

EFFECT OF ROUGHAGE TO CONCENTRATE RATIO ON QUALITATIVE AND QUANTITATIVE CHARACTERISTICS OF VEAL CARCASSES

Rabeea M. Mahmood[✉], Alrubeii, A. M. S.[✉], Natic Alkudsi[✉]

^{1,2,3} College of Agricultural Engineering Sciences, Baghdad University-Baghdad

ABSTRACT

This study was conducted in the animal farm of the College of Agricultural Engineering Sciences/ University of Baghdad/ Iraq, from 23 march 2014 to 23 may 2014 to investigate the effect of two levels of roughage to concentrate ratio on qualitative and quantitative characteristics of Holstein Friesian veal's, by studying the traits of three major muscles (*longissimus dorsi* LD, *biceps femoris* BF and *semimembranosus* SM). Two equal groups of Holstein Friesian veal's were used. Each group was consisted of five veal's at eight months old and weighted 228.800 ± 21.221 Kg and 227.800 ± 9.167 Kg respectively. Lean chemical composition were studied with characteristics (pH, WHC, TVN, TBA, P.V, FFAs, myoglobin concentrations Mb and protein solubility PS). The results were confirming that a high effect of the diets contents on the muscles properties especially the fat contents. The muscle location had a strong effect too on muscle properties. LD muscle was in high difference always with the other two, in spite of the differences among all kinds of muscle in all traits.

Keyword: longissimus dorsi, biceps femoris, semimembranosus, muscle location, roughage, IMF, marbling.



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INTRODUCTION

Beef meat occupied the third stage of globally consuming after poultry and pork (Felista et al, 2019; OECD, 2019). Its predicted that the world consuming of this kind of meat will be raised reaching the 21% in developing countries by 2027 more than 2017 (OECD, 2019). Beef meat is the major source of high value protein, niacin, vitamin B₆, B₁₂, Zinc, Selenium, Phosphorus, Iron and riboflavin (Asp, et al, 2012, Williams, 2007). The term *quality* in meat science refers to many aspects that deal with palatability, tenderness, nutritional value, hygiene, Etc. and quality with quantity of meat configuring the corner stone of the majority of the researches and studies in this field all over the world (Aberle et al, 2001). Meat (as a term) refers to the aggregated whole of lean, Bones and fat of the carcass. So, the attributes of these three essential components will strongly reflex on whole meat attribute as its quality or quantity

(Williams et al, 2002; Williams et al, 2006). There are many factors influence the meat quality, the main of them are the genetics and nutrition profile. Wolcott et al. (2009) and Felista et al. (2019) distinguished a broad of tastes of beef meat of various backgrounds of genetics, nutrition, environment in Australia. This variety is a summon of the levels of the different genetics, environment and nutritional factors that contributed with each other to configuring the final aspect of meat (OECD, 2019; Barendse et al, 2009). This study aimed to investigate the effect of two levels of roughage-concentrate feed on the qualitative and quantitative characteristics of Holstein Friesian veal meat in Iraq by studying the traits of three major muscles (*longissimus dorsi* LD, *biceps femoris* BF and *semimembranosus* SM).

MATERIALS AND METHODS

1. Diets and animals: This study was done in the animal farm of the University of Baghdad/

College of Agricultural Engineering Sciences in Iraq, in a period extended from 23 March 2014 to 23 May 2014. Two equal groups of Holstein Friesian were used. Each group was consisted of five veal in the age of eight month approximately and with average weight $228.800 \pm 21.221\text{Kg}$ and $227.800 \pm 9.167\text{ Kg}$ for each group respectively. The two groups placed in terraced barns and fed as a group daily with diets in percentage of 3% of live weight in the first two weeks, then, raised to 4% to the end of the experiment. Table 1 shows the ingredients of the concentration diets used. While the roughage diet was a good quality of alfalfa hay. Group one received daily feeding 40:60 concentration to roughage, while the second group of animal received a percent of 60:40 concentration to roughage as a daily feeding. The clean water was *ad libitum*. The diets were submitted two time a day in the morning and in the evening. Concentration and roughages diet was weighted daily with semi-sensitive scale. The animals were weighted as wall, and according to animals weights the feeding contents would be determined after each two weeks.

