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Effect of Boldenone or Estradiol as Growth Promoters on Some Quality Parameters of New Zealand Rabbit Meat

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Abstract

RABBIT'S meat has an excellent nutritional profile with a tender flavor. The most important perceptions of rabbit's meat are its high sensory, physical, and chemical properties. To achieve such quality, farmers rely on growth promoters either legally or illegally, regardless of their possible public health hazards. The aim of this study is to evaluate the effects of hormonal growth promoters on rabbit meat quality. Additionally, the study will examine how simmering affects the residue level of these growth promoters in rabbit meat. Thirty New Zealand White male rabbits were randomly divided into three equal groups: the first group was kept as the control; the second group received two doses of intramuscular boldenone undecylenate injections (5 mg/kg body weight) at three-week intervals; and the third group was intramuscularly injected with estradiol (40 µg/kg of body weight) day by day for 30 days. The findings indicated that the growth promoters used had no discernible impact on the sensory quality of rabbit meat. However, the cooking loss of simmered rabbit meat injected with estradiol was significantly increased. Boldenone administration causes a significant increase in the protein content of meat. Moisture and ash contents were significantly increased in all treated groups. Simmering rabbit meat reduced residual levels of boldenone and estradiol, but it did not completely eliminate their hazards to health of consumer. These results confirmed the inefficiency of using boldenone and estradiol compounds as growth promoters in animal production for safety and quality reasons.

Keywords: Growth promoters; Rabbit's meat; Boldenone; Estradiol; hormonal residue.

Introduction

According to predictions, the world population will grow by 11% by 2030, resulting in a significant 14% increase in meat consumption [1]. Meat is considered a beneficial source of high-quality protein and many micronutrients, such as vitamins and minerals [2]. Rabbit meat is one of the most tender and luscious white lean meats, which plays a key role as a functional food because it has an excellent nutritional profile, is high in protein content, low in fat, cholesterol, sodium [3] and purine levels, and does not contain uric acid [4]. Hence, it could bridge the gap in dietary protein consumption [3]. Rabbits can efficiently convert up to 20% of the protein in their diet into muscles, which is close to poultry (22%) [5]. There is varied information regarding the chemical composition of rabbit meat; it is based on the carcass's different parts [2], different intrinsic (genotype, sex, and age), and extrinsic (husbandry and diet) factors [6].

Animal nutritionists and farmers rely on chemical growth promoters, which are chemical compounds that are either added to the feeds as supplements or via injection into animals to enhance feed utilization, animal growth, protein metabolism, and ultimately, building up muscles [7].

Steroidal hormones have been used as growth promoters for livestock because of their positive effect on protein synthesis, muscle development, and final weight gain. Steroids are not orally active, require rather high dosages to be provided, and can temporarily alter the behavior of the treated animals [8]. However, hormonal growth promoters can be administered in the form of subcutaneous implants in

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the ear [9]. The hormonal depot capsules release a precise dose of hormones over a predetermined period. Natural hormones such as estradiol, testosterone, and progesterone, as well as synthetic hormones like trenbolone acetate and zeranol, are extensively applied in cattle production [10].

Hormonal growth promoters represent a hazard to consumer's health, regardless of the level of definitive proof. The adverse impact includes neurological, genotoxic, carcinogenic, and developmental implications. Both the parent compound and its metabolites can contribute to these effects [7]. Hormonal residues have the potential to suppress the immune system and cause a variety of common cancer types [11]. While other countries permit the application of anabolic steroids and hormone-like substances to increase weight gain and feed utilization in farm animals, the EU has outlawed the use of any hormones as growth promoters [12].

Animal's scientists have shown interest in modifying animal hormonal state to increase productivity and improve their products [13]. Boldenone is an anabolic steroid that is distinct from testosterone due to its low androgenic and high anabolic characteristics. Consequently, boldenone undecylenate has been used in the veterinary field to improve meat mass in livestock. Although most nations worldwide prohibit its use for meat production [14], it is still illegally used, even in some countries in the European Union [14,15]. Boldenone is banned in the EU by Council Directive 96/22/EC [16].

