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Effect of Feed Restriction on Some Chemical and Sensory Properties of Chicken Meat

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ABSTRACT

Feed restriction application in the early stage of growth in broiler is common to prevent some health problems. However, feed restriction may affect the quality of meat. The objective of this study was to determine the effects of feed restriction on sensory properties of chicken meat. Total 60 Ross 308 broiler chickens were divided into three groups. The chickens in the first group were fed *ad libitum* (control group; AD), whereas the chickens in the second and the third group were exposed to two different feed restriction applications. The chickens in the second group (FR) were fed with 20% less food of *ad libitum* food intake, while the chickens in the third group (NF) were not fed between 9 am-3 pm. Feed restriction in both groups was applied when the chickens were between 7-21 days old. The chickens were slaughtered at week six of the trial and the carcasses were stored at -25 °C until chemical and sensory analyses. Descriptive sensory analysis was conducted to determine characteristic descriptive terms for breast and thigh body parts. In addition to sensory characteristics, some chemical properties including titratable acidity, dry matter and fat contents of the meat samples were determined. The data of chemical properties were analyzed by repeated measurement variance analysis, while the data of sensory evaluation were analyzed by multivariate analysis of variance (MANOVA) and multidimensional scaling (MDS). The finding of this study demonstrated that juicy, chicken flavor and umami were leading sensory characteristics of chicken meat. Some undesirable flavor attributes including cardboard, feed, oxidized and organy were also determined at very low intensities. Juiciness and chicken flavor scores of breast meat in AD and NF groups did not show any significant differences. No significant differences were detected between feed regimes in the flavor intensities of thigh meat. Feed restriction did not affect acidity or dry matter, whereas feed restriction affected fat contents of breast and thigh.

Keywords: Chicken meat; Feed restriction; Sensory quality; Chemical properties

Yem Kısıtlamasının Tavuk Etinin Bazı Kimyasal ve Duyusal Özellikleri Üzerine Etkisi

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ÖZET

Kanatlı eti üretiminin ilk evrelerinde yem kısıtlaması uygulanması bazı sağlık sorunlarının engellenmesi için yaygın olarak kullanılmaktadır. Ancak, yem kısıtlaması et kalitesini etkileyebilmektedir. Bu çalışmanın amacı yem kısıtlamasının tavuk etinin duyusal özellikleri üzerindeki etkisinin araştırılmasıdır. Toplam 60 Ross 308 etçi tavuk üç gruba ayrılmıştır. Birinci gruptaki tavuklar *ad libitum* (AD; kontrol grubu) yemlenirlerken ikinci ve üçüncü gruptaki tavuklara yem kısıtlaması uygulanmıştır. İkinci gruptaki tavuklara (FR) *ad libitum* yem tüketiminin % 20'si kadar yem kısıtlaması uygulanmıştır. Üçüncü gruptaki tavuklara (NF) ise sabah 9 öğleden sonra 3 saatleri arasında yemleme yapılmamıştır. Yem kısıtlaması piliçlere 7-21 gün arasındaki yaşta uygulanmıştır. Piliçler denemenin altıncı haftasında kesilmişlerdir. But ve göğüs parçalarının karakteristik tanımlayıcı terimlerinin belirlenmesi için tanımlayıcı duyusal değerlendirme yöntemi kullanılmıştır. Duyusal özelliklere ek olarak, et örneklerinde bazı kimyasal özellikler (titrasyon asitliği, kurumadde ve yağ içeriği) saptanmıştır. Kimyasal özelliklere ilişkin veriler tekrarlanan ölçümlü varyans analizi, duyusal değerlendirme verileri ise çok değişkenli varyans analizi (MANOVA) ve çok boyutlu ölçeklendirme (MDS), yöntemleri ile analiz edilmiştir. Bu çalışmanın bulguları tavuk etinin en karakteristik duyusal özelliklerinin sululuk, tavuk aroması ve umami olduğunu göstermiştir. Örneklerde kartonumsu, yem kokusu, okside ve organımsı gibi bazı istenmeyen aroma özellikleri de oldukça düşük yoğunluklarda belirlenmiştir. Genel olarak AD ve NF gruplarında göğüs etinin sululuk ve tavuk aroması skorları farklı bulunmamıştır. But etinin aroma yoğunluğu açısından da gruplar arasında bir farklılık belirlenmemiştir. Yem kısıtlamasının asitlik veya kuru madde üzerine önemli etkisinin olmadığı saptanmıştır. Ancak yem kısıtlaması but ve göğüs etlerinin yağ içeriğini etkilemiştir.