Table 1. Ingredients of the concentration diet.

| ingredient | % |
|------------------|-----|
| Barely | 40 |
| Wheat bran | 35 |
| Yalow corn meal | 13 |
| Soybean | 7.5 |
| Sun flower meal | 2.5 |
| Salt and calcium | 2 |
| total | 100 |

2. Procedures: At the end of the feeding period the veal's were slaughtered after one night feed withdrawing. The slaughter was according to Islamic practice without stunning. Hot carcasses were weighted and kept in chilled container 4°C for 24 hours, weight again and cut into left and right sides. The right side was chosen to represents the whole carcass. Three muscles were chosen for further analysis ((longissimus dorsi LD, biceps femoris BF and semimembranosus SM) which would be dissected according to the procedure of Butterfield et al, (1983). The fat remove from muscle tissue and have been (with the muscle) conducted to chemical analysis

according to AOAC (1980). Figure 1 shows the location of muscles which demanded in this experiment.

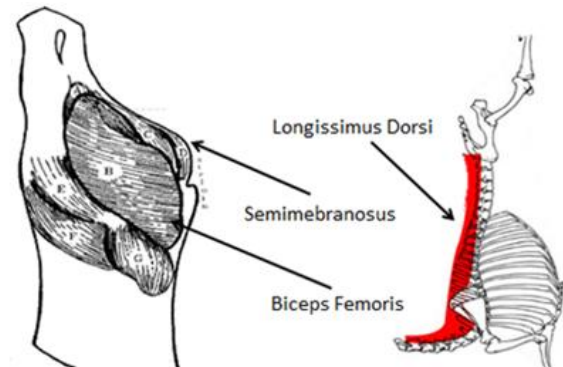


Figure 1. Locations of muscles

3. Studied properties:

pH: pH values were calculated according to Verma et al. (2005).

Water holding capacity (WHC): Water holding capacity (WHC) have been estimated following Dolatowski and Stasiak (1998).

Total volatile nitrogen compounds (TVN): as the method of Egan et al. (1981).

Thiobarbituric acid value (TBA): was been estimated according to Witte et al. (1970).

Peroxide value (P.V): was been measured as what was mentioned by Pearson and Duston (1985).

Free fatty acids (FFA): were according to procedure of Pearson and Duston (1985).

Myoglobin concentration (Mb): according to procedure of Zessin (1961).

Protein solubility (PS): the procedure of Dentlertog-Meiskchke et al. (1997) was followed.

Chemical analysis (Moisture, protein, fat and ash Percentage): according to Mahmood (2015).

Table 2. Chemical analysis of concentration and roughage diets as dry matter basis

| components | Concentration diet % | Roughage diet % |
|-------------|----------------------|-----------------|
| Dry matter | 94.06 | 94.89 |
| Protein | 12.3 | 11.52 |
| Crude fiber | 5.53 | 27.4 |
| ash | 3.6 | 9.33 |

Table 2 illustrated the chemical analysis of concentration and roughage diets while table 3 illustrated the total and daily gain and feed intake during the experiment.

Statistical analysis

The data was analyzed statistically using SAS program with Completed Random Design CRD (SAS, 2001), then, multi-limited test (Duncan) have done to the comparison between means.

RESULTS AND DISCUSSION

1. Chemical analysis: Table 4 shows the difference between the two treatments in chemical analysis of muscles (protein contents, moisture, fat contents and ash). It's could be obvious that all the muscles in T1 differed from their correspondences in T2 in moisture content. In another hand, the muscles inside the same treatment whether it was T1 or T2 had a significant differences ($P<0.01$) among each other. Also protein contents differed between treatments. The highest value was belong to SM muscle in T1 with a significant difference with its correspondence in T2. While it's would be found that the highest value of fat was belong LD muscle in T2. All muscles in T2 had the superiority in fat contents over their correspondence in T1. The

