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Review

Feeding Forage in Poultry: A Promising Alternative for the Future of Production Systems

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Received: 25 May 2018; Accepted: 8 June 2018; Published: 9 June 2018

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Abstract: The present review discusses the existing research findings on the nutritional impact of forages in poultry diet and the significance of forages in sustainable poultry production systems. The nutritional composition and antinutritional factors of the main forages and the pros and cons of feeding forage on poultry meat and egg quality under free-range and organic production systems are also discussed. This review highlights the importance of forages and forage meals in poultry ration, considering that these feedstuffs may have greater value to the success of local poultry production in many regions of the world due to their potential of production.

Keywords: forage; production system; poultry; sustainability; livestock

1. Introduction

Organic and free-range poultry have been increasingly available to the average consumer due to increased consumers' demand for meat and egg products [1]. In fact, with the increased intensity of modern production agriculture, many consumers share views that organic and free-range products are in some way better for them, or at least follow production practices that are more conducive to a cleaner, more balanced environment [2]. Organic farming is defined as the approach to agriculture in which the aim is to create environmentally and economically sustainable agricultural production systems [3].

In organic poultry farming, feeding covers an important role, since the dietary requirements of poultry are very different from those of ruminant livestock [4]. Poultry are particularly sensitive to dietary quality because they grow quickly and make relatively little use of bulky fibrous feeds such as pasture or hay [5]. In addition, poultry have specific requirements for essential amino acids, in particular lysine and methionine. In conventional systems, feeds are supplemented with synthetic amino acids, but these are not permitted in organic systems, so alternative sources, such as natural essential compounds from plants and vegetables, have to be investigated [5,6]. It is often difficult and expensive to source these products, and they are major contributors to the high cost of feed. In this regard, there is a growing interest in using novel feed resources, and the utilization of forage for poultry diet could be a sustainable and natural alternative for organic producers, especially under smallholder production system conditions.

Forages and forage meals could be valuable alternative sources of protein for commercial poultry where they are easily available and not expensive [7,8]. Moreover, forage utilization as local feed resource is important to facilitate the transition to 100% organic feed supply for organic poultry meat and egg producers [9]. Therefore, the present review discusses the available research findings on the nutritional impact of forages in poultry diet and the significance of forages in sustainable poultry production systems.

2. Forage Nutritional Composition

The demand for animal protein for human nutrition in the developing world is still rising, especially for poultry products and the cost of feed concentrates for livestock is increasing [3]. Therefore, to meet the nutritive requirements of poultry, it is necessary to identify alternative low-cost feed resources.

Forage based animal production plays a crucial role in the affordable supply of nutrient rich foods for humans [10]. Grassland and forage crops are recognized for their contribution to the environment, recreation and efficiency of animal production [11,12]. To maintain sustainability, it is crucial that such farming systems remain profitable and environmentally friendly while producing nutritious foods of high economical value. Thus, it is pertinent to improve the nutritive value of grasses and other forage plants to enhance animal production to obtain quality food, and it is also vital to develop new forages which are efficiently utilized and wasted less by involving efficient animals [13]. A combination of forage legumes, fresh or conserved grasses, crop residues and other feeds could help develop an animal production system which is economically efficient, beneficial and viable [9].

Livestock animals and forages are two significant factors in many animal production systems [13]. Grasses, legumes and cereals can be tested for their roles for sustainable animal production, and searching for new forages could help reduce the effects of animal production on climate change. In fact, forages can be tested further for their environmental benefits and contribution to the sustainable animal production [14]. Therefore, more research on the suitability of animal species and genotypes to utilize available and alternative feed resources more effectively may also help in developing sustainable forage based animal production.

