 2.08 | 75.2 | Christodoulou et al. (2006a) |
| | 120 | | 99.1 | 48.1 | 2.10 | 74.5 | |
| | 240 | | 93.8 | 42.6 | 2.24 | 72.3 | |
| Heated chickpea (g/kg) | 120 | Broiler chickens | 100.3 | 49.0 | 2.09 | 75.0 | |
| | 240 | | 94.1 | 43.5 | 2.21 | 73.1 | |
| Raw chickpea (g/kg) | 0 | Broiler chickens | 43.0 | 31.9 | 1.35 | | Brenes et al. (2008) |
| | 100 | | 41.3 | 29.5 | 1.40 | | |
| | 200 | | 41.6 | 28.9 | 1.44 | | |
| | 300 | | 41.8 | 29.8 | 1.41 | | |
| Extruded chickpea (g/kg) | 100 | | 43.4 | 31.8 | 1.37 | | |
| | 200 | | 44.5 | 32.1 | 1.39 | | |
| | 300 | | 41.2 | 30.3 | 1.36 | | |
| Raw chickpea (g/kg) | 0 | Broiler | 89.8 | 56.5 | 1.59 | 66.7 | Garsen et al. (2008) |
| | 120 | chickens | 92.3 | 57.4 | 1.60 | 67.1 | |
| | 240 | | 91.2 | 57.9 | 1.58 | 67.4 | |
| | 360 | | 89.5 | 56.7 | 1.58 | 66.9 | |
| | 480 | | 89.8 | 56.2 | 1.60 | 67.2 | |
| Extruded chickpea (g/kg) | 0 | Male broiler | 225.7 | 92.0 | 2.46 | 77.1 | Christodoulou et al. (2006b) |
| | 200 | turkeys | 229.0 | 92.2 | 2.48 | 76.3 | |
| | 400 | | 237.6 | 84.7 | 2.81 | 78.8 | |
| | 600 | | 240.4 | 85.0 | 2.83 | 76.2 | |
| | 800 | | 241.0 | 84.9 | 2.84 | 76.6 | |

[1] BW, body weight; DFC, daily feed consumption; FCR, feed conversion ratio.

**Use of chickpeas in layer nutrition**

The available information on the nutritional value of chickpeas for layers is limited. Perez-Maldonaldo et al. (1999) studied the nutritional value of chickpeas, field peas, faba beans and sweet lupins in an experiment with laying hens from 18 to 58 week of age. Chickpeas supported excellent production, when included at 250 kg/t of the diet of laying hens, but increased relative pancreas weight when compared to other diets (Table 6; Perez-Maldonaldo et al., 1999). Moreover, Garsen et al. (2007) showed that partial and total replacement of SBM with raw chickpeas resulted in similar productive performance and egg quality of laying hens (Lohmann), except for yolk color that decreased with increasing chickpea levels.

Table 6

The effect of chickpeas (CKP) on performance of layers summarized from several sources

| Feedstuff | CKP level | Poultry | DFC[1] (g/d) | EP (eggs/hen/day) | EW (g) | EM (g/hen/day) | FE (g feed/g EM) | Reference |
|---|---|---|---|---|---|---|---|---|
| Raw chickpea (g/kg) | 250 | Laying hens | 115.4 | 0.824 | 56.9 | 46.7 | 2.47 | Perez-Maldonado et al. 1999 |
| Raw chickpea (g/kg) | 0 | Laying hens | 118.2 | 0.718 | 71.7 | 51.8 | 2.28 | Garsen et al. (2007) |
| | 110 | | 117.6 | 0.726 | 69.8 | 53.2 | 2.21 | |
| | 210 | | 118.7 | 0.722 | 71.6 | 53.3 | 2.23 | |
| | 310 | | 117.1 | 0.742 | 71.0 | 53.3 | 2.20 | |
| | 410 | | 114.8 | 0.724 | 73.4 | 53.5 | 2.15 | |

[1] DFC, daily feed consumption; EM, egg mass; EP, egg production; EW, egg weight; FE, feed efficiency.

## Conclusions

In general, raw chickpeas can be used in poultry diets, at inclusion levels up to 150-200 kg/t, to support growth and egg production, without any detrimental effects on birds. Higher inclusion levels of chickpeas in poultry diets can be used after the removal of the containing anti-nutritional factors, using heat treatment that improves chickpeas nutritional value. As a heat treatment, extrusion offers very good results in destroying anti-nutritional factors of chickpeas and also improves the utilization of starch, fat and protein contained in chickpeas by poultry.

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