muscles in the same treatment whether were T1 or T2 had a significant differences ($P<0.01$) between each other's. No significant differences ($P>0.01$) were observed in ash contents whether between treatments or muscle among the same treatment. It can been seen that the relation between high concentration diet T2 and the increase of fat contents. (Park et al, 2018, Felista et al, 2019) referred to a high level of fat deposition relates always with high levels of energy in diets. The increasing in fat content related directly with the decreasing of moisture and protein contents in the same treatment, this eccentricity in chemical contents is usually observed in many researches dealing with the balancing between fat, moisture and protein as a chemical composition of meat (Jihad et al, 2009, Luna et al, 2012). Some researches referred to an enhancing in protein contents when the diet has its adequate levels of roughages in the presence of essential amino acids (Cole et al, 1976, Rodríguez et al, 2007).

Table 3. Total and daily gain and feed intake during the experiment.

| | First group | Second group | The different between them |
|------------------------------------|-------------|--------------|----------------------------|
| Initial weight (Kg/ group) | 1144 | 1139 | 5.00 |
| Final weight (Kg/ group) | 1428.33 | 1430.00 | 1.67 |
| Total gain (Kg/ group/day) | 284.33 | 291.00 | 6.00 |
| Daily gain (Kg/group/day) | 4.788 | 4.850 | 0.554 |
| The average of daily gain (Kg/day) | 0.957 | 0.970 | 0.11 |
| Roughage intake (Kg) | 1594.6 | 1594.8 | 485.8 |
| Concentration intake (Kg) | 1064 | 1549.8 | 485.8 |
| Total feed intake (Kg) | 2658.6 | 2620.4 | 38.200 |
| Feed efficiency conversion | 9.350 | 0.004 | 0.346 |

Table 4. Chemical composition of muscles

| Trait | Treatments | | | | | |
|----------|--------------|--------------|--------------|--------------|--------------|---------------|
| | SM | T1 LD | BF | SM | T2 LD | BF |
| Moisture | 72.45±0.4 Aa | 69.22±0.5 Ac | 71.65±0.6 Ab | 69.85±0.5 Ba | 67.28±0.5 Bc | 69.10±0.3 Bb |
| Protein | 20.72±0.5 Aa | 20.17±0.4 Ab | 20.03±0.5 Ab | 20.17±0.6 Ba | 19.05±0.7 Bb | 19.59± 0.5 Bb |
| Fat | 4.40±0.2 Bc | 8.10±0.6 Ba | 5.97±0.4 Bb | 7.48±0.5 Ac | 11.12±0.4 Aa | 8.75±0.6 Ab |
| Ash | 1.71±0.02 Aa | 1.80±0.01 Aa | 1.73±0.01 Aa | 1.80±0.01 Aa | 1.85±0.03 Aa | 1.82±0.01 Aa |

Means with the same capital letters are no significant differences between treatments

Means with the same small letters are no significant differences among muscles in any treatment

SM= Semimembranosus, LD= longissimus Dorsi, BF= Biceps Femoris

T1= 40:60 concentration to roughage T2= 60:40 concentration to roughage

2. pH values: figure 2 illustrated the differences between treatments and muscles in pH values. It could be seen that the LD muscle in the T2 had the lowest value (5.6) while the highest value was belong to SM muscle in T1 treatment (5.75). No significant differences were observed between treatments in LD and

SM muscles. But a significant difference ($P<0.01$) appeared between treatments just in BF muscle. In T1 there were no significant differences between SM and BF muscles. But the both (SM+BF) scored a significant differences in comparison with LD. But in T2 SM muscle differed from the other both, while

