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Challenges of production, nutritional quality and market prospects of chicken meat consumption without antibiotics (green)

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ABSTRACT

The chemical composition and reasonable price of chicken meat have made it one of the best sources of animal protein. The use of antibiotics in poultry has led to the accumulation of their residues in meat, which in turn has contributed to the development of antibiotic resistance. To overcome this problem, therefore, antibiotic-free (green) meat production has been developed. By searching international and internal databases, the results and achievements presented in various scientific documents have been widely reviewed. The reviewed results showed that antibiotic resistance, one of the major global public health concerns, is also a significant problem in our country. The "One Health" approach, including the connection of human health, animal health and the environment, has been emphasized to deal with complex health challenges such as antibiotic resistance. Antibiotic-free meat production is associated with challenges that have increased its production costs. At the same time, green meat has better nutritional and healthy properties than normal ones, and if public awareness increases, a suitable distribution and supply network, and especially a balanced price, can become a priority in consumer choice. In conclusion, by accepting the principles of the concept of One Health, the effect of antibiotic resistance can be reduced, as well as the responsible use of antibiotics, and the ongoing research and development to achieve effective and safe alternatives, the effectiveness of antibiotics protected, and a healthier future will ensure for humans, animals and the environment.

1. Introduction and Problem Statement

The nutritional profile of meat plays a crucial role in selecting appropriate food options and promoting a healthier diet. Chicken, in particular, is recognized for its low fat and cholesterol content, along with easily digestible proteins and minimal collagen levels, making it a healthier alternative to other animal protein sources, especially red meat. Furthermore, the incorporation of various dietary supplements can enhance the health benefits and quality of meat products [1].

Sustainable poultry production necessitates achieving optimal productivity while ensuring the welfare of the birds and safeguarding the environment. For instance, breeding programs aimed at enhancing production efficiency have inadvertently resulted in welfare and health issues among birds, such as rapid growth, excessive body weight, leg injuries, and reduced activity levels in fast-growing chickens [2]. Although commercial poultry farming can be lucrative, it also encounters significant challenges, particularly the prevalence of both infectious and non-infectious diseases. Over the last few decades, certain antibiotics have been incorporated into broiler diets to manage, prevent, and treat diseases, as well as to enhance feed efficiency [3, 4]. Since 2006, the European Union has prohibited the use of antibiotics as growth promoters, and since 2017, there have been restrictions on the use of antibiotics in livestock or animal feed intended for human consumption [5]. Despite these regulations, the unregulated application of these substances has resulted in the detection of their metabolites in the edible tissues of livestock, leading to negative health implications for consumers, including the rise of antibiotic resistance. The misuse of antibacterial has exacerbated the issue of antimicrobial resistance, which presents a complex challenge with serious implications for public health [6].

In recent years, there has been a growing focus on enhancing animal welfare and improving meat quality within poultry production. Concurrently, consumers have expressed concerns regarding antibiotic residues, antimicrobial resistance, pesticide residues, additives, feed composition, flavor, traceability, and genetic modifications. As a result, the production of healthy products devoid of substances deemed harmful to human health and the environment has become increasingly significant [7]. Consumers are showing a heightened interest in natural or eco-friendly products, which they believe offer superior nutritional quality, are free from contaminants, and possess good taste. Additionally, they favor products that ensure the welfare and health of the birds [8].

In numerous developing nations, poultry farmers frequently administer antibiotics without veterinary guidance or prescriptions, often neglecting the recommended withdrawal periods [7]. Contributing factors to this issue include inadequate services, lack of accessible support and monitoring systems, insufficient awareness and knowledge, and the pursuit of higher profits, which can lead some producers to misuse or illegally apply antimicrobial agents [9]. These agents can accumulate in various body parts and tissues, resulting in unintentional exposure of consumers to antibiotic residues. Studies have indicated that such residues can be found in the liver, kidneys, thigh meat, and breasts of broiler chickens [10]. In a study conducted in Mazandaran province, it was reported that out of 815 industrial poultry carcasses tested from three active slaughterhouses, 65.4% contained antibiotic residues in at least one of the examined organs (muscle, liver, kidney), with some carcasses showing residues in two or three organs [11].

