Plant Archives Vol. 20 Supplement 1, 2020 pp. 673-679 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF ANTIOXIDANT POTENTIAL OF ASTAXANTHIN AND ALLYL ISOTHIOCYANATE IN QUALITY CHARACTERISTICS OF RAW GROUND BEEF MEAT DURING COLD STORAGE

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Abstract

The objective of this study was to evaluate the effect of adding different concentrations of Astaxanthin (HP) and Allyl Isothiocyanate (AITC), in oxidative stability and quality characteristics of raw ground beef meat, stored at 2°C for 20 days. In this study, Eight different treatments of HP and AITC were analyzed *viz.* T_1 (control), T_2 (0.15 g/kg of HP), T_3 (0.30 g HP/kg of meat), T_4 (0.45 g HP/kg of meat), T_5 (125/ µLAITC/kg of meat), T_6 (125/ µLAITC/kg of meat + 0.15 g HP/kg of meat), T_7 (125/ µLAITC/kg of meat + 0.3 g HP/kg of meat), T_8 (125/ µLAITC/kg of meat + 0.45 g HP/kg of meat). The treatments were stored for 1, 5, 10, 15 and 20 days. Results were analyzed after the physical and chemical tests conducted. The following results were obtained: 1- The addition of HP and AITC to ground chilled beef, Meat during cold storage period led to a significant increases ($P<0.05$) in moisture, protein and fat percentages as compared with control treatment. 2- Addition treatments of HP and AITC showed a significant decrease ($P<0.05$) in Thiobarbituric acid (TBA) value as compared with control treatment. 3- The addition of HP and AITC to ground chilled beef, meat during cold storage have a significant increase ($P<0.05$) in pH value as compared with control treatment. 4- The HP and AITC treatments were recorded higher percentage in value than control treatment, which have shown a higher percentage in water holding capacity (WHC) in the meat. It can be concluded that the addition of HP and AITC to ground chilled, meat during cold storage have achieved higher antioxidant efficiency through lower oxidation indicator such as Thiobarbituric acid (TBA) value, increased pH value and improved water holding capacity (WHC) in the meat.

Key words : Astaxanthin, Allyl Isothiocyanate, antioxidant, ground chilled beef.

Introduction

Meat is an important source of human consumption, because it is rich in high- protein value and essential nutrients, such as essential amino acids, vitamins and minerals. Meat fat is rich in saturated fatty acids. Saturated Fat Acid (SFA), Mono Unsaturated Fatty Acid (MUFA), Polyunsaturated Fat Acid (PUFA) (Rubio *et al.,* 2008). The biological and chemical nature of the meat and their products makes lead to decompositions and deterioration corruption when stored, as a result of chemical and bacterial actions. The oxidation of meat and products as a result of the development of primary and secondary oxidation products (Kumar *et al.,* 2015). The oxidative rancidity is one of the main causes of deterioration to meat and their products, and the resulting of breakdown of unsaturated fatty acids and oxidized cholesterol products and all that effects on consumer health (Dzudie *et al.,* 2004). Therefore, chemical and microbial degradation are the main factors influencing the quality of food and decrease of biological value (Amaral *et al.,* 2018). Recent studies have tended to use antioxidants, which are compounds that are able to donate an H * hydrogen atom in conjunction with other free radicals available to prevent the oxidation process and thus retard fat oxidation, without any effect on sensory properties or nutritional value, and prolonging the shelf life of meat products (Kumar *et al.,* 2015). The antioxidants from natural sources are considered the best option for maintaining meat quality (Falowo *et al.,* 2014). Because there are safer and do not pose a risk to consumer health (Luo and Fang, 2008).

Carotenoids are one of the most important natural antioxidants that have proven superior to synthetic antioxidants in improving the sensory properties of meat products (Amaral *et al.*, 2018(. Astaxanthin (HP) is a type of carotenoids produced from the microalgae

Haematococcus pluvialis, one of the most important natural antioxidants that can be added to meat and their products and antioxidants with great effectiveness against fat oxidation. It is widely used in the food industry and also works to preserve protein from oxidation. Animals (Pogorzelska, *et al.,* 2018), in addition, Allyl Isothiocyanate (AITC), extracted from black and brown mustard seeds, is highly effective against spoilage bacteria in meat and their products and is widely used as an antibacterial agent (Chacon *et al.,* 2006). The aim of this study is to investigate the effectiveness of both HP and AITC as antioxidants and their contribution to improving the qualitative characteristics and undesirable flavors of ground fresh beef in cold storage.