The administration of estradiol growth promoter improves body weight gain in New Zealand rabbit bucks [17]. Estrogens promote body weight gain mainly through increasing growth hormone and insulin levels, which subsequently increase protein synthesis by increasing amino acid uptake, favoring positive nitrogen balance, potentiating calcium and phosphorus retention, and normalizing electrolyte balance. Additionally, they enhance the mucosa of the intestines [18]. Research suggests that 17β-estradiol should be classified as a complete carcinogen [19]. JECFA [20] established the Acceptable Daily Intake (ADI) value of 0–0.05 µg/kg of body weight for estradiol, which allowed establishing the Maximum Residue Level (MRL).

Therefore, the major goal is to demonstrate the effect of boldenone and estradiol as growth promoters on the sensory parameters (color, odor, consistency, overall acceptability), cooking losses, and chemical quality of rabbit meat by evaluation of protein, fat, moisture, and ash contents. Furthermore, for comprehension of the burden posed by anabolic hormone exposure, data on residue levels in food and animal products is needed and to detect quality and safety of rabbit's meat breading with hormonal growth promoters.

Material and Methods

Experimental design

Thirty of New Zealand White male rabbits, five weeks of age, appearing healthy were randomly selected to be bred using different types of hormonal growth promoters. After weighing each rabbit, they were allocated into three groups. Each experimental group consisted of ten rabbits. The first one was the control group which didn't receive any treatment. In the second group, rabbits intramuscularly injected with two doses of boldenone undecylenate (Five-Bold, Fivevet), 5 mg/kg body weight at three weeks intervals [21]. The third group received 40 µg/kg body weight intramuscular estradiol injections (Misr Co. for Pharma ind.) day by day for 30 days [22]. All rabbits were kept under the same management conditions (light, temperature). Rabbits were housed in cages with manual feeders and automatic drinking supplies. Rabbits were fed *ad-libitum*. A commercial pelleted standard rabbit ration with (18.2% crude protein, 14% crude fiber, 2.6% ether extract fat, and 2600 kcal/kg digestible energy).

Sample preparation

Five rabbits from each group, aged nine and eleven weeks, were slaughtered flowing Islamic rites. The collected rabbit meat samples (each sample weighed about 50 g from different body parts) were labeled, frozen and transferred to the laboratory in an ice bag for analysis.

Sensory evaluation

Sensory evaluation of rabbit meat was carried out by 10 untrained panelists. Each participant was sat comfortably, with lighting provided by white, fluorescent lamps. Rabbit flesh was chopped to roughly similar sizes and coded. The panelists evaluated the meat based on color, odor, consistency, and overall acceptance on a five-point hedonic scale that ranged from (1) dislike, (2) moderately dislike, (3) neither like nor dislike, (4) moderately like, (5) like extremely [23].

Physical evaluation (cooking loss)

Cooking loss has been determined by comparing the difference in weight of a rabbit meat sample before and after simmering, represented as a percentage [24].

Chemical analysis

Protein content is determined by using the Kjeldahl method to assess the nitrogen content by digestion of the sample with heated sulfuric acid to convert nitrogen to ammonium ions, then distillation into ammonia gas to finally titrate the amount of ammonia against N/10 NAOH to calculate nitrogen, and protein% = nitrogen% x 6.25. Fat content is determined by the Soxhlet method, and ash content is determined by ignition the samples in a muffle

furnace at 550 °C for 12 hours and calculating the loss in weight as a percent according to AOAC [25]. Moisture content analysis by drying in a hot air-oven for 2 hours at 120 °C and comparing the difference in weight of a rabbit meat sample before and after water evaporation, represented as a percentage [26].

Determination of hormonal residue in rabbit meat samples using ELISA technique

Quantitative determination of boldenone residues

Accurately, the Boldenone ELISA kit (Sedium RD, Czech Republic) is intended for the qualitative determination of boldenone in foodstuffs. The Boldenone ELISA kits provided a chart for the test procedures.