Antibiotic resistance has always been a natural phenomenon; however, the misuse of antibiotics has significantly accelerated the emergence and

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spread of drug-resistant pathogenic bacteria [12]. These resistant strains, equipped with resistance genes, can rapidly disseminate among humans, animals, and ecosystems. Consequently, it is essential to explore new strategies for producing antibiotic-free broilers to ensure their sustainable rearing and marketability [13].

The apparent lack of adequate knowledge and understanding regarding the characteristics of chicken meat available at various price points may lead to consumer uncertainty in their purchasing decisions. This article will address the approaches and challenges related to antibiotic resistance, quality, market share, and the potential for producing antibiotic-free poultry meat, commonly referred to as green chicken in our country.

2 .Chicken without Antibiotics

The term "antibiotic-free chicken" (indicated by a green label) signifies that no antibiotic medications have been administered through the birds' food, water, or injections. This standard can complicate the growth of chickens and the management of diseases, making it more inefficient and costly. There are three primary approaches to antibiotic use in global poultry production: 1) Poultry that receives no antibiotics whatsoever, including ionophore anticoccidials; 2) Poultry where antibiotic use is restricted to those not utilized in human medicine, such as chemical anticoccidials and ionophores; 3) Poultry that utilizes antibiotics as growth promoters. Although many countries have enacted laws or voluntary measures to ban growth-promoting antibiotics, some regions still employ them in lower doses to aid poultry growth [14].

To establish antibiotic-free poultry populations, various strategies can be employed, including effective biosecurity measures and management practices, as well as fostering beneficial microbes in chickens' digestive systems to enhance health and prevent pathogen establishment. Probiotics, prebiotics, or their combination (synbiotics) can be incorporated into poultry feed to promote a diverse and stable microbial community in the digestive tract, facilitating positive interactions with the host's digestive lining and immune system [15].

Standard antibiotic-free programs permit the use of chemical antibacterials, chemical anticoccidials, and ionophores, but exclude antibiotics. It is important to differentiate that while antibiotic-free poultry prohibits antibiotic use, organic poultry not only bans antibiotics but also disallows any chemical additives in their water or feed throughout their growth period. Thus, organic poultry adheres to stricter standards [16].

3. Industry Challenges in Raising Antibiotic-Free Chickens

The poultry sector encounters numerous obstacles in its efforts to produce birds without the use of antibiotics, which typically encompass one or more of the following areas:

1) Issues related to breeding and processing facilities, 2) Management difficulties (such as reducing flock density, extending downtime, adhering to health regulations, maintaining optimal temperatures, ensuring stringent biosecurity, minimizing stress, and selecting appropriate breeds), 3) Health-related challenges (including the rise of intestinal and systemic diseases), and 4) Animal welfare concerns (such as determining appropriate treatment timing and methods, and the possibility of reverting to conventional practices). Among these, health-related challenges are particularly pertinent to this review [17].

While some alternative substances exhibit specific physiological, immunological, or bacteriostatic properties in the gut, none have demonstrated the comprehensive effectiveness of antibiotics [18]. Producers opting for antibiotic-free poultry must be ready to confront various health issues, which can be categorized into two primary groups: intestinal and systemic diseases [14].

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The foremost challenges faced by producers of broiler chickens or turkeys raised without antibiotics are undoubtedly linked to intestinal health, particularly in the prevention and management of coccidiosis and necrotizing enteritis. The removal of ionophore anticoccidials and antibiotic feed additives is likely to complicate the control of coccidial parasites and bacterial pathogens, notably Clostridium perfringens, which are responsible for necrotizing enteritis in these birds. Notably, both intestinal coccidiosis and necrotizing enteritis, especially in their subclinical forms, are recognized as the most prevalent and economically burdensome diseases affecting broilers and turkeys [19].

