# UTILIZATION OF COTTON CROP RESIDUES (SEEDS, NUTS, LEAVES) AND BYPRODUCTS (STALKS, BROKEN FIBERS, CAKE) AS FEED ADDITIVES IN POULTRY DIET

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**Abstract**

*A lot of reviews highlight the need of utilization of agricultural by-products. Cotton is a crop of high importance for Greek agricultural production. Greece is the EU's main cotton grower, accounting for more than eighty percent of total European production. However, in Greece cotton by-products are considered as useless waste and remain unused. The woody parts of cotton and its by-products (stalk, broken fibers, cake), as well as the crop residues (nuts, leaves) are not utilized, so they are either thrown away from the gins or remain unused in the field. Their composition mainly in carbohydrates and raw fibers (lignin, cellulose and hemicellulose), fats, proteins and minerals and their low to zero purchase prices require their use as feed additives in poultry diet.*

*For this reason, the chemical composition of these by-products was determined to develop a proper feeding system for aviculture. Our results showed high protein and lignocellulose content in cotton by-products. Cotton residues of cake and seed can offer an important supply of energy in poultry diet attributed to contents of nitrogen and ether extract while cotton stalk and nut contained high soluble fiber levels.*

**Keywords:** *cotton byproducts, poultry diet, feed additives, crop residues*

## INTRODUCTION

Poultry farming is one of the most important sectors of Greek livestock covering a large percentage of domestic consumer needs. In our country every year more than 100.000 tons of eggs and 150.000 tons of poultry meat are produced. These quantities cover a large percentage of the country's needs for meat and eggs while provide an important financial incentive for future employment of new producers and companies. The intensive system of farming and the high cost of conventional feeds have aroused interest in the search for cheaper feedstuffs as substitutes. Agro-industrial by-products which are generated in large amounts every year would be an excellent choice in conventional diets for the animals due to their availability, their low cost, and their constituents (proteins, minerals, vitamins and trace elements) (Katsoulis et al., 2016; FAO, 1994). Cotton is produced mainly in three EU countries, Greece is the main cotton grower, followed by Spain and Bulgaria. Cotton (Gossypium hirsutum L.) is a crop of high importance for Greek agricultural production, accounting for more than eight percent of total agricultural output. However, in Greece cotton by-products remain unused. The woody part of cotton and its by-products (stalk, broken fibers, cake), as well as the crop residues (nuts, leaves) are not utilized, so they are either thrown away from the gins or remain unused in the field. Their utilization consists in the content of by-products mainly in proteins and raw fibers (cellulose, hemicellulose, lignin) and secondarily in fats and minerals.

Cellulose is a major structural component of plant cell walls, which is responsible for mechanical strength. It is made up of a linear polymer chain, which in turn consists of a series of hydroglucose units in glucan chains. Hemicellulose macromolecules are repeated polymers of pentoses and hexoses and thus can be a source of various polysaccharides, like xylose, galactose, mannose and arabinose. Lignin is a complex polymer of aromatic alcohols known as monolignols, contains three aromatic alcohols (coniferyl alcohol, sinapyl alcohol and coumaryl alcohol) that are produced through a biosynthetic process and forms a protective seal around the other two components (Calvo et al., 2010). Although fiber in poultry nutrition is often associated with reduced energy availability due to its minor

role in energy supply and interference with digestive processes, recent studies indicate that low to moderate amounts of fiber (Mateos et al., 2012) improve gizzard function, digestibility of non-fiber nutrients, gastrointestinal tract health and growth performance in broilers. Raw fibers pass through the digestive tract and remains almost intact, offering significant health benefits; as they do not dissolve, they form a kind of barrier, which internally retains nutrients (lipids, carbohydrates, proteins). The increased content of cellulose in the feed contributes to the better absorption of nutrients due to increased enzyme activity. Also, the feeling of satiety is created faster due to the swelling observed, attributed to the absorption of water by cellulose and hemicellulose. The increase in the abdominal load observed contributes to the improvement of the behavior of poultry among them in all breeding systems (reduction of stings, cannibalism). Finally, raw fibers enhance intestinal motility (peristaltic movements), limit the residence time of food in the intestine, reducing the time of contact of toxins of the intestinal contents with the surface of the colon (elimination of inflammation) (Svihus 2011; Jim´enez-Moreno et al., 2009a; Gonz´alez-Alvarado et al., 2010; Kalmendal et al., 2011; Mateos et al., 2012; Gonz´alez-Alvarado et al., 2007; Jim´enez-Moreno et al., 2013a; Langhout DJ, 1998; Jorgensen et al., 1996).

The main object of this study is the utilization of the residues of cotton crops that remain unused in the diet of poultry. An effort that is achieved systematically abroad (Hill et al., 2000; Rogers et al., 2002; El Boushy et al., 1989; Tang et al., 2012; Kanyinji et al., 2014; Swidiq et al., 2012; Bello 1984; Waldroup, 1981; Salda˜na et al., 2015) but in our country, has not yet found a response from producers and industry.