Hormone extraction

Boldenone was extracted by absolute ethanol (96%) in accordance with Zeitoun and Fathelbab's procedure [27].

Quantitative determination of estradiol residues

Hormone extraction

Samples were prepared and extracted by tertiary butyl methyl ether (TBME) and centrifugate according to Ibrahim et al. homogenized with 10 ml of phosphate buffer saline [28].

Test procedures

The test was performed in accordance with the chart for the test procedures included in the Estradiol ELISA (RIDAR and RIDS) kits that is ISO-certified, manufactures this product in Darmstadt, Germany. R-Biopharm AG.

Statistical analysis

The results were analyzed with GraphPad Prism 8. A one-way ANOVA test was used to compare the parameters of rabbit meat samples, followed by Tukey's test.

Results

Sensory evaluation

Figure 1 reveals the mean values for the participants' scores on each studied parameter (color, odor, consistency, and overall acceptability) of rabbit meat samples. Results show there are no significant differences between all tested groups.

Physical evaluation

The cooking loss percentage of rabbit meat during simmering is recorded in "Tables 1, 2" as 29.68%, 32.85%, and 35.50% for the control group, the boldenone injected group after one week of ceasing boldenone injections, and the estradiol injected group after one day of ceasing the estradiol injections, respectively, and was 31.63%, 33.7%, and 38.11% for the control group, the boldenone injected group after three weeks of ceasing treatment, and the estradiol injected group after two weeks of ceasing injections, respectively.

Proximate chemical analysis of the rabbit meat

The proximate chemical composition of NZW rabbit meat samples were assessed and represented in "Tables 3, 4" for rabbits slaughtered at 9^{th} week and 11^{th} week of age, respectively. The results show a significant increase ($P<0.05$) in protein and fat content in the boldenone-injected rabbit meat. Also, a significant increase ($P<0.05$) in moisture and ash contents in all treated groups. slaughtered at the of age

Hormone residues detection in rabbit meat

Table 5 represents boldenone residue (ppb) detected in raw and cooked rabbit meat for rabbits slaughtered at 9 weeks of age (after one week of ceasing boldenone injections) and 11 weeks of age (after three weeks of ceasing boldenone injections) and the estradiol residual level in raw and cooked rabbit meat for rabbits slaughtered at 9 weeks of age (after one day of ceasing the estradiol injections) and at 11 weeks of age (after 2 weeks of ceasing the injections). The obtained results show a reduction in both boldenone and estradiol residual level in simmered rabbit meat.

Discussion

Sensory evaluation

The notion of meat quality is changing dramatically, and modern customers are becoming more and more interested in every aspect of meat—that is, its nutritional content, texture, ease of preparation, and affordability. Meat quality has historically been assessed by sensory characteristics including color, odor, consistency, and overall appearance. These factors, along with the meat's nutritional profile, have a significant impact on consumer preferences and purchase decisions. It is necessary to understand the delicate interplay of numerous variables that influence meat quality. The obtained results agreed with Johnson et al. [29] that there is no discernible impact of hormone growth promoters on the sensory characteristics of rabbit meat. In sensory analysis, it is difficult to determine whether a difference in results between different treatments is relevant or not. Scoring does not suggest whether there are differences in meat quality or not [30].

Cooking loss

Depending on the degree of heat, meat loses its fluids while cooking, which causes connective fibers to shrink [31]. The high cooking loss (CL) of simmering rabbit meat was attributed to the longer cooking time (30 min) of boiling to attain a core temperature of 75°C, Obuz et al. [32]. However, according to Cheng et al. [33] and Vittadini et al.

[34] the boiling method reduces cooking loss due to the meat is submerged in water, resulting in decreased evaporation. The cooking loss percentage of the control rabbit meat obtained corresponded to those recorded by Rasinska et al. [35]. While Apata et al. [36] reported a lower CL% for stewed rabbit meat (25.50% for males and 27.40% for females). Belichovska et al. [37] and Rao et al. [38] reported a higher CL% for boiled untreated NZW rabbit meat. The estradiol-injected rabbit's meat shows significantly higher cooking loss percentage than the average cooking loss for NZW rabbit meat in many studies [35,38]. Although the CL% of rabbit meat may reach a higher percentage (39.15%) depending on several factors, such as the method of cooking applied (boiling, roasting, different temperatures, and duration of treatment), and other factors such as genotype, age, diet, part of the carcass, time postmortem, etc. [39].