Materials and Methods

This study occurred in the laboratory of meat science and technology in the Department of Animal Production and animal nutrition laboratory for graduate studies in the Faculty of Agricultural Engineering Sciences University of Baghdad, leg meat were used from a local calf after the slaughter, was imported Astazanthin by Amazon From America, it is a soft red powder extracted from *Haematococcus Pluvialis* micro algae and AITC was imported from Sigma Aldrich Chemical Co., St. Louis, MO, USA, a liquid aromatic oily substance. The meat was refrigerated at a temperature of 2°C for (12-10) hours and cut by a sterile knife into small pieces with dimensions of 3-4 cm^3 to facilitate the subsequent chopping process by using sterile gloves, and chop the meat with an electric grinding machine and the meat pieces were homogenized together to ensure the distribution of the components of the meat Equally, then the weight of the meat was divided into eight parts with 2.5 kg per part and each part was treated with the special concentration of each subject according to the control treatment. The experiment included eight transactions according to the added concentrations of meat and the required tests were conducted after 1, 5, 10, 15 and 20 days of refrigerated storage at 2°C to the effect of the experiment treatment mentioned above on fat oxidation and the study quality of fresh ground. Chilled beef meat SAS used data analysis to study the effect of different transactions on the qualities studied according to a complete random design (CRD) for each period and compared the moral differences between averages to the Duncan multi-border test.

Results and Discussion

Chemical composition of fresh ground beef meat, stored by chilling

Moisture percentage

Table 1 shows the effect of the interaction between different treatments and the storage period by refrigerating in the moisture percent of fresh ground beef meat, in this table show significant increase ($P<0.05$) in the moisture percent in T_8 (125/µL/kg AITC+0.45g/kg HP) it has recorded the highest percent of protein (75.37%) in the storage period of 1 day, as compared with treatment T_1 (control) which gave the lowest moisture percent that reached 68.59% in the period of 20 days of storage, There were varying differences between treatments and different storage periods.

This study agree with several studies that indicated the high moisture percentage when adding some medicinal plants or their extracts Muhammad and Al-Rubeii (2018) also pointed out that the addition of anatoo seeds to the meat sausages by refrigeration led to the increase of moisture percent. The results of the study Soltanizadeh and Ghiasi-Esfahani (2015) showed that the addition of aloe vera extract to the beef burger led to increase the moisture percent in the burger. The addition of natural substances such as lotus leaf extract and barley which increased the moisture percent of processed pork (Huang *et al.,* 2011).

Protein percentage

Table 2 explained the effect of the interaction between different treatments and the period of storage by refrigerating in the protein percent of fresh ground beef meat. We observed the significant effect ($P> 0.05$) for all addition (HP and AITC) treatments in percent of protein during the cold storage periods 1, 5, 10, 15 and 20 days respectively, T_8 (125µL/kg AITC + 0.45g/kg HP) showed the highest protein percent for the period (20), (21.41%) as compared with treatment T_1 (control), which recorded the lowest protein percent (17.03%) in the period of 1 day. The higher protein percent in treatments is due to the ability of HP and AITC to protect protein from oxidation and damage (Bortolotto *et al.,* 2018; Yamashita, 2018). Numerous studies have shown a higher protein percent when adding natural antioxidants. Feeding lambs on a dietary supplement to rapeseed oil, fish oil, black seed, yeast, carnosic acid, and various chemical forms of selenium have increased the protein percent of the meat and kept it from oxidation (Przybylski *et al.,* 2017). This result was agree with Huang *et al.*, (2011) and Soltanizadeh *et al.*, (2015) who showed that the lower percent value of protein increased period of storage, and increased in high concentration of addition materials, this agree with Muhammad and Al-Rubeii (2018).