Anahtar Kelimeler: Tavuk eti; Yem kısıtlaması; Duyusal kalite; Kimyasal özellikler

1. Introduction

Chicken meat is an important protein source for healthy and balanced nutrition (Stadelman et al 1988). It is obtained from mainly chicken, turkey, goose and quail. Chicken meat consumption has increased as parallel to the increase in human population in the world. In order to meet this increase in consumption, commercial broiler hybrids were developed that grow more rapidly and give a higher yield per unit. Nowadays, broilers have fairly high growth rates and consume more feed to gain live weight rapidly. Continuous feed consumption by broilers can cause some problems that might manifest themselves in health problems of broilers, such as foot disorders and flip-over, as well as decrease in meat quality due to over-fattening (Peter et al 1997; Beyni & Habi 1998; Savory & Lariviere 2000; Tumova et al 2002; Mendeş 2008).

Feed restriction is an effective strategy to increase commercial broiler forage intake (Moritz et al 2005). Different types of qualitative and quantitative feed restrictions are applied to broilers to prevent either health or meat quality problems as well as change in carcass composition (Beyni & Habi 1998; Nielsen et al 2003). Gonzales et al (1998) reported that feed restriction can be used to decrease mortality in male broilers through reduced growth rates. Slow-growing broiler lines are generally more active than fast-growing broiler lines (Nielsen et al 2003; Bokkers & Koene 2003). Feed restriction, therefore, is expected to increase the activity of broilers and decrease body fat and some health problems such as flip-over syndrome, leg disorders due to the lower live body weight of the birds combined with more appetitive foraging.

Schedle et al (2006) reported that length of feed withdrawal could have positive effect on the sensory quality of the final product. Farmer et al (1997) determined the effects of genotype, diet, stocking density and age on eating quality of chicken meat. One group of birds was fed with a restricted diet. The terms generated to describe the samples were divided into 4 groups: cooked appearance, texture, cooked odor and flavor. The results of this study indicated that the birds slaughtered at the age of 84 days were juicier, less fibrous and had less powdery

residue compared to the birds slaughtered at the age of 49 days. There are several studies conducted on sensory quality of chicken meat (Farmer et al 1997; Poste 1990; Ruiz et al 2001; Schedle et al 2006; Soyer 1999). Most of these studies focused on the effect of feed types, genotype, age or cooking types of meat. Little is known about the effects of feed restriction on sensory properties of chicken meat. The purpose of this study was to investigate the effects of feed restriction on some sensory and chemical properties of chicken meat.

2. Material and Methods

2.1. Animal feeding and feed restriction

The study was carried out at the experimental poultry house of Animal Science Department at Çanakkale Onsekiz Mart University. In the study, 60 Ross 308 broiler chickens were used. Chickens were fed with a starter diet between 0-3 weeks of age, a growth diet between 4-5 weeks of age, while they were fed with a finisher diet in the last week of the trial. The starter, growth and finisher diets contained 24.09% crude protein and 2818 kcal ME^{-1}, 25.32% crude protein and 2892 kcal ME^{-1} and 22.38% crude protein and 2912 kcal ME^{-1}, respectively.