Proximate chemical analysis of the rabbit meat

Protein content is an indicator of high-quality food. From Tables 3 and 4, the protein content in the meat of rabbits injected with boldenone was extremely significant ($P < 0.05$), nonetheless, the protein percentage in the control and estradiol injected groups show no significant difference. Boldenone stimulates protein synthesis and decreases protein destruction in muscles [15], and stimulates the kidneys to release erythropoietin and enhances appetite [40]. The percentage of protein content in the control group agreed with the result obtained by Baiomy and Hassanien [41]. The lower protein amounts were recorded in NZW rabbit meat by Haque et al. [42] and Fadlilah et al. [43]. Higher levels of protein content in the NZW rabbit meat were recorded by Nistor et al. [44], Asamoah et al. [23] and Frunză et al. [45].

Lipids are an essential nutrient for human health. Rabbit meat is considered lean and tougher than other meat types with low fat [46]. The fat content of the rabbits injected with estradiol did not differ significantly ($P > 0.05$) from the control group, whereas the groups that received boldenone did differ significantly. Fairly the same results were obtained by Asamoah et al. [23], lower values were reported by Fadlilah et al. [43], Frunză et al. [45]. Higher fat content was reported by Nistor et al. [44], and Haque et al. [42], that could be due to the different rabbit breeds [39]. Moreover, Baiomy and Hassanien [41] reported that the fat content in the NZW breed was 7.87 g/100 g. The rabbits' age, sex, and genotype all affect the amount of intramuscular fat [47]. Despite Belichovska et al. [37] suggested that the genotype and sex of the rabbits had no discernible effects on the amount of fat in their flesh. The moisture of the rabbit's meat ranged between 63.6% to 75.93% [48]. In this study, moisture content significantly increased ($P < 0.05$) in estradiol injected rabbits' meat, which may be related to estrogen retention and normalizing electrolyte balance [18]. Also, moisture content significantly increased ($P < 0.05$) in boldenone injected rabbits' meat as boldenone retains body minerals such as nitrogen, potassium, calcium, sodium and water [40]. The higher moisture content values in untreated fresh NZW rabbit meat were obtained by Fadlilah et al. [43] and Frunză et al. [45]. Conversely, Nistor et al. [44], and Asamoah et al. [23] reported lower moisture content in the untreated NZW rabbit meat. Ash contents is significantly increased ($P < 0.05$) in rabbit's meat of all treated groups. Fadlilah et al. [43], Frunză et al. [45] noticed that the fresh NZW rabbit meat had an elevated ash level compared to the levels recorded in the control group in this investigation. The difference in ash contents may be owing to the different mineral concentrations of the feed [49] and boldenone's role in holding the body's nitrogen, calcium, sodium, and potassium [18, 40].

Hormone residues detection in rabbit meat

The detected boldenone residue levels of all raw and cooked rabbit meat samples surpassed the acceptable boldenone residue limits (1 ppb in animal muscles) set by Community Reference Laboratories' guidance according to Council Directive 96/23/EC. Simmering rabbit meat samples for 30 minutes reduced the boldenone levels by 76.03% and 80.47% for rabbits slaughtered after one week of ceasing boldenone injections and rabbits slaughtered after three weeks of ceasing injections, respectively. The degradation rates of hormonal residues are usually proportional to the highest temperature and time of exposure [50]. The reduction in boldenone residue levels may be due to its lipophilic characteristics and low molecular weight [51].