Fat percentage

The result in table 3 showed the effect of the interaction between the different treatments and the periods of cold storage on the fat percentage in fresh ground beef meat, A significant decrease ($P> 0.05$) was

Table 1: The effect of the interaction between different treatments and the period of storage by refrigerating in the moisture percentage of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	74.57 ± 0.3^{CDB}	73.63 ± 0.12^{F}	71.25 ± 0.23^{G}	69.26 ± 0.21^{JMKIL}	68.59 ± 0.2^{M}
T_2	74.62 ± 0.1^{CDB}	73.74 ± 0.14^{FE}	71.27 ± 0.14^{G}	69.33 ± 0.13^{JKIL}	68.68 ± 0.14^{ML}
T_3	74.76 ± 0.4^{CAB}	73.8 ± 0.35^{FE}	71.35 ± 0.36^{G}	69.52 ± 0.2^{JHKI}	68.87 ± 0.21^{MKL}
T_4	75.15 ± 0.1^{AB}	73.91 ± 0.11^{FE}	71.48 ± 0.18^{G}	69.63 ± 0.17^{JHI}	68.98 ± 0.05^{JMKL}
T_5	74.67 ± 0.2^{CDB}	73.66 ± 0.23^{FE}	71.32 ± 0.21^{G}	69.36 ± 0.25^{JHKIL}	68.78 ± 0.03^{ML}
T_6	74.82 ± 0.21^{CAB}	73.83 ± 0.44^{FE}	71.31 ± 0.24^{G}	69.53 ± 0.23^{JHKI}	68.96 ± 0.09^{JMKL}
T_7	75.21 ± 0.31^{AB}	74.02 ± 0.16^{FDE}	71.42 ± 0.15^{G}	69.83 ± 0.12^{HI}	69.21 ± 0.12^{JMKIL}
T_8	75.37 ± 0.22^{A}	74.32 ± 0.13^{CDE}	71.57 ± 0.11^{G}	70.03 ± 0.16^{H}	69.5 ± 0.06^{JHKI}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP), T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/ kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

Table 2: The effect of the interaction between different treatments and the period of storage by refrigerating in the Protein percentage of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	17.03 ± 0.11^{L}	17.54 ± 0.02^{IJHK}	19.03 ± 0.3^{F}	20.67 ± 0.27^{C}	20.65 ± 0.13^{C}
T_2	17.2 ± 0.1^{LJK}	17.63 ± 0.1^{IGJH}	19.12 ± 0.13^{F}	20.75 ± 0.11^{C}	20.73 ± 0.12^{C}
T_3	17.25 ± 0.2^{ILJK}	17.7 ± 0.2^{IGH}	19.27 ± 0.3^{FE}	20.86 ± 0.23^{CB}	20.87 ± 0.22^{CB}
T_4	17.32 ± 0.01^{ILKJ}	17.93 ± 0.01^{GH}	19.43 ± 0.02^{FE}	20.97 ± 0.06^{CB}	21.03 ± 0.02^{CAB}
T_5	17.17 ± 0.04^{LK}	17.61 ± 0.02^{IGJHK}	19.15 ± 0.09^{F}	20.75 ± 0.04^{C}	20.81 ± 0.03^{CB}
T_6	17.21 ± 0.07^{LJK}	17.69 ± 0.05^{IGH}	19.39 ± 0.08^{FE}	20.73 ± 0.05^{C}	20.93 ± 0.12^{CB}
T_7	17.27 ± 0.12^{ILJK}	17.92 ± 0.12^{GH}	19.6 ± 0.13^{E}	21.03 ± 0.16^{CAB}	21.22 ± 0.1^{AB}
T_8	17.45 ± 0.06^{ILJK}	18.02 ± 0.06^{G}	20 ± 0.06^{D}	21.23 ± 0.2^{AB}	21.41 ± 0.12^{A}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP), T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/ kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

observed in T_8 (125µL/kg AITC + 0.45 g/kg of HP) it was recorded at (5.43%) for 1 day period, while T_1 (control) was recorded the highest fat percentage at (8.02%) for the period 20 days. Were significant difference between treatments with different storage periods. The reason for the highest fat percent in the additives was due to the ability of natural additives to protect fat from oxidation and decomposition by preventing the formation of free radicals and Reactive Oxygen Species ROS (Jaworska *et al.,* 2016). This is normal because when the progresses storage period, moisture decreased and the incresed dry matter, which includes both protein, fat and ash, this is consistent with many previous studies (Soltanizadeh and Ghiasi-Esfahani, 2015; Muhammad & AL-Rubeii, 2018).