no significant differences appeared between them (LD+BF). Josephson (1993) illustrated that muscle is a variously collection on muscle fibers, and its ability to function depend upon these variety. Muscle function in contraction depend upon the type of myosin in its fibers and the degree of it to metabolizing energy (Josephson, 1993, Picard et al, 1995). Many kinds of myosin protein consisting in many muscles (Lefaucheur, 2007, Weiss et al, 1999). Slow-contracting muscle have myosin type I the heavy chain myosin while the muscles with fast contracting function have a many other types of myosin like type II or other. These differences in muscle fundamentally structure have a shadow in the complete vision of the whole muscle systematic function and determines the pH finally profile demanding on the type of muscle in the same nutritional circumstances (Pette and Staron, 2000, Wicks et al, 2019). The increasing in pH values in all muscles in T1 in comparison with T2 is in accordance with many researches (Immonen et al., 2000, Wicks et al, 2019). Immonen et al. (2000) found a lower muscle glycogen contents in cattle fed hay only in comparison with fed grain diets. Anyway, in our experiment the least values of pH were belong to the high concentration diet, and that may because the tendency of muscle to compositing energy contents like fat (inter and intramuscular and droplets fat) which means high contents of glycogen which makes pH value lower after slaughter.

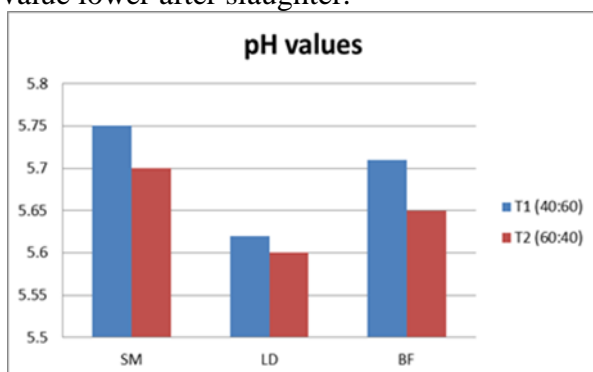


Figure 2. pH values

3. WHC values: there were high significant differences ($P < 0.01$) between the treatment T1 and T2 in the water holding capacity for each muscle. Figure 3 exhibiting that the highest value was from SM in T1 (52.1), while the lowest one was from LD in T2 (42.11).

Significant differences were observed among all muscles in each treatment as well. Huff-Lonergan and Lonergan (2005) referred to that the most water of meat is between the myofibrils lattice, and its demand completely on the net charges of this lattice (Ertbjerg, and Puolannem 2017). So, any changes in this electrical internal charges will reflex immediately on the WHC. Many reasons stand behind the changes in WHC. The main of them is the changes in pH values as a response of conforming lactic acid during the conversion of muscle into meat (Huff-Lonergan and Lonergan, 2005). When the pH value reach the isoelectric point of the myofibrils the net charge of the meat reach the zero point. That means no repelling forces between myofibril proteins. And means as well reducing in the cavities where the immobilized water was occupied before (Huff-Lonergan and Lonergan, 2005). This is way the T1 values in our experiment score more WHC as a reflexing of crossing the pH value over the step of isoelectric point which due to an increasing in WHC once more. While the differences among muscles in this trait due to the differences in the types of myofibrils protein especially myosin type which play the main role in this function (Offer, 1991, Huff-Lonergan and Lonergan, 2005).

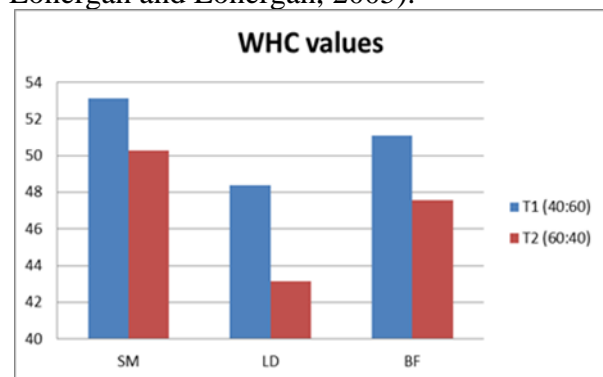


Figure 3. WHC values

Myoglobin concentrations (Mb): It is the nature which bestowed the muscles tissues with this water soluble protein to can transport and store oxygen from the blood stream to the muscle (Wittenberg et al, 1975, Wittenberg, 1970). This protein pigment is so relevant around the world to predicting and determine the meat status. Demanding on differences in metabolism of energy and needing for oxygen

the myoglobin concentrations vary not only between species or animal but between muscles in the same animal as well (Wittenberg, 1970). The results in this experiment were showed in figure 4. It could be seen the differences between treatments and between muscles in this trait. LD muscle in the both two treatments has the lowest values with significant differences ($P < 0.01$) in comparison with others. And without significant difference between the muscle LD in the two treatments.