The adverse impact of hormonal residues varies depending on a number of parameters, including consumption patterns, age, sex of consumers and the level of hormone residues in meat as well as meat products [52]. Misuse of boldenone can be associated with adverse impacts on animal and human health, including disturbances of endocrine functioning, which can lead to impairments in physiological processes and immunological function, complications with the urogenital tract, heart, liver, and circulation, and carcinogenic consequences [53]. Several reports implicate anabolic androgenic steroids (AAS) inducing hepatocellular adenoma and carcinoma [45]. Europe and the United States have different perspectives on hormone administration. The FDA permits the restricted use of certain hormones with natural origins in the fattening of animals; however, the European Economic Community (EEC) forbids the use of any hormones or hormone-like substances as growth promoters [13]. The Veterinary Drugs Directorate has also authorized the use of estrogen in Canada for beef production [54]. The detected 17β-estradiol residue levels in samples exceeded the

recommended concentration for estradiol residue 1 ppb in animal muscles set by Community Reference Laboratories' (CRLs) guidance according to Council Directive 96/23/EC. The 17β-estradiol residues in rabbit meat samples persist even after simmering. Zeitoun and Ahmed [55] and Abbas et al. [56] recorded high levels of 17β-estradiol hormone residues in imported meat that exceeded the acceptable hormone limits. The obtained results comply with the finding of Sadek et al. [57] that 17β-estradiol residue levels in uncooked chicken muscle and beef were reduced after boiling, which is the best way compared to other methods of cooking to decrease hormonal residue content. According to Salem et al. [58] the boiling of chicken meat reduced the estradiol residual level by 98.52%. Cooking of meat reduces but does not totally eliminate the risk of dietary exposure to estrogen growth promoters [55].

The more hydrophobic substances, like estradiol, are subsequently lost from tissues during cooking. The reduction of estradiol levels by cooking is related to 17β-estradiol association with the fats that are liquefied during cooking [18]. For that reason, the lipid content in animal tissue was proportionally related to estradiol withdrawal. On the other hand, according to Abu-Taleb [59], there is no difference in the level of estradiol residues in meat when it is boiled for thirty minutes, roasted, or frozen at -20 ºC. According to the report of the Scientific Committee on Veterinary Measures, estrogen must be considered a complete carcinogen that acting as both an initiator and a promoter for cancer [60]. Consuming meat containing estrogenic residues has toxic effects on the endocrine, immune, and nervous systems, and may lead to infertility, arteriosclerosis, genotoxicity, and carcinogenesis [61]. Ultimately, the use of growth-promoting agents must be beneficial for farmers, animals, and customers. This entails accelerating animal growth with little residue in its edible tissues and no negative impact on the health or physiological functions of consumers. Any anabolic agent that does not comply with these three requirements has to be outlawed completely [62].

On a national and international level, estradiol and boldenone is mostly illegal for use as a growth promoter in food animals, although there is limited work on the effect estradiol and boldenone on quality parameters of meat generally and rabbit meat specially. Detecting residues of growth prompters in rabbit's meat is one of the most important control issues that concerns consumers in general and athletes in particular. On the other hand, studying the impact of these residues on quality standards in rabbit's meat and searching for ways to control this risk was a primary goal in the current research to ensure the health and safety of rabbit meat consumers.

Conclusion

In conclusion, the hormonal growth promoters, boldenone undecylenate, and estradiol did not influence on the organoleptic properties of rabbit meat. The results confirmed that rabbits injected with two doses of boldenone undecylenate had higher protein content, which improved their nutritional values. While estradiol injected rabbits didn't show a significant increase in protein content. The estradiol-injected rabbit's meat shows significantly higher cooking loss percentage. Cooking results in a considerable reduction in boldenone and estradiol hormonal residue levels but does not totally eliminate their hazard impact on consumers. This data may discourage the use of boldenone and estradiol as growth promoters in animal production due to safety and quality reasons. In addition, the obtained results encourage all countries to have a specific program for testing estradiol and boldenone residues in animals raised for food production.

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Declaration of Conflict of Interest

The authors commit that there is no conflict of interest.

Ethical of approval

The study was conducted at the Faculty of Veterinary Medicine at Suez Canal University in Egypt followed the ethical committee's guidelines number (201938).