In both chickens and turkeys, septic bacterial infections are predominantly attributed to strains of Escherichia coli. Often, Escherichia coli is not the primary pathogen but acts as an opportunistic invader. When birds experience stress or have weakened immune systems, these bacteria can proliferate, leading to systemic infections that typically result in significant losses and damage. Birds diagnosed with systemic Escherichia coli infections must receive antibiotic treatment to mitigate the disease and alleviate unnecessary suffering. Even in cases where the disease is mild and losses are minimal, untreated flocks can carry a higher bacterial load to slaughterhouses and processing facilities, increasing the risk of bacterial contamination in carcasses [20]. Several documented drawbacks of antibiotic-free production include the following :

A) Generally, herds that do not use antibiotics experience declines in performance metrics such as average daily gain, feed conversion ratios, and overall efficiency. Consequently, to counteract these declines, many producers may need to invest more in expanding breeding space, enhancing feed and water intake, extending the breeding period, and improving health management. B) The reduced productivity associated with antibiotic-free production results in higher costs for producing each kilogram of meat, ultimately leading to increased prices for consumers. C) In light of current global trade dynamics, the food preferences in developed nations may have negative repercussions for populations in other countries. For instance, the decreased efficiency of poultry production without antibiotics necessitates the allocation of more agricultural land and water resources for poultry feed, which in turn generates more animal waste and exacerbates environmental pollution [14].

4 .Antibiotic Resistance and Its Significance

The World Health Organization characterizes antibiotic resistance as the phenomenon where bacteria, viruses, fungi, and parasites evolve, rendering them unresponsive to medications intended to treat infections. This situation complicates treatment efforts and heightens the risk of disease transmission, worsening health outcomes, and mortality. Essentially, antibiotic resistance denotes the capacity of bacteria to withstand the effects of antibiotics, thereby diminishing their efficacy or rendering them entirely ineffective against infections. This issue is recognized as a critical challenge in global health, impacting not only human populations but also animals and the environment [21]. A report from the World Health Organization warns that without appropriate interventions, antibiotic resistance could lead to the deaths of 10 million individuals annually by the year 2050 [22]. To combat this pressing issue, the organization advocates for a comprehensive health strategy that includes recommendations such as the immediate cessation of using vital antimicrobials for growth enhancement and disease prevention in agricultural practices.

This comprehensive health strategy emphasizes the interconnectedness of human health, animal health, and environmental factors, highlighting the necessity for collaboration and coordination across these domains to effectively address complex health issues like antibiotic resistance. It is crucial to recognize that improper and excessive antibiotic use in human healthcare—

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such as inappropriate prescriptions and patients not adhering to medical advice—can facilitate the emergence and spread of resistant bacteria. Similarly, the use of antibiotics in livestock to promote growth and prevent illness can lead to the development of antibiotic resistance in animals, which may subsequently be transmitted to humans through the food supply. Tackling the challenge of antibiotic resistance necessitates a unified health approach, engaging healthcare professionals, veterinarians, researchers, and policymakers in the effort [23].

A significant portion of antibiotics consumed is excreted through poultry waste, which is then utilized as fertilizer in agricultural fields. Many of these antibiotics can be absorbed by plant roots, leading to their accumulation in plant tissues and resulting in toxicity to the plants [24]. The application of antibiotics in livestock is a primary factor in the reduction of both pathogenic and commensal bacteria that are resistant to these drugs, which can be transmitted to humans through various pathways, including the food supply [25]. Research indicates that post-rearing processes, such as transportation and slaughter, can contaminate carcasses and negate the beneficial effects of raising animals without antibiotics on their microbiomes [26]. Conversely, evidence suggests that the role of antibiotic use in livestock regarding antibiotic resistance in human medicine may be overstated. The primary drivers of antimicrobial resistance issues in human healthcare are largely attributed to antibiotic use in humans rather than in animals. It has been estimated that the contribution of antibiotics used in livestock to the overall challenge of antibiotic resistance in medicine is, at most, less than 1% [27].