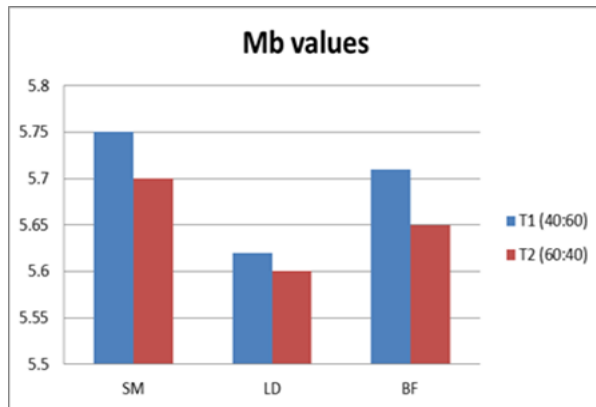


Figure 4. Myoglobin concentrations Mb

No significant differences between SM and BF muscles as a comparison between muscles, but a significant differences appeared between each muscle in the comparison between treatments. All muscles with high concentrated feed T2 had the lowest concentration of Mb, this results came accorded with those of (46, 33). The reason of this less in pigment is because the abundant of energy sources which means a less of pigment being enough to do their job (Wicks et al, 2019). While the less of pigment in LD muscle due to the more movable muscle need more pigment to compensating the increasing requirement for energy (Lefaucheur, 2007). One more matter, many researches illustrated that the nearest muscle to bone would be the darkest one (Huff-Lonergan and Lonergan, 2005; Wicks et al, 2019). This thesis may be clear in our result which illustrates a superiority of SM over other as a result of its nearness to bone.

5. Protein solubility (PS): The results had been shown in figure 5 exhibit a significant differences ($P < 0.01$) between treatments for each muscle in this trait. T1 had always the superiority over T2 and had the highest value (52.10) which belong to the SM muscle in it. The lowest value was came from LD in T2

(42.11). The muscle inside the same treatment differed from each other's as well in the both treatments significantly.

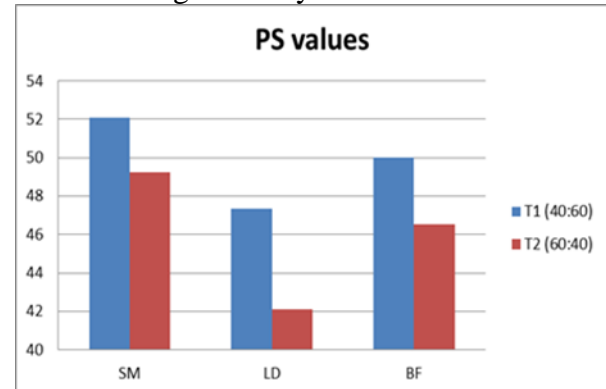


Figure 5. Protein solubility values

Protein solubility values may be a good indicator to determine the degree of postmortem protein proteolysis (Huff-Lonergan and Lonergan, 1999). Wicks et al. (2019) and Melody et al. (2004) referred to a differences in calpastatin activity between muscles in the same animal measured after 24 hour of slaughter. The highest value was from *semimbranosus* SM and the intermediate was from longissimus dorsi LD. This results are in accordance with ours, and hypothesize to a relation between calpastatin activity in muscles and the postmortem proteolysis as a high positive correlation. There is another important relation between postmortem changes and the oxidation state if muscles (Wicks et al, 2019). Oxidizing conditions may cause an inactivation of calpain and reducing or stopping its activity. That is because calpain enzyme contains histidine in its active site and that amino acid could be inactivated an inhibited under oxidizing conditions, and all that would have and affective role upon the posmortem proteolysis process (Guttmann and Johnsonm, 1998). The diets influence was clearly appears as a high in PS value in T1 with low concentration and that may be due to the pH levels which may be closed to the proteolysis optimum rang of activity as what was mentioned by (Juncher et al, 2001).