The chickens in the first group were fed *ad libitum* (control group; AD). Two different feed restriction methods (restriction of food amount and feeding duration) were applied to chickens in the second and the third groups. The chickens in the second group were fed with 20% less food of *ad libitum* food intake. The chickens in the third group (NF) were not fed between 9 am-3 pm. Feed restriction in both groups was applied, when the chickens were between 7-21 days old. Starting from 22nd day, all the groups were switched to *ad libitum* feeding until day 43. The chickens were kept under intensive conditions with an artificial lighting program (23 h. light: 1 h. dark). Stocking density of the experimental poultry house was 18 chickens m^{-2}. The temperature of the room was 33 °C in the first two weeks, 30 °C in the third week, 27 °C in the fourth week and 24 °C in the fifth and sixth weeks of the study. Nipple drinkers and round feeders were used to satisfy the water and feed requirement of the chickens. The chickens were slaughtered, when they were six weeks old.

2.2. Chemical and sensory analyses of meat samples

All chemical analyses were performed on both breast and thigh, separately. Samples were stored at -25 °C until analysis. Frozen meat samples were thawed within 24 h at 7 °C. Three males and three females from each group were used to determine fat, titratable acidity and dry matter contents of thigh and breast.

A procedure described by Paneras and Bloukas (1984) was followed to determine titratable acidity (lactic acid, %). Dry matter (%) analysis was performed by using Moisture Analyzer Ohaus MB 45 (Pine Brook, NJ). Soxhlet extraction method (AOAC 1990) was used to determine fat contents of samples.

The skin of each sample was removed before cooking for sensory analysis. Breast and thigh parts of each sample were boiled (Soyer et al 1999) separately in a beaker until the inner temperature reached to 90 °C for 15 min. No salt was added to the samples. Then, pieces of cooked meat samples were used for sensory evaluation.

A roundtable discussion panel with 6 members was conducted to determine the descriptive terms for the samples. Panel members were selected based on willingness to participate and time available. Panelists were staff and graduate students in Department of Food Engineering at Çanakkale Onsekiz Mart University; four were women and two were men, ranging from 24 to 39 years of age. The panelists received about 40 h of training during generation and definition of descriptive terms. During training sessions, potential references were presented to panelists to identify descriptive terms. Panelists were asked to identify and define the texture and flavor terms from representative samples of both breast and thigh. The terms used to define texture and flavor are outlined in Table 1. Panelists quantified the attributes using 15-point

Table 1- Descriptors used to evaluate texture and flavor of chicken meat

Çizelge 1- Tavuk etinin tekstürünü ve lezzetini değerlendirmede kullanılan tanımlayıcılar

Descriptor (abbreviation)	*Definition*	*Reference**
Juicy	Amount of wetness/juiciness released from the meat while chewing	Assignment by panel
Chicken flavor *(chkflv)*	Aromatics associated with cooked fresh chicken meat	Boiled and unsalted chicken meat
Feed	Aromatics associated with chicken feed	Assignment by panel
Cardboardy *(cardb)*	Aromatics associated with wet cardboard	Cardboard paper soaked in water
Oxidized *(oxid)*	Aromatics associated with warmed- over flavor	Reheating meat after refrigeration
organy/liver/bloody *(organ)*	Aromatics associated with organ, liver or blood	Boiled chicken liver
Umami *(umam)*	Chemical feeling factor elicited by certain peptides and nucleotides	1% monosodium glutamate solution in water*
Sweet	Taste sensation elicited by sugars	2% sucrose solution in water*
Salty	Taste sensation elicited by salts	0.5% sodium chloride solution in water*

* , reference adapted from Meilgaard et al (1999a)

product specific scales anchored on the left with 'not' and on the right with 'very' (Meilgaard et al 1999a).

Approximately 10 g of sample was presented to each panelist in 3-digit coded plastic plates. Six samples were evaluated in each session. Water was presented to the panelists to cleanse the palate between samples. Evaluation was conducted over an 8-wk period with panelists evaluating each sample twice. Duplicate samples were served in the different sessions. All panelists in a session evaluated the same sample in a randomized order.