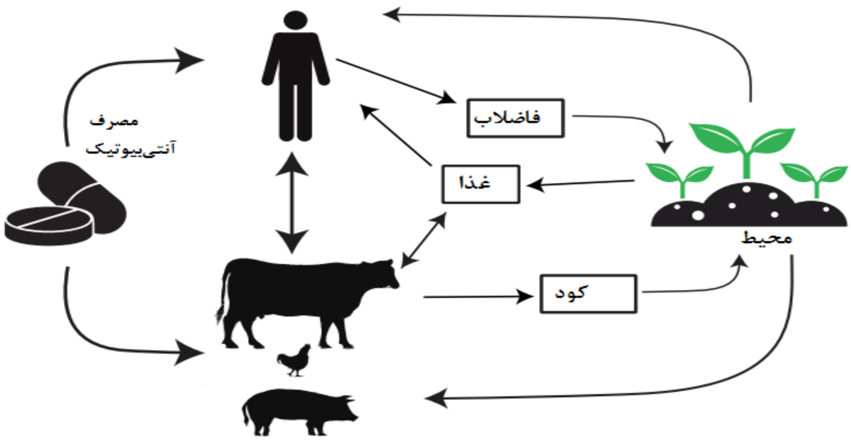

Figure 1. Diagram of antimicrobial resistance transmission routes between farm animals, environment and human populations [23]

Numerous studies conducted by researchers in our country have explored the antibiotic resistance of various bacterial strains. For instance, research on the antibiotic resistance of Helicobacter pylori, which is linked to numerous stomach and esophageal diseases, revealed that this bacterium exhibits a resistance rate of 60-70% to commonly prescribed antibiotics. This figure is notably higher than the global resistance rate of 30-50% [28]. Hasanvand *et al*. (2017) reviewed 36 studies related to Helicobacter pylori strains isolated from different regions of Iran and reported an increase in antibiotic resistance prevalence among these strains from 1997 to 2017 [29]. *Escherichia coli*, a significant bacterial species concerning food safety and human and animal health, serves as an effective model for studying antibiotic resistance. A study aimed at assessing the resistance levels to tetracycline in

Escherichia coli strains from food, humans, and livestock in Iran up to 2017 found that 86.74% of poultry affected by colibacillosis showed resistance. Additionally, 64.11% of Escherichia coli strains responsible for human infections and 60.9% of strains isolated from food also demonstrated resistance to tetracycline [30]. Furthermore, a hospital study indicated that vancomycin had the highest resistance rate in Escherichia coli at 98.8%, while nitrofurantoin exhibited the lowest resistance, with a high sensitivity rate of 3.8% [31]. Collectively, these findings, along with numerous similar studies, underscore the critical nature of antibiotic resistance in our country, highlighting the need for further investigation.

5. Antibiotic Residue and the Shared Threat of Antibiotic Resistance in Humans and Animals

The misuse of antibiotics in humans, animals, and agricultural practices, coupled with inadequate management of pharmaceutical waste during production, has led to the emergence of antibiotic resistance, particularly in low- and middle-income countries. Contributing factors include poor hygiene, limited healthcare access, and insufficient regulatory frameworks, all of which facilitate the proliferation of antibiotic resistance. The Covid-19 pandemic exacerbated these issues, resulting in increased antibiotic misuse in these regions and diverting focus from the critical threat posed by antibiotic resistance [32].

An analysis investigated the direct factors influencing antibiotic resistance in both humans and livestock on a global scale. A bidirectional relationship was identified: (1) the use of antibiotics in animals was positively correlated with resistance in human pathogens deemed critically important (1.01-1.13, with an average of 1.07, p=0.020), and (2) human antibiotic consumption was positively associated with antibiotic resistance in animals (1.01-1.09, with an average of 1.05, p=0.010). The prevalence of antibiotic resistance is significantly linked to antibiotic usage in both humans and animals. Additionally, social and economic factors, such as income disparity, gross domestic product, and the quality of governance, are associated with antibiotic resistance. Variability in resistance rates is observed across different regions, with low- and middle-income countries typically exhibiting higher rates compared to their high-income counterparts [33].

The adoption of integrated health principles, which includes the responsible use of antibiotics, enhancement of infection control practices, establishment of monitoring systems, and ongoing research and development, can facilitate a collective effort to combat antibiotic resistance. This approach must also consider the unique socio-economic conditions of the country to ensure the preservation of these essential medications for future generations [34]. In a study conducted in 2016, 270 samples of liver, muscle, and kidney from poultry were collected from 90 chicken farms in Tehran province to assess residual levels of enrofloxacin using high-performance liquid chromatography. The findings revealed that 24.44% of the samples contained residues exceeding the maximum residue limits (MRLs), indicating a lack of control over enrofloxacin usage in Iranian poultry farms and non-compliance with the recommended withdrawal period prior to slaughter [35].