Ash percentage

In table 4 were observed the effect of the interaction between the treatments and the different storage periods on the ash percentage of ground fresh beef meat chilled was recorded T_8 (125µL/kg AITC + 0.45 g / kg of HP) the lowest significant ($P< 0.05$) (0.97%) in the ash percent in one day period in refrigerating storage, while control treatment (T_1) was recorded highest percent of ash (1.91%) in period 1 day. As of the same table, it was also found that there was a significant effect ($p <0.05$) on the ash percent in freshly chopped veal for all treatments. And all periods of cold storage. There was a significant decrease in treatment T_8 (125µL / kg AITC + 0.45 g / kg of HP) it was recorded (0.97, 1.21, 1.34, 1.39 and 1.53) respectively for periods 1, 5, 10, 15 and 20 days sequentially followed by treatment T_7 (125µL / kg AITC + 0.3 g / kg of HP) with ash percent of 1.02, 1.26, 1.42, 1.44 and 1,74%, respectively, for the same periods indicated above. Regarding the control treatment which increased significantly, it recorded 1.21, 1.49, 1.57, 1.74 and 1.91% respectively for the same treasury periods mentioned above. This is consistent with the results obtained by Muhammad & Al-Rubeii, 2018), as the concentration of natural additives increases, the ash

Table 3: The effect of the interaction between different treatments and the period of storage by refrigerating in the fat percentage of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	6.29 ± 0.3^{JKI}	6.58 ± 0.3^{GJHFI}	7.34 ± 0.27^{CEDB}	7.65 ± 0.12^{CAB}	8.02 ± 0.13^{A}
T_2	6.2 ± 0.21^{LJK}	6.53 ± 0.13^{GJHI}	7.28 ± 0.11^{CED}	7.52 ± 0.3^{CADB}	7.9 ± 0.13^{AB}
T_3	6.03 ± 0.22^{LJK}	6.42 ± 0.3^{JHI}	7.13 ± 0.23^{CEDF}	7.39 ± 0.24^{CEDB}	7.69 ± 0.24^{CAB}
T_4	5.78 ± 0.02^{LMK}	6.31 ± 0.02^{JKI}	7.02 ± 0.07^{GEDF}	7.21 ± 0.04^{CED}	7.53 ± 0.22^{CADB}
T_5	6.25 ± 0.03^{JKI}	6.54 ± 0.09^{GJHI}	7.22 ± 0.05^{CED}	7.48 ± 0.05^{CADB}	7.87 ± 0.19^{AB}
T_6	6.13 ± 0.12^{LJK}	6.32 ± 0.08^{JHKI}	7.13 ± 0.02^{CEDF}	7.38 ± 0.18^{CEDB}	7.56 ± 0.28^{CADB}
T_7	5.75 ± 0.1^{LMK}	6.04 ± 0.13^{LJK}	6.89 ± 0.16^{GEHF}	7.01 ± 0.14^{GEDF}	7.13 ± 0.14^{CEDF}
T_8	5.43 ± 0.12^{M}	5.67 ± 0.06^{LM}	6.33 ± 0.2^{JHKI}	6.61 ± 0.16^{GJHFI}	6.83 ± 0.03^{GEHFI}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP), T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/ kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

Table 4: The effect of the interaction between different treatments and the period of storage by refrigerating in the Ash percentage of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	1.21 ± 0.12^{ORPSQN}	1.49 ± 0.01^{KHGJLI}	1.57 ± 0.03^{FKHGJIE}	1.74 ± 0.03^{CADBE}	1.91 ± 0.02^{A}
T_2	1.21 ± 0.03^{ORPSQN}	1.44 ± 0.03^{KHMJLI}	1.58 ± 0.01^{FKHGJDIE}	1.66 ± 0.1^{FCHGDBE}	1.85 ± 0.01^{AB}
T_3	1.17 ± 0.04^{RPSTQ}	1.41 ± 0.02^{OKMJLIN}	1.55 ± 0.02^{FKHGJLIE}	1.62 ± 0.02^{FCHGDIE}	1.79 ± 0.02^{CADB}
T_4	1.11 ± 0.03^{RST}	1.39 ± 0.02^{OKPMJLN}	1.52 ± 0.07^{FKHGJLI}	1.59 ± 0.04^{FKHGJDIE}	1.73 ± 0.02^{FCADBA}
T_5	1.21 ± 0.01^{ORPSQ}	1.44 ± 0.09^{KHMJLI}	1.54 ± 0.02^{FKHGJLIE}	1.67 ± 0.05^{FCGDBE}	1.87 ± 0.09^{AB}
T_6	1.13 ± 0.11^{RSTQ}	1.36 ± 0.03^{OKPMLN}	1.496 ± 0.02^{KHGJLI}	1.61 ± 0.02^{FCHGJDIE}	1.81 ± 0.03^{CAB}
T_7	1.02 ± 0.1^{ST}	1.26 ± 0.1^{ORPMQN}	1.42 ± 0.11^{KMJLI}	1.44 ± 0.01^{KHMJLI}	1.74 ± 0.1^{CADBE}
T_8	0.97 ± 0.11^{T}	1.21 ± 0.05^{ORPSQN}	1.34 ± 0.2^{OPMLQN}	1.39 ± 0.03^{OKPMJLIN}	1.53 ± 0.02^{FKHGJLIE}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP), T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