6. Total volatile nitrogen (TVN): total volatile nitrogen concentrations TVN may be a good indicator to investigate a progress oxidation in meat. It means that the oxidation reaches the myofibril proteins level (Lund et al, 2011). The investigation is based on the

amounts of free nitrogen compounds like ammonia and its concentrations in meat as an indicator if amino acids progress oxidation (Hassanin et al, 2017). This experiment investigated the differences between muscles and the effects of diets on this trait. The results in figure 6 illustrated significant differences between muscles in TVN value. The highest value was came from LD muscle and the medium was from BF while the lowest one was belong to SM muscle.

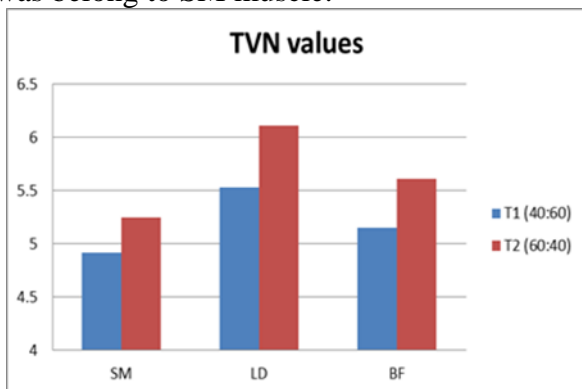


Figure 6. Total volatile nitrogen values (TVN)

The oxidation initiators came in the first place from the products of lipid oxidation or the proteolytic enzymes of the muscles themselves (Alina and Ovidiu. 2007). So, the differences between muscles in this trait came from this very point. The contents of inter and intramuscular fat play a role and the types of myosin would play a role to determine the final profile of TVN concentration, this is way the LD muscle had the highest obvious value in comparison with the two others. And that was mentioned by (Josephson, R. 1993). The differences between treatments may come from the same differences in fat contents which related strongly with diet energy contents.

7. Free fatty acids (FFAs) and cholesterol concentrations: Figure 7 shows the significant differences ($P < 0.01$) in cholesterol concentrations between muscles in the same treatment and between the same muscles in the both treatments. The treatment of high concentration T2 had the overlapping on other significantly in all types of muscles. LD muscle showed the superiority over the two others muscle in cholesterol contents regardless the treatment type.