Additionally, an investigation in 2017 analyzed residues of various antibiotics, including quinolones, macrolides, and florfenicol, in muscle and liver tissues from 90 samples across 13 slaughterhouses and herds in Tehran. The study identified enrofloxacin, lincomycin, and ciprofloxacin as the most prevalent antibiotics. Notably, no samples contained combinations of two different antibiotics, and all detected levels were within the limits set by the Standard Administration and the European Union's MRLs [36]. Comparative analysis of these results with

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previous studies in Iran and other countries has led researchers to advocate for the implementation of monitoring programs by veterinary departments to track pharmaceutical residues in animal products. They emphasized the positive impact of veterinary education on poultry farmers and the importance of adhering to guidelines regarding the cessation of antibiotic use.

Research indicates that approximately 73% of all antimicrobials sold globally are utilized in livestock intended for food production [37]. The presence of antibiotic resistance in these food-producing animals poses a risk not only to those who handle them but also to individuals residing near agricultural operations. Additionally, food items tainted with drug-resistant bacteria can jeopardize human health due to the presence of antibiotic-resistant pathogens. The application of antibiotics in farming practices may also lead to environmental contamination with these harmful pathogens [38]. Consequently, it is crucial to monitor the use of veterinary antimicrobials to mitigate the rise of antibiotic resistance and to ensure ongoing surveillance of antimicrobial use in both humans and animals. In 2017, the worldwide consumption of veterinary antimicrobial drugs was estimated at 93,309 tons, with projections suggesting an increase to 104,079 tons by 2030, reflecting an 11.5% rise [39]. Furthermore, it is anticipated that between 2015 and 2030, there will be a 15% increase in antibiotic usage among humans [40]. This trend indicates a parallel rise in antibiotic consumption in both humans and animals. A study conducted in our country revealed that in 1389, a total of 607.1 tons of antibiotics were distributed across poultry farms, equating to 249.5 mg per kilogram of poultry food products (meat and eggs). These findings highlight the significant and comparatively higher use of antibiotics in Iran's veterinary sector relative to developed nations [41].

6. Quality of chicken meat

1-6 factors affecting poultry carcasses and quality characteristics

The quality of poultry meat is significantly influenced by various factors, particularly in standard production systems that utilize high-growth strains raised in densely populated environments. Different production methods can lead to variations in carcass and meat quality. Meat quality can be categorized into six key characteristics: commercial, sensory, nutritional, technological, health, and socio-cultural aspects, which encompass ethical, cultural, and environmental considerations related to the meat production process, as well as its origin and quality certifications.

It is important to note that there can be conflicting aspects among these quality dimensions. For instance, while genetic selection aimed at enhancing breast meat yield has successfully produced carcasses with greater meat output, it has also led to a rise in breast meat quality issues and myopathy over the past decade. Additionally, free-range rearing can positively influence the nutritional profile and cultural-social aspects of meat due to its impact on fatty acid and lipid composition. However, this method also poses risks, including exposure to environmental pollutants and increased susceptibility to various pathogens such as parasites, viruses, and bacteria.

The shift towards both non-conventional and conventional breeding systems presents potential benefits for health and nutritional attributes, yet it also poses challenges for trade, such as reduced carcass weight and breast yield, inconsistent supply, and sensory characteristics, including stronger taste, less crispiness, and darker meat color. Additionally, this shift results in a variety of properties that impact quality [42, 43]. Table 1 outlines several factors that influence the quality assessment of poultry meat and carcasses.

Table 1- Main factors related to quality variability of poultry carcass and meat [43].

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Factor	Commercial properties	Organoleptic properties	Nutritional properties	Technological properties
Strain (growth rate)	+++	+++	++	+++
Age	+++	+++	++	+++
Sex	+	+	+	+
Feed Characteristics	++	++	++	+++
Raring conditions	++	+	+	+
Preslaughter conditions	+	+	−	+
Slaughter conditions	+	+	−	+
Postmortem treatment of carcass and meat	+	+	−	+
Cooking conditions	−	+++	++	++

no effect (-), low effect (+), average effect (++), strong effect (+++).