Acceptance test was also used to determine acceptability of breast and thigh parts by 6 panelists who were the members of descriptive panel (Meilgaard et al 1999b). Sensory attributes of samples including texture, flavor and overall acceptability were evaluated using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). Three males and three females from each group were used for both descriptive sensory evaluation and acceptability tests.

2.3. Statistical analyses

Repeated measurement analysis (Equation 1) was used to test whether the breast and thigh parts were different for percent fat content, titratable acidity, dry matter and acceptance. The tests were also performed for the differences between the feeding regimes and the interaction of feeding regime by body part. The differences were determined using Bonferroni multiple comparison test. Statistical model used was:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \pi_{l(ij)} + \gamma_k + \alpha\gamma_{ik} + \beta\gamma_{jk} + \alpha\beta\gamma_{ijk} + \gamma\pi_{kl(ij)} + \varepsilon_{m(ijkl)} \quad (1)$$

Where; Y_{ijkl}, observed value for percent fat content, titratable acidity and dry matter; μ, overall population mean; α_i, effect of i^{th} feeding regime (i = 1, 2, 3); β_j, effect of j^{th} gender (j = 1, 2); $\alpha\beta_{ij}$, feeding regime by gender interaction; $\pi_{l(ij)}$, random effect of the animal l in i^{th} feeding regime and j^{th} gender; γ_k, effect of k^{th} body part (k= 1 thigh, k = 2 breast); $\alpha\gamma_{ik}$, feeding regime by body part interaction; $\beta\gamma_{jk}$, gender by body part interaction; $\alpha\beta\gamma_{ijk}$, feeding regime x body part x gender interaction; $\gamma\pi_{kl(ij)}$, chicken l by body part interaction in i^{th} feeding regime and j^{th} gender; $\varepsilon_{m(ijkl)}$, random error term.

Multivariate analysis of variance (MANOVA) was used to detect the effect of feeding regime, gender and feeding regime by gender interaction with respect to sensory characteristics. The statistical model for MANOVA is given in Equation 2.

$$Y_1, Y_2, Y_3, Y_4, Y_5, Y_6, Y_7, Y_8, Y_9 = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijk} \quad (2)$$

Where; Y_1, juicy; Y_2, chicken flavor; Y_3, feed; Y_4, cardboard; Y_5, oxidized; Y_6, organy; Y_7, sweet; Y_8, salt; Y_9, umami score of breast and thigh of chickens; μ, general population means; α_i, effect of feeding regime (i = 1, 2, 3); β_j, effect of gender (j = 1, 2); $\alpha\beta_{ij}$, feeding regime by gender interaction; ε_{ijk}, random error term.

Multidimensional scaling (MDS) was also used to produce visualizations for the exploration of descriptive sensory data. MDS plots the objects on a map such that objects that are very similar to each other are placed near each other on the map, and objects that are very different from each other, are placed far away from each other on the map.