## MATERIALS AND METHODS

All the chemicals and solvents used were purchased from Sigma-Aldrich at the analytical grade or highest level of purity available and used as received. All solutions were freshly prepared in distilled water. The agricultural by-products that used for the research work were collected from field and ginning mills during 2018-2019 in the region of Thessaly in Greece. The following cotton by-products were investigated: cotton cake, nuts, leaves, broken seed and cotton stems. Acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin, ether extract (EE), ash and nitrogen content were determined. The samples initially were purified from impurities, little stones and tracks of dust. Laboratory sample preparation was needful in order to convert the sample into a homogeneous material suitable for analysis. Before grinding, the biggest parts of samples were cut and divided in smaller. Drying samples grinded in a mill (System POLYMIX® PX-MFC 90 D) into smaller particles using sieve with 1 mm wide opening. Drying of samples (approximately 2000 mg) was obtained by heating in a drying oven (model R. Espinar, S.L.) at 100-103 °C until constant weight was obtained between two sequential measurements. pH measurements were made using a digital laboratory pH meter (model WTW pH 525) which was calibrated using certified pH= 4.0 and pH= 7.0 buffer solutions, according to the official method. The ether extract (EE) was determined using the method of Soxhlet. Approximately 2000 mg of solid sample were mixed with anhydrous sodium sulfate, placed in an extraction thimble and were extracted using an appropriate solvent in the Soxhlet extractor. Ash contents were determined using dry ashing method. The samples (2000 mg) were ashed for about 8 hr. until a white or grey ash residue had been obtained using a furnace (model P. Selecta, 3000 W) where temperature had been gradually increased from room temperature to 450 °C in 1 h. The procedures were repeated three times. Acid detergent fiber (ADF), neutral detergent fiber (NDF) and lignin were determined using an extraction unit for determining raw fiber content (model DOSI-FIBER-P. SELECTA). NDF is the amount of substances obtained from residue after boiling of 1000 mg sample with neutral detergent solution. NDF residue contains hemicellulose, cellulose, lignin, cutin, insoluble mineral substances and some proteins of cell walls. ADF is the amount of substances obtained from residue after boiling of 1000 mg sample with acid detergent solution. ADF residue contains cellulose, lignin, cutin and mineral substances insoluble in an acid environment (silica). The difference between NDF and ADF is given mostly by hemicelluloses. Kjeldahl method was used to determinate the nitrogen content of samples. Kjeldahl digestion converts nitrogen compounds (proteins, amines, organic compounds) into ammonia compounds (ammonium sulfate). Alkalizing the digested solution

liberates ammonia which is absorbed in an excess of boric acid. The quantification of distilled ammonia is generally achieved by titration with standard acid in the presence of a suitable indicator (AOAC, 1990, Van Soest et al., 1991).

## RESULTS

Mean % values of parameters of cotton by-products that have been studied in this work have shown a variety of characteristics as it is demonstrated in **Table 1** and in **Table 2**.

**Table 1.** Chemical characterization (% content of nitrogen, ether extract, ash) of cotton by-products.

| Cotton by products | % Ether extract | % Nitrogen content | % ash |
|---|---|---|---|
| Stalk | 1.3 | 6.8 | 1.28 |
| Cake | 6.23 | 23.9 | 4.67 |
| Seed | 16.8 | 19.1 | 2.42 |
| Nut | 4.1 | 9.53 | 3.7 |
| Leave | 5.5 | 10.79 | 5.08 |

**Table 2.** Raw fiber content of cotton by-products.

| Cotton by products | % Raw fiber | | |
|---|---|---|---|
| | cellulose | hemicellulose | lignin |
| Stalk | 34.19 | 17.02 | 26.4 |
| Cake | 11.51 | 9.77 | 6.08 |
| Seed | 33.4 | 11.1 | 9.3 |
| Nut | 38.51 | 19.6 | 10.2 |
| Leave | 17.07 | 8.5 | 5.28 |

The higher values of lignin were observed in cotton stalk (26.4 %) and in cotton nut (10.2 %) while the lower has been observed in cotton leaves (5.28 %). The higher values of cellulose were observed in cotton stalk (34.19 %) and in cotton nut (38.51 %) while the lower has been observed in cotton cake (11.51%). The measurement for % nitrogen content, % ether extract and % ash content has varied from 6,8 % to 10.79 %, from 1.3 % to 16.8 % and from 1.28 % to 5.08 % respectively. The higher values of % nitrogen content were observed in cotton cake (23.9 %) and in cotton seed (19.1 %) while the lower has been observed in cotton stalk (6.8 %). The ash content (minerals) was less than 5.08 % for all samples that have been analyzed with the higher value has been observed in cotton leave (5.08 %) and the lowest in cotton stalk (1.28 %). The higher percentage of ether extract was observed in cotton seed (16.8 %) and the lower in cotton seed stalk (1.3 %).

## DISCUSSION

It is well known that dietary fiber can contribute significantly to the nutritive value of diets both directly as energy source and indirectly through its effects on digestive and metabolic processes (Jorgensen et al., 1996, Smits et al., 2000, Annison 1993, Mertens 2003). Our data reveal a variety in

percentages of raw fiber, nitrogen, ash and ether extract contents. Results from this work clearly demonstrate the high row fiber and nitrogen contents that most of cotton by-products possess. Raw fibers of cotton stalk, seed and nut, may enhance peristaltic movements and limit the residence time of feed in the intestine, reducing the contact time of toxins of the intestinal contents with the surface of the colon. Cotton residues of cake and seed can offer an important supply of energy in poultry diet attributed to content of nitrogen and ether extract. Cotton stalk and nut containing high soluble fiber levels (hemicelluloses) could be used to increase the activity of intestinal bacteria with cellulolytic and hemicellulolytic activities. Cotton is the major agricultural product of Greece and all these by-products can be found in significant amounts. Due to their availability and low cost, cotton by products can be used as constant additives developing a proper mixed feeding system in poultry diet. Producers are continuously looking for ingredients with a value added because of the intensive system of livestock production and the high cost of conventional feeds and local agricultural byproducts present a possible solution in poultry feed.

## CONCLUSIONS

Moderate supply of dietary fibers from cotton byproducts with their important energy content may have numerous positive benefits in poultry health. Favorable impact on behavioral characteristics such as aggressive pecking and cannibalism, stabilization of digestion, intestinal motility, better litter quality, stimulation the growth of the villi and improved protein and fat digestibility are some unique characteristics achieved using agricultural by products.

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