Given that nearly all animal products are cooked before consumption, one might wonder whether cooking alters the presence of antibiotic residues in meat. A study examining the effects of various cooking methods—boiling, grilling, and microwaving—on enrofloxacin residues in the muscles, liver, and bones of treated broilers found that these cooking processes significantly reduced the levels of the antibiotic. The most substantial reductions were observed in boiled meat and giblets, as well as grilled liver samples, while the highest detectable residue levels were found in microwave-cooked samples. It is important to note that cooking does not eliminate antibiotic residues entirely; it merely decreases their concentration, with a significant portion being removed from tissues during boiling [44].

2-6 Factors Influencing Protein and Lipid Levels in Poultry Meat

Poultry meat, particularly chicken, is characterized by a high protein content, with fillets containing approximately 23-25% protein and thighs around 18%. The amino acid profile of poultry meat remains relatively consistent, featuring key amino acids such as glutamine, asparagine, lysine, leucine, arginine, and alanine. However, variations can occur based on dietary adjustments to amino acid intake [43]. The protein levels in poultry meat are significantly affected by the age at which the birds are slaughtered. For instance, in heavy strains of standard chickens, the protein content in fillets rises from 23.5% to 24.9% as the birds age from 35 to 63 days [45].

In contrast, the lipid composition of poultry meat exhibits greater variability. The average fat content in chicken fillets is about 1.3%, while regular chicken thighs contain approximately 4.5% fat. Duck meat tends to be richer in fat, with fillet fat content ranging from 1.5% to 2%, depending on the species. The lipid profile is primarily influenced by triglycerides, which show a positive correlation with overall fat content, measuring around 0.7% in fillets and 3% in chicken thighs, with duck fillets containing between 0.5% and 0.8% fat [43, 46].

Additionally, factors such as age, genetic strain, and production methods play a crucial role in determining the fat content of poultry meat. For heavy strains of standard chickens, the fat

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content in fillets increases from 1.29% to 1.68% as the birds mature from 35 to 63 days. Similarly, in male ducks, the fat content in fillets rises from 1.79% to 2.74% between 8 and 13 weeks of age [46].

The fatty acid profile of chicken meat is comprised of roughly one-third saturated fatty acids, one-third monounsaturated fatty acids, and one-third polyunsaturated fatty acids (PUFA). The predominant fatty acid is oleic acid, followed by palmitoleic acid. Linoleic and arachidonic acids are the primary polyunsaturated fatty acids present. Chicken muscle lipids also include linolenic acid and long-chain polyunsaturated fatty acids from both the omega-6 and omega-3 families. The composition of fatty acids in poultry meat is significantly influenced by the fatty acid profile of the feed [43]. Additionally, the rearing system plays a crucial role, particularly through feeding practices and the availability of open space. A study comparing the lipid content, cholesterol levels, and fatty acid composition in the breast and thigh meat of Cobb strain chickens raised under various breeding systems is summarized in Table 2 [47]. Besides the age at slaughter, the breeding system also impacts the fat deposition in the carcass.

7. Market for Antibiotic-Free Meat Consumption

Forecasts indicate that global chicken meat production is anticipated to exceed 146 million tons, rising from 145 million tons in 2023 by the end of 2024, reflecting a growth rate of 0.8%. This increase is likely to align with the ongoing trend of globalization. The majority of the growth in poultry meat production is expected to occur in China, Brazil, and the European Union, with contracts also being established in Pakistan, Türkiye, South Africa, and the Islamic Republic of Iran. Furthermore, the rise in white broiler prices at the beginning of 2023 has resulted in improved profit margins, leading to a 4% increase in production during the first nine months of 2023, despite persistently high feed costs [48].

Consumer perceptions of antibiotic-free poultry meat as superior to conventional broiler chicken have driven a surge in its production. The number of antibiotic-free poultry farms is on the rise, motivated by concerns regarding health, environmental impact, animal welfare, and the quality and taste of meat. While precise statistics are lacking, there are over 150 antibiotic-free chicken farms in the country, with 13 provinces equipped for green chicken production. This figure represents a small fraction of the approximately 16,000 meat poultry farms nationwide. Additionally, data from the Agricultural Jihad indicates that green chicken production accounts for only about 5% of the total chicken meat output in the country [49].