percent increases (Huang *et al.,* 2011; Soltanizadeh and Ghiasi-Esfahani, 2015; Muhammad & Al-Rubeii, 2018).

pH value

Table 4 shows the effect of the interaction between the treatments and the different storage periods on the pH value of freshly ground beef, Treatment T_8 (125µL/ kg AITC + 0.45 g/kg of HP) has significantly ($p < 0.05$) exceeded the pH value it was recorded the highest pH value (6.1%) in the 20-day period, while control treatment T_1 was recorded the lowest significant difference in pH value of (5.53%) in the 1-day period. There were significant differences between treatments for different storage periods.

The reason for the low pH in the early storage periods can be attributed rapid activity of calpain-µ and cathepsins, or because of reduced meat water retention (Li *et al.,* 2014). As well as the decomposition of meat proteins with the progress of the storage period, which causes the rise of nitrogenous compounds (Muhammad & AL-Rubeii., (2018). These results are consistent with those of Muhammad & AL-Rubeii (2018) and Falowo *et al.,* (2017).

Thiobarbituric acid

The results of table 6 indicated a significant decrease ($P<0.05$) in the value Thiobarbituric acid (TBA) (0.14 mg malonealdehyde/Kg meat) in treatment T_8 (125µL AITC/kg of meat + 0.45 g HP/kg of meat) as compared with T_1 control treatment has significant increase (0.7 mg malonealdehyde/Kg meat) in 1 day period, Significant differences were observed between the treatments and for different storage periods.

From the same table, there is a decrease in the value of TBA in treatment T_8 (125µL AITC/kg of meat + 0.45 g HP/kg of meat) compared with all treatments and for all storage periods 1, 5, 10, 15 and 20 days, respectively, which has recorded 0.14, 0.6, 0.91, 1.28 and 1.56 mg malonealdehyde/Kg meat, respectively. Followed by T_7 (125µL AITC/kg of meat + 0.3 g HP/kg of meat). Which

Table 5: The effect of the interaction between different treatments and the period of storage by refrigerating in pH value of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	5.53 ± 0.03^{S}	5.69 ± 0.01^{MNNOL}	5.76 ± 0.13^{NOLMP}	5.83 ± 0.02^{GKHILJM}	$5.89 \pm 0.01^{GKHFIDLJE}$
T_2	5.62 ± 0.03^{RSQ}	5.74 ± 0.04^{NOQMP}	5.78 ± 0.02^{KNOLJMP}	5.84 ± 0.04^{GKHFILJM}	5.94 ± 0.01^{HIG}
T_3	5.68 ± 0.03^{ROQP}	5.79 ± 0.01^{KNIOLJMP}	5.82 ± 0.05^{GKHNILJM}	$5.89 \pm 0.03^{GKHFIDLJE}$	5.97 ± 0.03^{GCHFDBE}
T_4	5.73 ± 0.07^{NOQMP}	$5.86 \pm 0.03^{GKHFIDLJME}$	$5.88 \pm 0.03^{GKHFIDLJE}$	5.92 ± 0.02^{GCHFIDBE}	6.05 ± 0.04^{AB}
T_5	5.57 ± 0.01^{RS}	5.73 ± 0.02^{NOQMP}	5.77 ± 0.02^{KNOLMP}	$5.85 \pm 0.01^{GKHFILJME}$	5.94 ± 0.07^{GCHFDBE}
T_6	5.66 ± 0.02^{RQP}	5.76 ± 0.02^{NOLMP}	5.81 ± 0.02^{GKHFIDJE}	5.90 ± 0.05^{MNOKL}	5.98 ± 0.02^{CADBE}
T_7	5.74 ± 0.05^{NOQMP}	$5.88 \pm 0.05^{GKHFIDLJE}$	5.91 ± 0.05^{GCHFIDJE}	5.93 ± 0.02^{GCHFDBE}	6.04 ± 0^{CAB}
T_8	5.77 ± 0.05^{KNOLMP}	5.71 ± 0.01^{GCHFDBE}	5.95 ± 0.02^{GCFDBE}	5.99 ± 0.01^{CADB}	6.1 ± 0.03^{A}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP),T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