TABLE 1. Mean values of cooking loss of rabbit meat treated with hormonal growth promoters slaughtered at 9 weeks of age

Percent	Control	Growth promoters	
		Boldenone	Estradiol
Maximum	30.90	37.16	39.90
Minimum	27.59	31.10	31.50
Mean	29.68^{a}	32.85^{ab}	35.50^{b}
***± S.E.M.**	0.63	1.12	1.50

*± S.E.M. Standard error of the mean.

*Mean in the same row with different letters is considered extremely significant at (P<0.05). P value is 0.0033**

TABLE 2. Mean values of cooking loss of rabbit meat treated with hormonal growth promoters slaughtered at 11 weeks of age.

Percent	Control	Growth promoters	
		Boldenone	Estradiol
Maximum	32.40	40.55	43.90
Minimum	29.87	31.23	32.00
Mean	31.63^{a}	33.7^{ab}	38.11^{b}
***± S.E.M.**	0.51	1.73	2.27

*± S.E.M. Standard error of the mean. *Mean in the same row with different letters is considered extremely significant at (P<0.05). P value is 0.0380*

TABLE 3. Chemical composition of rabbit meat slaughter at 9 weeks of age

Parameters %	Control	Growth promoters		
		Boldenone	Estradiol	P value
Protein	20.22^{a}±0.099	21.66^{b}±0.27	20.55^{a}± 0.07	0.0002
Fat	3.79^{a} ± 0.197	4.45^{b}±0.13	3.61^{a}±0.08	0.0036
Moisture	72.35^{a}±0.54	74.53^{b}±0.10	74.26^{b}±0.45	0.0052
Ash	0.898^{a}±0.02	1.38^{b}±0.03	1.64^{c}±0.03	<0.0001

*± S.E.M. Standard error of the mean. *Mean in the same row with different letters is considered extremely significant at (P<0.05).

TABLE 4. Chemical composition of rabbit meat slaughter at 11 weeks of age

Parameters %	Control	Growth promoters		
		Boldenone	Estradiol	P value
Protein	20.11^{a} ±0.33	22.89^{b} ± 0.23	20.62^{a}±0.26	<0.0001
Fat	3.89^{a}±0.20	4.84^{b}±0.195	3.73^{ab}±0.05	0.0010
Moisture	71.28^{a}±0.17	76.8^{b}±0.18	73.20^{c}±0.22	<0.0001
Ash	0.95^{a}±0.04	1.40^{b}±0.04	1.85^{c}±0.04	<0.0001

*± S.E.M. Standard error of the mean. *Mean in the same row with different letters is considered extremely significantly different at (P<0.05).

TABLE 5. Determination of boldenone and 17β-estradiol residues (ppb) in raw and simmering rabbit meat samples.

Treatment	Rabbits age	Raw meat		Cooked meat		Reduction of Residual level %
		Range	*M± S.E.M.	Range	*M±S.E.M.	
Boldenone	9 weeks of age	63.7-45.2	54.45±9.3	6.1-5.94	6.02±0.98	76.03
	11 weeks of age	26.9-11.5	19.2±3.8	3.9-3.6	3.75±0.53	80.47
17β-Estradiol	9 weeks of age	77.6-98.5	88.05±15.4	8.6-11.2	9.9±1.7	88.76
	11 weeks of age	20.7-34.2	27.45±4.5	5.8-7.4	6.6±0.98	75.96

* M± S.E.M. =Mean ± standard error of mean.