To advance the meat market for organic broiler chickens and promote the sustainable production of antibiotic-free meat, the initial step involves conducting experimental research on the consumption of antibiotic-free poultry. It is essential to identify the factors influencing household consumption patterns of this type of meat. The impact of antibiotics is notable [50]. In Iran, the marketing of green meat faces significant challenges for several reasons. A lack of awareness regarding the benefits of antibiotic-free meat is a contributing factor, but perhaps the most critical issue is the price disparity, with this meat costing nearly twice as much as conventional options. This emerging industry requires government support in the form of facilities, inputs,

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export incentives, subsidies, and other necessary resources, which are currently inadequate [49]. Over the past decade, advancements in biodegradable and active packaging have been made to enhance the shelf life of meat [51]. This type of packaging not only minimizes secondary pollution associated with meat but also addresses environmental concerns raised by consumers [52, 53].

Table 2- Lipids (%) and cholesterol (mg/100g) of breast and thigh meat and fatty acid composition (% of total fatty acids) of fat from breast and thigh meat from broilers (Cobb) raised in different rearing systems [47]

		Conventional (n=50)	Organic (n=50)	Antibiotic-free (n=50)	P-value
Lipids†	Breast	1.47	1.09	0.93	0.0400
	Thigh	4.82	6.57	3.30	<0.0001
Cholesterol	Breast	34.13	23.51	36.78	<0.0001
	Thigh	35.33	39.58	33.59	<0.0001
Total SFA	Breast	38.47	33.59	29.20	<0.001
	Thigh	36.39	32.19	34.11	0.0003
Total MUFA	Breast	43.21	36.63	33.77	<0.001
	Thigh	42.81	41.65	43.55	0.0003
Total PUFA	Breast	18.33	29.88	36.38	<0.001
	Thigh	21.25	26.70	26.51	0.0004
MUFA/SFA	Breast	1.12	1.09	1.16	
	Thigh	1.18	1.29	1.28	
PUFA/SFA	Breast	0.48	0.89	1.25	
	Thigh	0.58	0.83	0.78	
Total ω3	Breast	0.48	1.60	2.59	
	Thigh	1.19	1.48	1.50	
ω6 / ω3	Breast	36.23	17.35	12.93	
	Thigh	16.76	16.90	16.53	

†Results expressed on a fresh matter basis; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids

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Some researchers identify key factors driving the growth of the organic products market as cultural influences, distribution and sales channels, ongoing inspection and monitoring, as well as educational and promotional initiatives that facilitate access to licenses and certifications [54]. Talebi *et al*. (1400) highlighted the significant impact of government financial support, export facilitation, import regulation, and information dissemination by the government on the advancement of green chicken marketing. They recommended measures such as targeted credit allocation, attracting foreign investors, and enhancing product branding through advertising to bolster the capabilities of stakeholders in this sector [49]. Additionally, a study examined the factors influencing consumer preference for chicken meat with sustainability labels. The findings revealed that gender, frequency of chicken purchases per month, and a reasonable price relative to quality significantly increase the likelihood of choosing chicken with a green and healthy label over that with an organic label. Conversely, factors such as the importance of chicken in the household, quality, nutritional value, trust, and the absence of chemical and medicinal substances enhance the preference for chicken with an organic label compared to those with a green and healthy label. The study suggests that marketers should implement diverse marketing strategies tailored to consumer characteristics, including gender [55].

A study conducted in Mashhad aimed to explore the factors influencing consumer preferences for poultry meat, particularly focusing on the demand for antibiotic-free options. The findings indicated that variables such as age, the education level of the household head, awareness of poultry meat's nutritional advantages, advertising, and income played significant roles. Statistically, family dynamics emerged as a crucial factor in poultry meat consumption. Additionally, it was revealed that only approximately 30% of consumers are able to purchase antibiotic-free poultry, primarily due to its higher cost. The study suggests enhancing consumer awareness, strategically distributing antibiotic-free poultry based on the economic and demographic profiles of consumers, ensuring competitive pricing, and employing effective marketing strategies to promote sustainable consumption of antibiotic-free poultry meat [50].