Table 6: The effect of the interaction between different treatments and the period of storage by refrigerating in thiobarbituric acid values of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	0.70 ± 0.05^{PQ}	1.82 ± 0.08^{RS}	2.07 ± 0.03^{D}	2.8 ± 0.05^{B}	3.16 ± 0.05^{A}
T_2	0.46 ± 0.03^{RS}	1.33 ± 0.08^{MJLK}	1.4 ± 0.1^{IJK}	1.77 ± 0.15^{FGE}	2.09 ± 0.15^{D}
T_3	0.35 ± 0.05^{TS}	1.16 ± 0.10^{MNL}	1.3 ± 0.12^{MLK}	1.64 ± 0.1^{GH}	1.88 ± 0.05^{FDE}
T_4	0.24 ± 0.03^{T}	0.89 ± 0.05^{PO}	1.16 ± 0.05^{MNL}	1.38 ± 0.03^{IGLK}	1.68 ± 0.05^{FGH}
T_5	0.47 ± 0.04^{FGE}	1.6 ± 0.05^{IGH}	1.81 ± 0.07^{FGE}	1.95 ± 0.05^{DE}	2.32 ± 0.07^{C}
T_6	0.24 ± 0^{T}	1.04 ± 0.07^{NO}	1.37 ± 0.02^{IJLK}	1.53 ± 0.033^{IJH}	1.8 ± 0.04^{FGE}
T_7	0.18 ± 0^{T}	0.93 ± 0.05^{O}	1.11 ± 0.06^{MNO}	1.29 ± 0.03^{MLK}	1.6 ± 0.08^{IGH}
T_8	0.14 ± 0.01^{T}	0.6 ± 0.08^{RQ}	0.91 ± 0.06^{PO}	1.28 ± 0.13^{MLK}	1.56 ± 0.1^{IGH}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP), T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

recorded 0.18, 0.93, 1.11, 1.29 and 1.6 mg malonealdehyde/Kg meat, respectively, for the same periods described above, The highest TBA values were recorded in the control treatment T_1 and for all the above mentioned storage periods as 0.70, 1.82, 2.07, 2.8 and 3.16 mg malonealdehyde/Kg meat respectively. This is consistent with the results of Falowo *et al.,* (2017) which indicated a decrease in TBA value by increasing the concentration of additives when studying the antioxidant effect of Moringa oleifera and Bidens pilosa leaf extract on the physical and chemical properties of minced beef and cold storage for 6 days at 4^0C. which is one of the by-products of oxidation of fats in meat and meat products due to the breakdown of peroxides. The gradual rise in the value of TBA during periods of cold storage of meat is normal as a result of oxidative processes and the production of free radicals and ROS and peroxides etc. (Amaral *et al.,* 2018; Maqsood *et al.,* 2015). The addition of HP to meat reduced the value of TBA at the progresses storage. The HP's ability to suppress free radicals and compounds from lipid oxidation and HP. It has two asymmetric carbon atoms in place (3, 3') with the hydroxyl group (HO^-) of HP which reacts with fatty acids. (Ambati *et al.,* 2014).