3. Results and Discussion

Repeated measurement variance analysis results revealed that the feed restriction by body parts (breast and thigh) interaction for fat content was statistically significant (P=0.035). Therefore, the differences between feeding regimes varied depending on meat region. Bonferroni multiple comparison test was used to determine differences between the feeding regimes in each region. Table 2 shows titratable acidity, dry matter and fat content of the samples. The mean fat content of AD was significantly higher than that of NF and FR groups in thigh meat, while the mean fat content of FR was significantly higher than that of the AD and NF in breast meat (Table 2). There were no significant differences between breast and thigh meats with respect to dry matter and titratable acidity. The mean dry matter of thigh meat was significantly higher than that of the breast meat in every feeding regimes, while the vice versa for titratable acidity. Composition of chicken meat was also investigated by other researchers (Bogosavljevic-Boskovic et al 2010**;** Kolsarıcı et al 2010; Meluzzi et al 2009). In general, dry matter compositions of chicken meat samples used in previous studies were similar to our findings. Fat content of breast meat was much lower than thigh meat. Similar results were also reported by Meluzzi et al (2009). Ponte et al (2004) investigated the cholesterol levels and sensory characteristics of meat from broilers that consumed moderate to high level of alfalfa. Male broilers were fed with a high energy diet at 3 different levels: *ad libitum*, 75% restriction and 50% restriction. Chickens with restricted diets were also presented dehydrated alfalfa meal available in separate feeders. The results of this study revealed that total lipids in chicken meat decreased significantly, when a higher level of restriction was applied. The results demonstrated that consumers were more satisfied with meat from broilers fed with low levels of alfalfa. There was also a significant decrease in fat content of thigh in chickens fed with restricted diets (Table 2). Similarly, Arafa et al (1985) found that dietary energy restriction could decrease fat content.

Table 2- Titratable acidity, dry matter and fat content of meat samples
Çizelge 2- Et örneklerinin titrasyon asitliği, kuru madde ve yağ içeriği

Groups		*Titratable acidity*	*Dry matter*	*Fat content*
AD	Thigh	0.871± 0.005^{b}	28.235±0.971^{a}	8.330± 0.620^{a}
	Breast	1.209±0.005^{a}	26.190±0.375^{b}	0.440±0.050^{c}
FR	Thigh	0.862±0.002^{b}	28.717±0.574^{a}	6.500±0.650^{b}
	Breast	1.116±0.007^{a}	26.675±0.320^{b}	1.010±0.190^{a}
NF	Thigh	0.946±0.003^{b}	28.582±0.377^{a}	6.970±0.560^{b}
	Breast	1.223±0.003^{a}	26.638±0.376^{b}	0.730±0.180^{b}
Overall	Thigh	0.890±0.010^{b}	28.510±0.380^{a}	7.270±0.610^{a}
	Breast	1.200±0.020^{a}	26.500±0.200^{b}	0.720±0.130^{b}

AD, *ad libitum;* FR, restriction of food amount; NF, restriction of feeding duration; $^{a\text{-}c}$ different letters denote significant differences between feeding regimes in each body part (thigh and breast)

Thighs in all three feeding regimes had higher fat contents than breast meat. The fat content of thigh in AD was higher than that of FR and NF. However, the breast meat in FR and NF had higher fat contents than that of AD.

MANOVA results of sensory analysis were presented in Table 3. There were significant differences among groups in terms of chicken flavor and cardboard attributes ($P<0.05$). Statistically significant differences were detected between AD-NF and AD-FR groups with respect to chicken flavor intensity ($P<0.05$). The differences between AD-FR and NF-FR were also statistically significant for cardboard intensities ($P<0.05$). Juicy, flavour and cardboard intensities in breast meat were significantly different among groups (Table 3). The mean flavour intensities of AD and NF groups were significantly higher than that of FR ($P<0.05$; Table 3). Similar results were also observed for cardboard and juicy attributes. Mean cardboard intensity of AD was not significantly different from that of NF ($P>0.05$), but the mean cardboard intensity of FR was significantly lower than those of AD and NF. Similar results were also detected in juicy intensities of these groups.

Multidimensional Scaling (MDS) was used to produce visualizations for the exploration of data. The points close to each other in the map indicate relationship between the pairs as well as similarity of behavior with respect to the remaining variables or objects (Başpinar et al 2000; Bronstein et al 2006). In the present study, the first two dimensions were used since they accounted for about 60% of the total variation. Subsequent dimensions contributed 8% or less each.