Forages as feed for monogastrics, including poultry, contribute to improve sustainability of animal production within farming systems [15]: high biomass production in environments where other crops cannot compete; no or limited competition with human food requirements; high levels of protein with a desirable amino acids profile, especially lysine, methionine and other sulfur-amino acids, which for monogastrics adequately balances the limitations of cereal proteins (leaf and grain); and additional benefits from the integration of forages in the farming system [15]. The chemical composition and nutritive value of many forages were widely summarized by the French Institut National de la Recherche Agronomique (INRA) [16].

Plants produce a variety of simple to highly complex anti-nutritional substances, many of which have been identified and characterized [17]. The most common major groups are polyphenols, cyanogenic glycosides, alkaloids, saponins, steroids, toxic proteins and amino acids, non-protein amino acids, phytohemagglutinins, triterpenes, and oxalic acid [18], and are either toxic or act as antinutritive factors. Secondary compounds can exert both anti-nutritional and nutritionally beneficial effects upon forage feeding value. Secondary compounds that occur in both temperate and tropical forages [19]. Lectins are sugar-binding glycoproteins, which are classified as toxic (*Phaseolus vulgaris* and *Canavalia ensiformis*), growth inhibitory (*Glycine max*, *Amaranthus cruentus*, *Phaseolus lunatus*, and *Dolichos biflorus*) [20], or essentially non-toxic or beneficial (seeds of *Vigna subterranea*, *Vigna umbellata* and *Vigna unguiculata*) [20]. Condensed tannins are complex heat-stable phenolic compounds and common in many plants, especially shrub legumes such as *Gliricidia sepium*, *Acacia species*, *Leucaena leucocephala* and *Albizia falcataria*. Polyphenols are a major group often related to taste, odor, and color of animal products [21]. Saponins are found in *Brachiaria decumbens*, *B. brizantha* [22], *Amaranthus hypochondriacus*, *Chenopodium quinoa*, *Atriplex hortensis* [23], and *Medicago sativa* [24]. Alkaloids of legumes such as the bitter-tasting quinolizidine in lupins [25] reduce the feed intake, may affect the liver, and paralyze respiration [26].

The presence of secondary compounds can have a profound effect on both the nutritive value and the feeding value of both temperature and tropical forages and these effects can be beneficial in some instances as well as being detrimental in others [19,27]. To completely understand the influence of these compounds on animals, it is essential to develop a knowledge of their chemical structure and reactivity, particularly with proteins [27].

However, forage plants can be successfully processed to enhance palatability, intake and digestibility, and to conserve, detoxify the antinutritional factors, or concentrate nutrients [19,28]. In particular, milling, pelleting and micronizing processes increase the digestibility in poultry of protein and starch and apparent metabolizable energy values of forages [28,29]. In this regard, some antinutritional factors such as tannins are mainly concentrated in the seed coat, so that hulling is a simple method to remove them [30,31]. There have been various attempts to mix different exogenous enzymes into feeds to reduce antinutrients [32].

3. Poultry Production Systems

Free-range and organic poultry production systems have increased in recent years worldwide, and it is widely known that the suitability of the genetic strain to extensive environments largely affects the animal welfare and the meat and egg characteristics [6,33]. In fact, when poultry are reared under extensive system having access to pasture, health, welfare, meat and egg quality parameters result enhanced [34,35].

3.1. Free-Range System

Free-range defines a production system where the chickens can access outdoor runs for most of their lives [36]. These systems are well known and extensively used by small-scale farmers and, normally, slow-growing broilers are used [37]. However, free-range does not mean that the production methods follow certified organic standards as some consumers may perceive. A conventionally-raised chicken could be labeled as free-range if it were allowed to have access to the outdoors. Free-range production typically follows an alternative rearing practice compared to that of conventional production [38].

The U.S. free-range system definition does not include any specification for how long broilers should remain outdoors and under what conditions they should be raised and fed [37,39]. In addition, there is no specification for appropriate genotypes and no minimum age for slaughter. To label broilers as free-range, farmers in the U.S. must demonstrate that birds have had free access to the outdoors for more than half of their lives. Conversely, the European legislation for free-range systems specifies maximum stocking rates for indoors and outdoors, minimum age at slaughter as well as the feed composition for both laying hens and broilers [5].