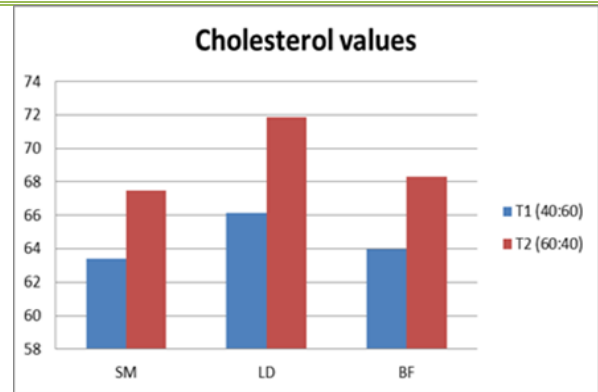


Figure 7. Cholesterol concentrations

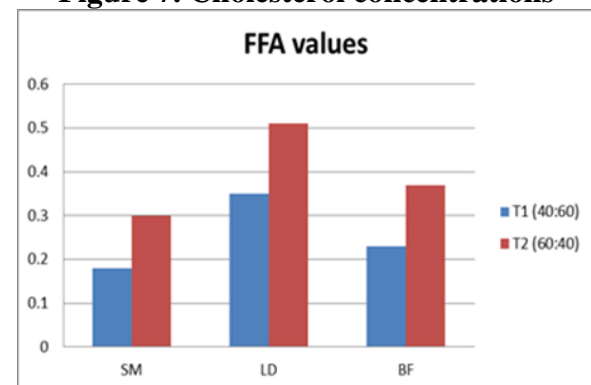


Figure 8. Free fatty acids concentrations

In a similar pattern with little deviation figure 8 exhibits the free fatty acids contents in our results. LD muscle scored the overlapping on others regardless the treatment type and the T2 had the superiority over T1 in it. No significant differences between SM and BF in T1 either in cholesterol concentrations or in FFAs contents. The main reason behind investigate FFAs and cholesterol contents is to determine the status of IMF in muscles and then in meat. IMF or intramuscular fat is an item refers to the amount of fat within muscle which would differs from intermuscular fat which refers to the fat locates between muscles (Hocquette et al, 2009). From chemical view IMF refers to the amount of phospholipids, triglycerides and cholesterol in muscles (Newcom et al, 2002). The importance of determining IMF is because its relation with marbling preferred proper. Marbling from its side is the appearance of white veins of intramuscular fat between of muscle fibers in steaks (Hocquette et al, 2009). Many researches (Hodgson et al, 1991; Hocquette et al, 2009) confirmed that a medium contents of IMF in meat has a positive effects on flavor, tenderness and juiciness. But this subject is a blade with two edges, because the excessing of

IMF is a main source of cholesterol which would have a dangerous hygiene influence (WHO, 2003; Valsta et al, 2005). The superiority of LD muscle over SM and BF in the both traits (cholesterol and FFAs contents) is an indicator of containing this muscle (LD) of a high amount of IMF in comparison with the two others. This results are in accordance with what was mentioned by Hocquette (1998, 1999) how suggested that the high mass muscle is associated with low fat and less intramuscular fat. The effect of treatments were appeared as a decreasing in fat contents relating with T1 as a reflexing of using high roughages diet instead of concentrations. This results accorded with that of Rhoades et al. (2007) how suggested that using low concentrated diets provides a high amounts of acetate which would be used more affective in subcutaneous fat instead of intramuscular fat and that would decrease fat content within the muscles and increase it subcutaneously.

8. TBA and P.V values: peroxide value P.V is a test would be proceeded to investigate the concentrations of peroxides and hydroperoxides compounds which may be built in meat or meat products as a response of oxidation occurred in unsaturated double bonds lipids or fatty acids (Dave and Ghaly, 2011). While TBA values is another test evaluates lipids oxidation in its final phases. TBA value had a strong relation with lipolysis enzymes whether in muscles themselves or in microorganisms (Gheisari, 2011).

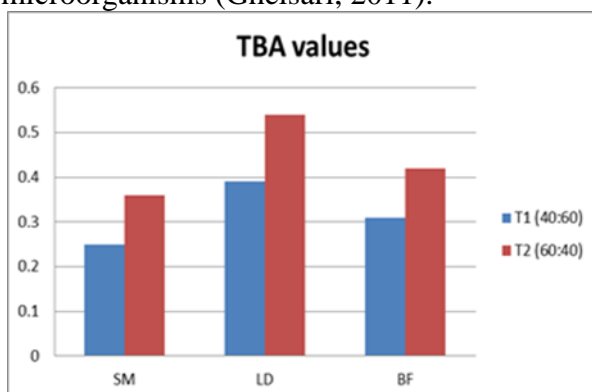


Figure 9. TBA concentrations

Figure 9 showed TBA value with significant differences ($P < 0.01$) between treatments and among muscle in the same treatment. The superiority was belong to T2 the treatment with high concentration diet in addition to

another overlapping of LD muscle on other types. While figure 10 exhibited in a similar style the superiority of T2 again in P.V values over T1 and an overlapping to LD muscle over the two others. But the superiority of T2 over T1 was less in P.V in comparison with TBA. Though. The both were had a significant different.