Figure 1 shows the MDS map of descriptive terms for breast meat samples. Except chicken flavor for FR samples, juicy and chicken flavor terms for other samples were clearly clustered and separated from other terms. They were located on positive and right side of the map (Figure 1). These results indicated that panel members rated very close and high scores for these attributes. Umami as a single attribute did not show any similarities with other attributes. Umami scores were also significantly lower than juicy and chicken flavor. Other flavor terms including cardboard, feed, organy and oxidized clustered on the left side of the map (Figure 1). Intensities of these four attributes were low. In other words, low intensities of these undesirable flavors were noticed by panel members. However, FR group chicken had higher intensities of cardboard, feed, oxidized and organy than other attributes. For this reason, chicken flavor term in FR was located in different region of the map. The location of NF on the map is also similar to the locations of other groups.

The descriptive sensory analysis results of thigh are presented in Figure 2. Umami intensity of thigh was lower than that of breast. On the other hand, juicy scores of all feeding regimes were higher than other attributes. Juicy and chicken flavour scores of FR and NF were slightly higher than that of AD. The intensities of organy, oxidized, feed and cardboard in thigh of each feeding regime had similar distribution as observed in breast. Farmer

Table 3- MANOVA results of sensory characteristics

Çizelge 3- Duyusal özelliklere ait MANOVA sonuçları

Groups		*Attributes*		
		Chicken flavor	*Cardboard*	*Juicy*
AD	Thigh	5.43 ± 0.23^{a}	0.48 ± 0.06^{b}	5.03 ± 0.32^{a}
	Breast	5.26 ± 0.18^{A}	0.54 ± 0.10^{A}	5.37 ± 0.18^{A}
FR	Thigh	4.59 ± 0.17^{b}	0.54 ± 0.06^{a}	5.33 ± 0.45^{a}
	Breast	4.42 ± 0.21^{B}	0.42 ± 0.09^{B}	4.69 ± 0.20^{B}
NF	Thigh	4.97 ± 0.24^{b}	0.49 ± 0.09^{b}	5.06 ± 0.22^{a}
	Breast	5.01 ± 0.25^{A}	0.49 ± 0.13^{A}	5.05 ± 0.23^{A}

AD, *ad libitum;* FR, restriction of food amount; NF, restriction of feeding duration. Small letters denote significant differences between means of thigh meat and capital letters denote significant differences between means of breast meat

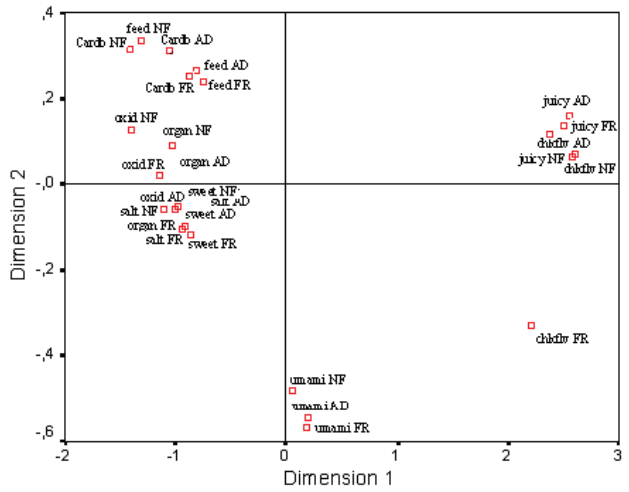

Figure 1- Multidimensional scaling map of breast meat of chickens reared under AD, FR and NF feeding regimes (chkflv, chicken flavor; cardb, cardboard; oxid, oxidized; organ, organy; umam, umami; AD, *ad libitum;* FR, restriction of food amount; NF, restriction of feeding duration)

Şekil 1- AD, FR ve NF besleme rejimlerinde yetiştirilen tavukların göğüs etlerine ait çok boyutlu ölçeklendirme haritası (chkflv, tavuk lezzeti; cardb, kartonumsu; oxid, okside olmuş;organ, organımsı; umam, umami; AD, ad libitum; FR, yem miktarı kısıtlaması; NF, yemleme süresi kısıtlaması