Improving poultry welfare is one of the key reasons for the re-development of free-range poultry production in Europe. The European legislation also differentiates free-range into three main systems: free-range, traditional free-range and total freedom (Council Regulation EC No 1234/2007) [40]. In free-range systems, poultry houses are normally fixed and an adequate number of popholes is required based on the size of the houses and number of animals [40]. In traditional free-range, such as the label rouge systems in France, stipulates a minimum slaughter age of 81 days and no more than 4800 broilers can be produced per flock [36,40]. In Brazil, the "caipira" production system (another example of national labeling program) specifies regulations for free-range systems. The amount of free-range space is subjective as there are no regulations requiring a standard stocking density [37]. Depending on the amount of time broilers spend outside, it could be argued that free-range are no different than conventional if the free-range chickens never leave the housing structure [37]. In free-range poultry systems, runs are often not well managed and animals may not feel safe in it. Outdoor runs could be made more attractive by offering different kinds of shelter [4,6]. A free-range area contributes to the welfare of laying hens. Studies that looked at the relation between the use of a free-range area and the degree of feather pecking damage, found that if a higher proportion of a flock uses the free range area, then significantly less feather pecking damage is seen [41–43]. A higher proportion of hens using the free range area can be achieved by providing shelter [41]. This can be artificial structures or natural, for example trees or bushes. It was found a relation between tree cover and injurious feather-pecking: less feather pecking was seen in the case of more tree cover [44]. Besides an advantage for animal welfare, a higher degree of woody cover in the free-range area seems to be related to less avian influenza risk for birds in the free range area [43]. The presence of trees can help chicken feel more secure from predators and more sheltered from sun and the elements so they can venture further away from the huts and eat more forage [45]. Another benefit of tree and forage cover is a better distribution of hens across the range area, which may reduce the risk of parasitic contamination [46].

Finally, a better distribution of hens may prevent local accumulation of nitrogen and phosphate [47]. It has been shown that range enrichment is not only beneficial for the animal behavior [48], but can also be economically advantageous (e.g., reduction of animal mortality rate), resulting in a win–win situation for poultry welfare and production [6]. According to Cobanoglu et al. [49], free-range producers commonly utilize the same fast-growing broilers as conventional systems; however, the suitability of these birds may not be adequate since conventional broilers do not acclimate themselves well with outdoor conditions [39].

3.2. Organic System

Organic refers to the way agricultural and livestock products are reared and processed, which involves avoiding agrichemicals such as synthetic fertilizers and pesticides. Given the current demand for organic foods, organic poultry production has become a growing segment of the poultry industry. Organic poultry have access to pasture [6,39], a nutrient source that has not been completely investigated for use in poultry. Organic poultry production focuses particularly on animal health and wellbeing, good environmental practices, and product quality and focuses less on economic concerns, such as reducing costs and maximizing production [37,50].

Overall, the EU regulations (No 889/2008) [51] for organic production of poultry specify that land should be free of synthetic fertilizers, pesticides and herbicides for a specific time. The dietary supplementation is subject to some specific requirements and synthetic ingredients and GMOs in feed are regularly forbidden [36]. In some European countries and in the U.S., some limiting synthetic amino acids are still permitted at low levels if organic sources are not available to farmers. However, in the EU, the feed ingredients must be organically produced, if not the meat or eggs will not be labeled as organic. In the U.S., organic labeling is available at three different levels based on the amount of organic feed supplemented to broilers: "100% organic broiler"; "organic broiler", meaning that at least 95% of the ingredients were produced organically; and "made with organic ingredients", meaning that birds consumed at least 70% of organic ingredients in feed [36,52]. The U.S. regulation does not specify indoor or outdoor stocking density, but certification agencies look for a maximum of 8 birds/m^2 indoors [37].