The mixing of HP with ally iso-thiocyanate has delayed the process of fat oxidation further AITC is one of the phenolic compounds, and there is many studies explained the phenolic compounds were extract from different plant sources lead to important and essential role in prevent oxidative because it protect the protein from decomposition bacterial and oxidative (Delaquis *et al.,* 1999; Brewer, 2003). The decrease in acid values in HP treatments may be due to its antioxidant properties (Yamashita, 2013). It is also highly effective for removing free radicals by possessing a methyl group along the pol in chain of the ring which helps break the chain of oxidation reaction due to the ability of these substances to give a hydrogen atom to a fatty acid (Liu, 2018; Pogorzelska *et al.,* 2018). The addition of natural antioxidants reduces the concentration of malone aldehyde

Table 7: The effect of the interaction between different treatments and the period of storage by refrigerating in Water Holding Capacity WHC of fresh ground beef meat (mean ± SE):

Treatments	Period of cold storage/day				
	1	5	10	15	20
T_1	40.72 ± 0.27^{F}	37.29 ± 0.23^{L}	33.53 ± 0.07^{S}	29.85 ± 0.03^{SW}	27.5 ± 0.1^{X}
T_2	42.20 ± 0.01^{D}	39.35 ± 0.01^{I}	37.15 ± 0.07^{L}	33.31 ± 0.1^{S}	31.91 ± 0.16^{U}
T_3	42.80 ± 0.11^{C}	39.80 ± 0.07^{H}	37.97 ± 0.07^{K}	34.49 ± 0.03^{Q}	32.56 ± 0.04^{T}
T_4	42.99 ± 0.23^{C}	40.81 ± 0.11^{F}	38.08 ± 0.03^{K}	36.21 ± 0.06^{O}	33.73 ± 0.13^{RS}
T_5	41.8 ± 0.23^{DE}	38.97 ± 0.21^{IJ}	36.66 ± 0.28^{MN}	34.02 ± 0.13^{R}	30.32 ± 0.21^{V}
T_6	43.23 ± 0.02^{C}	41.57 ± 0.2^{E}	38.84 ± 0.13^{J}	36.13 ± 0.06^{O}	35.15 ± 0.25^{P}
T_7	43.81 ± 0.20^{B}	43.02 ± 0.10^{C}	39.04 ± 0.1^{IJ}	36.86 ± 0.25^{LM}	35.22 ± 0.12^{P}
T_8	45.16 ± 0.06^{A}	44.01 ± 0.03^{B}	40.27 ± 0.02^{G}	37.09 ± 0.12^{L}	36.41 ± 0.19^{NO}

The averages that carries different letters are significantly different (P>0.5) among them.

T_1 (Control),T_2(0.15 g/kg of HP), T_3(0.30 g/kg of HP), T_4(0.45 g/kg of HP), T_5(125/ µL/kg AITC), T_6(125/ µL/ kg AITC + 0.15 g of HP), T_7(125/ µL/kg AITC + 0.3 g/kg of HP), T_8(125/ µL/kg AITC + 0.45 g/kg of HP).

in fats chilled beef at 4°C for 11 days (Cando *et al.,* 2014). This is consistent with the results of AL-Rubeii et al (2009), Muhammad & AL-Rubeii (2018). The US specification indicates that the maximum permissible of thiobarbituric acid values are 2 mg malone dialdehyde / kg flesh proposed for quality (FSIS, 2000).

Water Holding Capacity WHC

Table 7 shows the effect of the interaction between the treatments and the different storage periods in WHC percentage of ground fresh beef, significant treatment T8 (P <0.05) (125µL / kg AITC + 0.45 g / kg of HP) was recorded the highest WHC percentage (45.16%) in the period 1 day compared with control treatment T_1, which recorded the lowest significant difference (0.05 P <) (27.5%) In the 20-day period, in the same table, there were significant differences between the treatments for different storage periods. This is due to the ability of the active compounds added with the treatments to protect meat proteins from oxidation and decomposition Soltanizadeh *et al.,* (2014) confirmed that natural additives protect protein and improve WHC with increase the concentration of natural additives. Viuda-Martos et al (2015) also pointed out that the reason for the rise in WHC% is that these compounds contributed to raising the pH of treated meat, which increased WHC. This is consistent with the results of Muhammad & Al-Rubeii (2018).

Conclusion

From the results obtained from this study we can conclude that the addition of HP and AITC to ground fresh beef which chilled stored resulted in increased moisture, protein and fat percent and led to a significant improvement in pH meat WHC percent for ground beef and decreased oxidation indicators TBA.

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