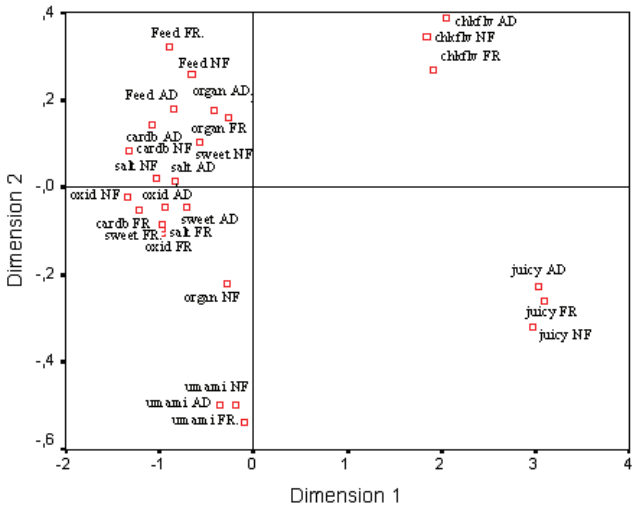

Figure 2- Multidimensional scaling map of thigh meat of chickens reared under AD, FR and NF feeding regimes (chkflv, chicken flavor; cardb, cardboard; oxid, oxidized; organ, organy; umam, umami; AD, *ad libitum;* FR, restriction of food amount; NF, restriction of feeding duration)

Şekil 2- AD, FR ve NF besleme rejimlerinde yetiştirlen tavukların but etlerine ait çok boyutlu ölçeklendirme haritası (chkflv, tavuk lezzeti; cardb, kartonumsu; oxid, okside olmuş; organ, organımsı; umam, umami; AD, ad libitum; FR, yem miktarı kısıtlaması; NF, yemleme süresi kısıtlaması

et al (1997) determined the effects of genotype, diet, stocking density and age on eating quality of chicken meat. The results of Farmer et al (1997) indicated that the chickens slaughtered at the age of 84 days, on a restricted diet were juicier, less fibrous and had less powdery residue than the chickens slaughtered at the age of 49 days. In addition, they did not find any significant difference in terms of flavor intensities of breast meat of chickens that were *ad libitum*-fed or restricted fed.

Acceptance test scores were presented in Table 4. Repeated measurement analysis of variance showed that there were no significant differences between texture, flavor and overall acceptance scores of breast and thigh meat of both male and female chickens ($P > 0.20$). Farmer et al (1997) indicated that acceptance of meat from birds reared on a restricted diet or fed *ad libitum* did not show any significant differences. Our findings are consistent with the result of Farmer et al (1997). In general, texture, flavor and overall scores of the samples were in the acceptable range of the scale.

Table 4- Texture, flavor and overall acceptance scores of meat samples*

Çizelge 4-Et örneklerinin tekstür, lezzet ve genel beğeni puanları

Groups	*Texture*	*Flavor*	*Overall*
AD	6.24±0.17	6.13±0.15	6.19±0.16
FR	6.66±0.16	6.43±0.14	6.45±0.15
NF	6.65±0.19	6.30±0.17	6.67±0.18

AD, *ad libitum;* FR, restriction of food amount; NF, restriction of feeding duration; *9-point hedonic scale (1=dislike extremely, 9=like extremely)

4. Conclusions

The most important sensory attributes of chicken meats were juicy, chicken flavor and umami. Some undesirable flavor attributes were detected in chicken samples at very low intensities. No significant differences were found between AD and NF in juiciness and chicken flavor scores. In addition, cardboard intensity of breast meat in FR was lower than those of other two feeding regimes. Therefore, we can conclude that feed restriction application at the level of 20% resulted in some desirable effects (lower cardboard intensity) on sensory properties of chicken meat. However, further studies on different feeding regimes can be recommended. In addition, the data from more animals will provide more detailed information on the effects of feed restriction on sensory quality of chicken meat.

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