In European countries, even though the law is the same for all members, there are specific local regulations and labeling programs related to the organic poultry production. In particular, the maximum flocks size cannot exceed 4800 broilers and a maximum stocking rate of 10 birds/m^2 is obligatory. Further, if mobile housing is used, the stocking density can be increased to 16 broilers/m^2, but the maximum flocks size cannot be modified [36,52]. Poultry must be able to walk around the outdoor runs at stocking rate of 4 m^2 per subject. Regarding the minimum age at slaughter, the starting point is the 81 days specified in the European regulation (No 889/2008) [51]. Under organic production systems, antibiotics and drugs are substituted by alternative natural products [53] and birds are raised for longer periods (>81 days) until slaughter.

4. Influence of Feeding Forage on Poultry Egg and Meat Quality

Poultry diets are commonly corn–soybean meal-based displaying a high energy concentration and low fiber levels. Nevertheless, many feedstuffs having high fiber content have been commonly included in poultry diet, especially in extensive poultry production systems. However, depending on the solubility levels and concentrations, fiber in diets influences poultry performance [54–56].

Outdoor systems are sustainable alternatives for poultry production where laying hens are able to ingest nutrients from pasture and forage, minimizing the intake of commercial feed. Poultry can eat forage, pebbles, weeds, crop seeds, earthworms and insects in the paddock [57]. It was also reported that an outdoor system could benefit the environment because of increased nutrients circulation within the system [58].

Laying hens and broiler chickens given access to pasture may meet various nutrient needs through foraging [7,59]. It was reported that laying hens having access to grass resulted in a 20% reduction in feed consumption and increased egg production compared with hens raised under conventional conditions [59,60]. Moreover, hens reared on alfalfa or clover need significantly less feed protein than confined hens [7]. In particular, alfalfa forage can supply carotene, vitamins and other nutrients, especially high amount of protein up to 19% as dry matter basis [61,62]. In addition, it was found that organically reared broilers may overcome growth impairments associated with methionine deficiency through foraging [63]. The primary benefit of forage consumption is that plant matter is typically high in both vitamins and minerals; moreover, forages contain components such as fiber, protein, energy, and other compounds such as carotenoids and n-3 fatty acids having important metabolic functions in all animals, including poultry [64]. Pasture intake by poultry may acts as a form of nutritional insurance and pasturing poultry and giving them access to high-quality forages will help in balancing out any deficiencies. Moreover, forages can provide supplemental minerals, and the calcium found in plants such as alfalfa is highly bioavailable. Poultry digestive system is able to utilize calcium from forages as efficiently as calcium from more common sources such as limestone or oyster shell [61]. It was reported that broilers and laying hens fed low-protein diets increased their intake of forages compared to flocks fed a ration with adequate protein concentration [58,65]. Similarly, poultry nutritionists have found that forages consumption is inversely tied to protein levels, since a higher protein content in the diet can result in a lower amount of plant matter consumed on pasture [63]. Further, poultry are able to utilize most of amino acids consuming forages, resulting in a significant level of methionine and lysine digested (88% and 79%, respectively) [7,59]. On the other hand, forages are low in energy, but these plants can contribute to the overall energy requirements of poultry. In this regard, Rivera-Ferre et al. [66] reported that poultry raised on pasture obtained only 3% of their energy requirement from forages. Although grains are noticeably the most important energy source in poultry diet along with oils, even the low amounts of energy supplied by forages are vital when feed prices increase [59].

