Chapter

Poultry Meat Production in the South American Andes

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Abstract

This chapter will explain some of the research carried out in the production of poultry meat in natural hypobaric areas, where the development of industrial poultry farming is not traditional. Relevant aspect of the production of chickens, hens and turkeys for meat purposes will be clarified, as well as their benefits, and characteristics and why it must still be carried out in the Peruvian Andes. Physiological aspects of birds, use of unconventional food; as well as the productive evaluation of poultry species not used intensively, are approached with the purpose of generating and stimulating the obtaining of meat as an economic source for the rural sector and small companies.

Keywords: turkey meat, indigenous chicken, ecological poultry, lupine, hypobaric conditions

1. Introduction

In South America and Peru, poultry production is developed industrially in the coastal region with geographical heights that guarantee conditions of oxygen concentrations necessary for the growth of improved birds. However, it is necessary to take advantage of very important resources such as land, water and human resources in Andean areas, under hypobaric conditions; being necessary to demonstrate that the raising of birds and the production of meat is possible in such conditions.

For this reason, a series of works have been developed that guarantee and corroborate these statements. In Lavras, MG, Brazil, located at 919 m altitude, selenomethionine improved the weight gain and feed conversion in broilers of 1 to 42 d [1]. Broilers are raised to cool conditions at high altitudes in Shahrekord, Iran, at 2,100 m above sea level, with good cardiac parameters due use flavonoids bioactive compounds [2] and with dietary arginine supplementation to boost performance [3]. In Cajamarca, Peru at 2,700 m above sea level, the commercial turkey is raised up to fourteen weeks old with body weights 8 and 12 kg in females and males [4]. This review shows some works carried out in the Peruvian Andes region, with emphasis on the production of chicken and turkey.

2. World and regional poultry production

The first producer of chicken meat in the world has been the United States (17.6%), followed by Brazil (12.5%), then China (12.4%), Russia (4.1%), India

(3.2%) and Mexico (2.9%) mainly. In this ranking, Peru is ranked number 18. Brazil is indisputably the largest chicken producer in Latin America with 6,468.6 million chickens slaughtered in 2019. Brazilians represent 51.6% of all chicken production at the regional level, out of a total of more than 12,500 million birds. The 10 largest chicken production companies in the region are located in Brazil, Mexico, Peru, Colombia, Argentina and Central America. In 2019, Peru was the fourth largest producer of chickens in Latin America and the fifth largest producer of eggs in the region.

Peru, during the years 2017, 2018 and 2019, occupies the first position of per capita consumption of chicken in Latin America, with a consumption of 51.1 kilos of chicken per person in 2019. Behind is Argentina (46.6 kilos), Bolivia (43 kilos), Brazil (42.6 kilos) and Panama (41.28 kilos). The average consumption of the region was 31.42 kilos.

In 2019, at least 28.24 million turkeys were produced in Latin America, with Brazil being the largest producer of this animal protein with 13 million turkeys or 46% of the total poultry produced in the region. In terms of the countries that produce the most turkeys, behind Brazil is Peru (5.43 million turkeys), Chile (6.05 million), Ecuador (1.33 million), Mexico (1.18 million) and Bolivia and Colombia (each with 400,000 turkeys). produced in 2019).

3. Dietary inclusion of alfalfa meal in organic type broiler chicken

In Peru, 31 tons of meat from laying hens that have finished their productive cycle and about 46 tons of meat from backyard poultry and commercial hybrid breeding hens are consumed annually [5]. These birds are of advanced age and the laying hens at the end of the laying cycle end up with bone and liver problems [6], have low muscle mass and low carcass performance; Although it has been determined that meat from commercial laying hens, under the same diet, due to its composition in fatty acids, is more favorable for human health than meat from local breeds [7]; however, its mature and cross-linked thickened muscle fibers make it lose tenderness [8].