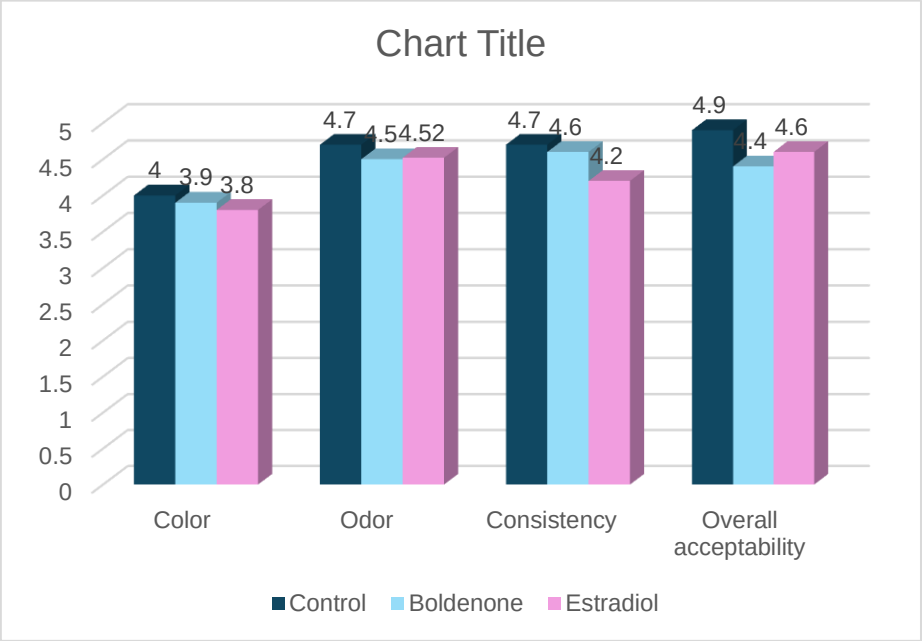

Fig. 1. Effect of hormonal growth promoters on sensory quality of rabbit meat.

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تأثير مركبات بولدينون واستراديول كمحفزات للنمو على بعض معايير الجودة للحوم الأرانب النيوزيلندية

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الملخص

توفر لحوم الأرانب مصدرا جيدا للبروتين الحيواني عالي الجودة. يعتمد المزارعون على محفزات النمو إما بشكل قانوني أو غير قانوني، في التربية بغض النظر عن المخاطر المحتملة على صحة المستهلكين. لذلك ، فإن الهدف من هذه الدراسة هو تقييم تأثيرمحفزات النمو (بولدينون واستراديول) على الجودة الحسية والفيزيائية والكيميائية للحوم اللأرانب النيوزيلندية بالأضافة الى تأثير الطهي على تركيز متبقيات الهرمونات المستخدمه. لذلك، تم تخصيص عدد 30 أرنبا من الذكور، بعمر 5 أسابيع، وتقسيمهم إلى 3 مجموعات. تم الاحتفاظ بالمجموعة الأولى كمجموعة ضابطة، وشملت المجموعة الثانية الأرانب التي تم حقنها مرتين في العضل بمحفز النمو بولدينون (5 ملجم / كجم من وزن الجسم) بفارق 3 أسابيع، وشملت المجموعة الثالثة الأرانب التي تم حقنها بمركب استراديول 40 ميكروجرام/كجم من وزن الجسم يوما بعد يوم لمدة 30 يوما. أظهرت النتائج التي تم الحصول عليها أن محفزات النمو ليس لها تأثير معنوي على الجودة الحسية للحوم الأرانب. استخدام مركب بولدينون أدى إلى زيادة معنوية في نسبة البروتين للحوم الأرانب مقارنة بالمجموعات الأخرى. وأظهر تحليل عينات الأنسجة العضلية لمجموعات الأرانب المعالجة بمحفزات النمو الهرمونية نسبة عالية من متبقيات المركبات بولدينون واستراديول. طهي لحوم الأرانب عن طريق السلق أدى الى انخفاض مستوى المتبقيات الهرمونية بشكل ملحوظ ولكنها لم تصل للحدود الأمنه مما يشكل خطرا جسيما علي صحة مستهلكي هذة اللحوم. وأكدت هذه النتائج على عدم جدوى استخدام مركبات بولدينون واستراديول كمحفزات للنمو في الإنتاج الحيواني لأسباب تتعلق بالسلامة والجودة.

الكلمات الدالة: محفزات النمو ، لحوم الأرانب ، بولدينون ، استراديول ، متبقيات الهرمونات.