Research is beginning to investigate claims of particular nutritive characteristics of eggs and meat from pastured birds. It was assessed that the poultry products from grass-fed flocks tend to have less total cholesterol and more vitamins A and E, as well as high omega-3, and an improved omega-3 to omega-6 ratio [67]. It was found that egg cholesterol decreased as alfalfa meal increased in a laying hen diet [62]. Studies demonstrated that hens with access to high-quality pasture had eggs with at least twice as much vitamins A and E and omega-3s, compared to hens having no access to different pastures [68–71]. Furthermore, it is well established that a large range of forages, such as alfalfa, perennial ryegrass, red clover, and grass meals, although containing significant fiber levels, are valuable sources of xanthophylls and can be successfully used in diets as natural pigmenting agents [72]. Available studies have reported increasing levels of n-3 fatty acids in meat from pasture-raised broilers as well as higher levels of vitamin E and other nutrients [34,35,71].

The evaluation of including dehydrated leguminous-based forages in common poultry diets under intensive production systems on growth performance and meat quality remains to be more deeply investigated. Leguminous-based forages may be considered as a source of fiber and protein for broilers, and forages are also a source of natural antioxidants [73]. Antioxidant supplementation of feed is an efficient method for increasing poultry meat oxidative stability [74]. Moreover, β-carotene, a pro-vitamin A compound abundant in forages, is the predominant carotenoid in meat and meat products [75]. Feeding of dehydrated leguminous-based forage vitamin E homologs and β-carotene for broiler meat oxidative stability remains, however, to be established [73]. It has been previously found that including dehydrated leguminous forages in broiler diet contributes to decrease cholesterol levels of meat [76]. Conversely, it was demonstrated that the consumption of a dehydrated leguminous-based forage, offered free choice and ad libitum, by broilers of a fast-growing genotype exploited under an intensive production system had no effect on broiler performance, on the profiles of vitamin E homologs and on the cholesterol content of meat [73]. However, the intake of the dehydrated forage had a major influence in the fatty acid profile of broiler meat, resulting the levels of n-3 long-chain PUFA (EPA, DPA, and DHA) in breast meat significantly higher when animals consumed the leguminous biomass. Further, it was reported that feeding of citrus pulp or dehydrated pasture at 10% levels changed broiler meat fatty acid profiles, depressing MUFA and increasing the predominance of n-6 and n-3 PUFA [8]; thus, these findings suggested that dehydrated pasture may be an interesting supplement to add in broiler diet to enhance meat lipid quality.

Several antinutritional substances (such as saponins, phenolic compounds and protease inhibitors) influencing negatively the performance of poultry fed forage-diets have been reported. For example, based on the findings of many studies, it was found that dehydrated alfalfa may contain some antinutritional factors (saponins and isoflavones) reducing the productive performance of both broilers and laying hens [76–80]. It was also assessed that poultry are more sensitive to dietary alfalfa saponins than other monogastric species [81]. Levels up to 20% alfalfa meal in broiler rations resulted in growth rate depression due to the saponin content [81]. Further, tannic acid was also found to reduce the metabolizable energy of the broilers diet, depressing the nitrogen retention by chicks [82]. Finally, in a series of studies with geese, turkeys, quails and chickens fed with high-saponin and low-saponin alfalfa meal, at levels ranging 1–20% of diet, it was found that the only discrimination between the two alfalfa types was observed in geese fed 20% alfalfa [23].

5. Conclusions and Future Outlook

The improvement of poultry production systems may be essential to produce quality animal products; thus, it is crucial that production systems are compliant to the needs of populations being associated with animal production in both developing and developed countries. The use forage as the advantageous alternative to the conventional feeds may be an input to increase the forages utilization in poultry production systems. In alternative poultry production systems, both organic and free-range, it is imperative to improve the outdoor area utilization and to optimize forage intake, which still requires further investigation in poultry. Poultry production would benefit from feeding forage as substitute to conventional cereals and oil seeds to reduce the dependence on these feedstuffs, especially in particular areas of the world. Moreover, there are many forage species as alternative protein sources for livestock species, thus forages could provide the basis for most animal production systems for the near future.

Author Contributions: All the authors equally contributed and commented on early and final version of manuscript.

Acknowledgments: No funds or grants were received in support of our paper.

Conflicts of Interest: The authors declare no conflict of interest.

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