On the other hand, hedonism, health and the economy are factors that strongly influence the consumer [9] and drive the intake of organic foods [10]; Therefore, production systems with principles based on animal welfare and organic production with good sensorial quality of meat are increasing [11–13]. Also, according to the European Commission, 2008, organic meat can be obtained from fast-growing broiler chicken, fed diets that include green, dried or preserved forage, slaughtered after 81 days of age, without specifying the amount of pasture that the birds would have to eat. Several rearing systems have been evaluated [14], including the duration of the free rearing period, reporting that the sources of dietary fiber affect the oxidative stability of the meat, the blood parameters, and the content of proteins, cholesterol, fatty acids and triglycerides [15], as well as an increase in the weight of the gizzard and alterations in growth [16]. The antioxidant bioactive compounds of alfalfa, Phleum sp., *Dactylis glomerata*, Italian ryegrass (*Lolium multiflorum*) and balansa clover (*Trifolium michelianum*), among other forages, have been shown to improve the content of polyunsaturated fatty acids (PUFAs) n-3 and the proportion between PUFA n-6 and n-3 [17]. It has been determined that the saponins of dehydrated alfalfa have a hypocholesterolemic effect in chicken meat [18] and that the natural extract of alfalfa reduces the deposition of abdominal fat and improves the antibody titter against Newcastle disease, without an adverse effect on bird performance [19]. Additionally, alfalfa xanthophyll esters are known to produce better skin pigmentation in broilers [20].

As alfalfa is a widely available forage in Cajamarca, it was included in dehydrated form in the diet of the fast-growing chicken aimed at achieving the classification of organic chicken, with the hypothesis that alfalfa has beneficial effects on growth, carcass weight, weight digestive organs and lymphoid organ weight as it is an immunomodulatory food [21, 22]. For this reason, the effects of three levels of alfalfa meal (AM) included in the diet of female chicken, Hubbard line, supplied from 35 to 84 days of age [23].

The data suggest that the variables feed consumption and feed efficiency were not affected by the inclusion of dehydrated forage in the diet. Birds that consumed diets with 10% AM had lower carcass weight; however, no such differences are observed in carcass performance, indicating that the difference in carcass weight is due to the size of the live bird. On the other hand, the absolute and relative abdominal fat weights were higher with the HA-containing diets. The greater accumulation of abdominal fat in chickens agrees with some researchers [24] who by increasing the crude fiber of the diet from 3.19 to 3.52% in guinea fowl increased abdominal fat, without finding different carcass yields. Carcass performance is associated with the FC content of the diet; where lower feed intake and pasture consumption can have a negative effect on the carcass performance of birds compared to birds without access to pastures. On the other hand, the greater accumulation of abdominal fat in birds that consumed AM may be due to the fact that alfalfa strengthens the immune system, and this regulates lipid metabolism, hence, as there were no health challenges, lipolysis did not occur, but increased of abdominal fat deposition.

Not observed effects of AM on the absolute and relative weights of the digestive organs on the absolute value of the weight of the organs of the gastrointestinal tract, except for the intestines. In relative terms, the differences observed in the total weight of the GIT and higher gizzard development were also reflected in favor of the birds with 10% AM. According to the fiber content in the diets of the present study, from 3.56% (0% AM) to 4.54% (5% AM) produced an increase of 5.3 and 3% in the relative weight of intestines and gizzard, respectively. Likewise, the relative weight of intestines and gizzard increased to 19% with 5.56% fiber (10% AM), which could be due to the fact that dietary fiber intake causes an increase in the gastrointestinal tract of the birds, as a result of the increase in size. of the blind [25]. Similar results have been reported [26] with an 8.7% increase in gizzard weight of 35-day-old birds with the inclusion of 4% straw in the diet, and also when including 3% sunflower husk in the diet of the bird. Broilers from 0 to 21 days of age, resulting in an increase in gizzard weight [27]. Although it can be concluded that the inclusion of 10% AM in the diet in the present study produces a greater development of intestines and gizzards; It should be considered that the size of the gizzard can not only be increased by the inclusion of fibrous food in the diet, but also when the food particle is large [28].

4. Growth and carcass characteristics of six genotypes in chickens reared in Andean region of northern Peruvian

The per capita consumption of chicken meat in Peru exceeds 51 kg, with imports exceeding 34 and 13 million tons of frozen chicken and hen meat, respectively [29], showing there is still demand to be satisfied. In this regard, statistics indicate that poultry meat is the main driver of the meat sector in the world, due to the need for animal protein and because it is cheaper than red meat, with poultry meat being preferred by producers and consumers in developing countries [30].