Given the rising public awareness regarding the benefits of green chicken and the increasing consumer inclination towards healthier poultry options—coupled with the higher costs associated with red meat—it is anticipated that there may be a future surge in the production of antibiotic-free poultry. This growth could be supported by government initiatives aimed at the private sector, alongside further research and development efforts to identify alternatives to antibiotics in poultry feed.

8. Conclusion

The poultry industry, a significant contributor to the economy, is currently grappling with numerous challenges, particularly those related to force breeding and associated health issues. Antibiotics have been employed as a preventive and therapeutic measure against intestinal and systemic infections. While their use can enhance animal health and productivity, it presents a dual challenge. The rampant and unregulated application of antibiotics has contributed to rising antibiotic resistance and the presence of residues in meat and the environment, posing risks to both human and

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animal health. The development of antibiotic-free poultry farming has emerged, utilizing safe alternatives and enhanced biosecurity measures to address these concerns. Poultry meat produced without antibiotics, often referred to as "green" meat, offers benefits over conventional options, particularly in terms of chemical composition and fatty acid profiles, owing to improved breeding and processing practices. However, the production costs for this type of meat are higher, and consumer awareness of its advantages remains limited, making it a less prioritized choice. The government needs to facilitate the growth of antibiotic-free poultry farms by providing necessary incentives and support to producers, as well as enhancing public awareness, to increase the availability of healthier poultry options in the market.

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چالش‌های تولید، کیفیت تغذیه‌ای و چشم‌انداز بازار مصرف گوشت مرغ بدون آنتی‌بیوتیک (سبز)

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چکیده

ترکیبات شیمیایی و قیمت مناسب گوشت مرغ، آن را به یکی از بهترین منابع تأمین پروتئین حیوانی تبدیل کرده است. استفاده از آنتی‌بیوتیک در طیور موجب تجمع بقایای آن در گوشت و متعاقباً مقاومت آنتی‌بیوتیکی شده است. تولید گوشت بدون آنتی‌بیوتیک (سبز) در جهت فائق آمدن بر این معضل توسعه یافته است. با جستجو در پایگاه‌های اطلاعاتی بین‌المللی و داخلی، نتایج و دستاوردهای ارائه شده در اسناد علمی مختلف مورد استفاده قرار گرفته و مرور شده است. نتایج بررسی‌ها نشان داد؛ مقاومت آنتی‌بیوتکی به‌عنوان یکی از نگرانی‌های عمده سلامت عمومی جهانی، در کشورمان نیز موضوع حائز اهمیتی است. رویکرد سلامت یکپارچه، شامل پیوستگی موضوع سلامت انسان، سلامت حیوانات و محیط‌زیست، برای مقابله با چالش‌های بهداشتی پیچیده مانند مقاومت آنتی‌بیوتیکی مورد تاکید قرار گرفته است. تولید گوشت بدون آنتی‌بیوتیک با چالش‌هایی همراه است که موجب افزایش هزینه‌های تولید آن شده است. در عین حال گوشت سبز واجد ویژگی‌های تغذیه‌ای و بهداشتی مطلوب‌تری نسبت به نوع معمولی بوده و در صورت افزایش آگاهی‌های عمومی، شبکه توزیع و عرضه مناسب و به‌خصوص قیمت متعادل می‌تواند در الویت انتخاب مصرف‌کنندگان قرار گیرد. نتیجه اینکه با پذیرش اصول مفهوم سلامت یکپارچه می‌توان تأثیر مقاومت آنتی‌بیوتیکی را کاهش داد و از طریق استفاده مسئولانه از آنتی‌بیوتیک از یک‌سو و تداوم تحقیق و توسعه جهت دستیابی به جایگزین‌های مؤثر و ایمن، از اثربخشی آنتی‌بیوتیک‌ها محافظت کرد و آینده سالم‌تری را برای انسان‌ها، حیوانات و محیط زیست تضمین کرد.