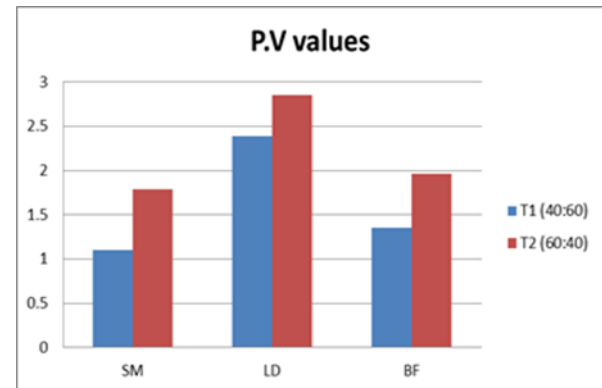


Figure 10. P.V concentrations

This results are like a confirming of what was mentioned before. LD muscle had the highest values for both traits (TBA and P.V) because its possession of high contents of IMF as a results of its location in body and its fewness of movement in comparison with other muscles SM and BF. This high contents of IMF (intramuscular fat) exposes it to a high probability to being under intense oxidation conditions. This is in parallel with what was mentioned before in Hocquette (1998, 2009). The tendency to increasing fat in the status of IMF was related with high concentrations diet T2 because of the same reason that referred before by Rhoades et al. (2007) how suggested that using low concentrated diets provides a high amounts of acetate which would be used more affective in subcutaneous fat instead of intramuscular fat. And all this results in this two previous subjects confirm each other's strongly.

CONCLUSION

The muscles within the same animal had differences between each other's in depositing lipids whether in contents or in types. The LD muscles has the clearer different in comparison with BF and SM which were in the same cut. Even in the same cut, the muscles would be different in response to different diets according to its differences in type. Marbling would be increased in LD more than others

muscles when high concentrations diets were used. But this may cause an increment in oxidation conditions. Roughage to concentrate ratio have an intrinsic effects on the whole muscles properties.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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تأثير نسبة العلف الخشن الى المركز في الصفات النوعية والكمية للحوم ذبائح العجول.

ربيع مزهر محمود، اميرة محمد صالح الربيعي، ناطق القدسي

قسم الانتاج الحيواني ، كلية علوم الهندسة الزراعية، جامعة بغداد- بغداد/ العراق

المستخلص

اجريت هذه الدراسة في الحقول الحيوانية التابعة لكلية علوم الهندسة الزراعية في جامعة بغداد/ العراق. لفترة امتدت من 23 اذار الى 23 ماي من العام 2014 لبحث تأثير احلال نسبتي من العلف الخشن الى المركز في الصفات النوعية والكمية للحوم العجول بواسطة دراسة صفات ثلاث انواع من العضلات الرئيسية في ذبائح عجول الفريزيان هولشتاين وهي كل من العضلة العينية *LD longissimus dorsi* والعضلة ذات الرأسين الفخذية *BF biceps femoris* والعضلة شبه الغشائية *SM semimembranosus*. طبقت نسب الاحلال على مجموعتين من العجول، كل مجموعة تتكون من خمس عجول بعمر ثمان اشهر وبمعدل وزن 228.800 ± 21.221 كغم و 227.800 ± 9.167 كغم على التوالي. تمت دراسة التركيب الكيميائي للعضلات اضافة الى الصفات (درجة الحموضة pH، القدرة على احتفاظ العضلات بالماء WHC، كمية النيتروجين المتطاير، مستوى حامض ثايوباربيتوريك TBA، مستوى البيروكسيد P.V، ونسبة الاحماض الدهنية الطيارة FFAs، تركيز صبغة الميوغلوبين، ومستوى ذائبية البروتين). اكدت النتائج ان هناك تأثير عالي المعنوية لمستوى التغذية ونسبتها من الاعلاف الخشنة الى المركزة في خصائص كل العضلات المدروسة وخصوصاً صفة محتوى الدهون في العضلات. كان هناك تأثير عالي المعنوية ايضاً لموقع العضلة في صفاتها المدروسة، في كل الصفات المدروسة كانت العضلة العينية تسجل اختلافاً معنويًا مع العضلتين الاخرين اضافة الى اختلاف كل العضلات مع بعضها في اغلب الصفات المدروسة.

الكلمات المفتاحية: العضلة العينية، العضلة ذات الرأسين الفخذية، العضلة شبه الغشائية، موقع العضلة، اعلاف خشنة.