The poultry meat supply comes mainly from fast-growing broiler genetic lines with high carcass yields; although, its flavor characteristics and meat qualities are

not highly appreciated by some consumers [31]. There is also the sector of native or creole poultry meat, eaten locally due to the consumer' perception that highlights its good taste and organic characteristics, without negative impact on human health as it is raised free of antibiotics [32], whose meat is low in fat and cholesterol [33], and its production is complemented with eggs rich in protein and iron [34].

Faced with such a situation, there is a supply of different genotypes of birds with colored plumage, by incubator companies registered in the Peruvian poultry system; reporting an approximate placement of 15 million crossed BB chickens nationwide, which is why the growth of this sector has been accentuating unconventional production with the use of the intensive rearing system at the level of small farms, without even having more technical information about the productive performance of these birds and especially in the Andes region.

Researchers from several countries are studying the native chicken, having determined in five Egyptian chicken breeds a genetic difference between pure native and improved native [35]. In high mountain areas of Thailand, they characterized different phenotypes of indigenous chicken reared in various production systems [36]. In Saudi Arabia they used microsatellite markers to assess the genetic diversity of their native chicken populations [37]. In Indonesia they did similar studies with single nucleotide polymorphism markers [38]. In northern Thailand they compared the meat of indigenous chickens and crossbred chickens of imported origin, in southern Thailand they determined the heritability and genetic correlations between growth indicators and meat quality of a line of improved indigenous chicken [39]. Chee chicken from Thailand was crossed with specialized lines of meat and other native breeds in order to improve meat quality and carcass performance [40]; while in India they conducted studies to conserve and characterize the germplasm of the Aseel chicken, which is considered in danger of extinction [41]; having been compared to the Kadaknath breed in terms of growth, egg production, semen quality and health indicators. In South Africa, indigenous chicken was fed canola meal instead of soybean without negative impact on carcass, organ size and meat quality [42]. Determined the proximal composition and amino acid content of the meat of the 180-day-old Italian chicken Poverara [43]; also, in Italy evaluated the growth of the local races Berlanda and Padovana [44] and work on the conservation of germplasm of other races such as: Ermellinata di Rovigo, Pépoi, Robusta Lionata and Robusta Maculata [45]. The Spaniards evaluated the crossing of the indigenous Galician rooster Mos with the line chicken Sasso T-44 [46]. In Ghana they carried out hematobiochemical studies in indigenous chickens to determine better performance and adaptability of the various genotypes [47]. Therefore, in Peru, among a variety of studies to be carried out on Creole chickens, it is necessary to evaluate the productive performance of the available birds of local origin and recently introduced, determining their biological capacity to thrive in high areas of the Andes.

With this objective, six chicken genotypes were comparatively evaluated: Native French, Hubbard red, Improved Peruvian Creole, Pure Peruvian Creole, Babcock Brown male chickens that are of the laying genetic line, contrasted with the Hubbard white, specialized in meat production; in order to determine its growth parameters, carcass characteristics, weight of internal organs and proximal composition of meat in conditions of the Cajamarca valley at 2684 meters above sea level.

The performance of the growing chickens evaluated up to 13 weeks of age indicated que both varieties of Hubbard chicken showed higher growth speed, followed by French Native and Improved Creole, as opposed to improved Peruvian Creole and Babcock Brown chickens that showed the lowest rates of increase in body mass. Proximal composition of the six types of chicken breast meat differ markedly in fat. Breast meat from the Creole, Native French and Babcock line breeds has the

lowest content fat, while the breast meat from Hubbard broilers has the highest amount. There is a trend for higher protein in the meat of native French and Creoles compared to Hubbard chickens, possibly due to the fact that lipidosis involves the replacement of muscle fibers by adipose tissue [48].

5. Lupine seed meal (Lupinus mutabilis) in Turkey feed

The interest in the food sector to identify, produce and use new protein sources for the nutrition of humans and animals is a task that has no end [49]. The national and global poultry sector is looking for alternatives in this field in order to include ingredients that efficiently replace or exceed soybean cake (TS), the most widely used protein ingredient in poultry feed, as many countries, such as Peru, they do not have an industrial production of this oil seed, depending on its permanent importation. However, in the Peruvian highlands there are various protein crops of the legume family, grown locally, such as chocho, commonly known as lupine, tarwi or lupine. Studies with yellow lupine (*Lupinus luteos*) seeds indicate that it could be included in the diet of broilers up to a proportion of 20 g/kg [50].

The main limiting factor for the use of lupine seeds yellow in the diet of poultry is the high concentration of non-starch polysaccharides (NAP), which reduce the nutritional value of the seeds [51], where raffinose can hinder the transport of nutrients through the intestinal wall [52]. The protein value of the *Lupinus mutabilis* (LM) seed harvested in the Peruvian highlands is similar to that of soybean, but its use has been limited by another additional factor, such as the presence of large amounts of quinolizidine alkaloid structures, with certain degree of toxicity and strongly bitter taste [53].

Other species and varieties of lupines such as yellow lupine, white lupine (*Lupinus albus*) or blue lupine (*Lupinus angustifolius*) have been included in the finisher diets of 18-week-old turkeys at levels of up to 180 g / kg, without affect gastrointestinal function and without adverse effects on the growth or quality of the meat [54], even though it can cause an increase in the weight of the gizzard, a decrease in the pH of the contents of the gizzard and problems in viscosity of the small intestine digest [55]. On the other hand, Samulikowska et al. [56] indicated that starter diets with 100 g/kg of yellow lupine seeds reduced body weight in broilers due to a lower feed intake, in addition to changes in the gastro-tract intestinal caused by increased concentrations of PNA and raffinose. However, inclusion of LM in feeding turkeys in their first weeks of life is not documented. Likewise, LM contains more than 20 types of alkaloids or toxic substances that could cause hemolysis and anemia [57], as happens with other plant alkaloids whose toxic effect can be combined with the ferric ion in the blood, affecting the transport capacity of erythrocyte oxygen; as has been demonstrated in young fish and ducks [58].

The effect of four dietary levels of lupine seed meal (*Lupinus mutabilis*, HCH) on growth performance, intestinal tract development and hematological values were evaluated in male turkeys of the one-day BUT line [59]. The turkeys were distributed in four groups with different diets for 56 days: L0 (control) diet without HCH, and L30, L60 and L90 diets containing 30, 60 and 90 g/kg of HCH, respectively. Increased levels of HCH inclusion in the diet, added at the expense of soybean meal contributed to an increase in fiber concentrations in the experimental diets. Daily feed intake decreased in HCH treatments and feed conversion and bodyweight gain of birds were affected in treatments of 60 and 90 g/kg of HCH inclusion. High dietary levels of HCH led to an increase of the digesta in the ileum and in the cecum, an increase in the relative tissue mass, as well as a decrease in pH values of the digesta. The increase in HCH in the diet did not alter the hematological

values. It is concluded that HCH can be considered as a safe and effective alternative for dietary inclusion at levels of 30 g/kg in starting diets for young turkeys.

6. Vitamin C and the productive performance of Turkey reared in a natural hypobaric environment

The Andean zone of Peru (natural hypobaric environment) has more than eight million of inhabitants [60] grouped in more than a million families; A lot of they consume turkey meat at Christmas parties, maintaining the custom of consuming it from birds raised in the same area and from native species; However, in the last few years the supply of turkeys from lines commercial genetics has increased and the inhabitants of the Andean cities have reversed their preferences for this type of turkey due to its lower cost and higher meat yield, but it relates the breeding turkey in the same area with the good taste, which would have a biochemical basis because the transport of the turkey during several hours from the farm to downtown processing produces high levels of corticosterone [61], in addition to bruising that the bird suffers during transfer; so the consumer prefers to buy live birds, which they slaughter after a previous inspection of its appearance bodily.

There are three important factors that hinder optimal rearing of the turkey for fattening: genetics, cold weather and lower oxygenation; in this regard, the intense selection of broilers for rapid growth and high meat yield is a great achievement, but it has led to an increase in the incidence of metabolic syndromes caused by the hypoxemic condition resulting from an imbalance between the requirement and the oxygen supply [62]. These birds in conditions of temperatures low and high geographical areas have problems of pulmonary hypertension and ascites [63]. Birds raised to high altitude achieve higher body weights lower than their level zone counterparts from the sea [64, 65], where there is a minimal incidence of ascites and right ventricular hypertrophy, lower red blood cell counts and low hemoglobin values [66]. Also, fast-growing broilers present dilated cardiomyopathies without presenting ascites, these cases being differentiated by elasticity and density of the arterial vascular structure, and the thickness of the fibers in the vena cava. These cases of cardiomyopathies with or without the associated presence of ascites occur very often in turkeys fattening raised in the Peruvian highlands. The low ambient temperature induces appearance of ascitic syndrome due to increased metabolic rate and oxygen requirement. In these conditions of environmental stress are produce at the mitochondrial level species of reactive oxygen such as oxygen ions, free radicals and peroxides that cause changes in the shape, structure and function of this key organelle in metabolism, causing oxidative stress [67]. Vitamin C (VC) is known to be an antioxidant capable of eliminating reactive oxygen species induced by low ambient temperatures, reducing stress [68–70], which in turkeys reflected by the increase in the heterophile/lymphocyte ratio [71]. VC prevents pulmonary vascular remodeling that causes ascites syndrome in broilers [72]. VC supplementation restores xanthine oxidase activity that meets the function of buffering the effects of superoxide in broilers raised under hypobaric hypoxia [73]. Likewise, CV is a powerful activator of the immune system, enhancing the antioxidant activity of other dietary compounds and improving the productive performance of growing species by reducing stress in environments exposed to ammonia production.

Also, it should be noted that for the formulation and production of animal feed turkey for fattening is not recommended to include VC because it is synthesized from glucose, via glucuronic acid and lactone from gulonic acid in the presence of the enzyme L gulonolactone oxidase; unlike fat soluble vitamins and B complex vitamins that must be included in specific amounts in the diet of the turkey using

vitamin premixes; therefore, the supplementation of VC in the diet could generate in the turkey for fattening subject to permanent selection and raised under environmental conditions hypoxia, better productive results in terms of growth, reduction of stress and immune response against the main diseases that occur in this species.

With the objective of determining the best level of dietary supplementation of vitamin C in the fattening turkey raised in a natural hypoxic environment of the Cajamarca valley an experiment was carried out. Vitamin C decreased heterophile/lymphocyte levels. Compared to the control group, vitamin C at a level greater than or equal to 1000 mg/kg decreased bird mortality, reduced the stress indicator, increased the antibody titer, but did not improve growth parameters. Consequently, dietary supplementation with vitamin C could regulate productive performance, by reducing the level of mortality, promoting immune function, and improving the state of stress in commercial turkeys, reared in a natural hypoxic environment. These results encourage commercial turkey meat production in hypoxic areas.

7. Opportunities and challenges to produce poultry in South America

World meat production in 2016 increased only 1%. Among the various sectors, poultry and beef production increased. The increase in world exports of meat products was led by Brazil and the European Union, followed by the United States, and sales also increased in South American countries such as Argentina and Paraguay.

Global meat production is projected to be 13% higher in 2026 than in the 2014–2016 base period. Developing countries are estimated to account for the vast majority of the total increase, given the more intensive use of food in the production process and the lower cost of human resources. Poultry meat is the main driver of growth in total meat production, due to the greater world demand for this animal protein, which is cheaper than red meat. Low production costs and lower product prices contribute to poultry meat being the preferred meat for both producers and consumers in South American countries.

8. Conclusion

The physiology of birds for meat purposes is adaptable to hypobaric challenges, with convenients feeding strategies and programs, to generate in birds an efficient use of feed nutrients, which synthesized as poultry body nutrients will be very necessary to human nutrition in of highlands.

The production of fast-growing poultry meat in territories with natural hypobaric conditions is technically feasible. You can use food produced in the same region. Organic chickens, indigenous chickens, turkeys and muscovy ducks can be raised on a small scale and industrially.

Conflict of interest

I have no conflict of interest'.

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