Global Veterinaria 14 (3): 297-303, 2015
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2015.14.03.9380

Application of Hazard Analysis and Critical Control Point (HACCP) in Egyptian Slaughter Houses to Obtain High Quality Meat

[1]*Ebeed, A. Saleh*, [2]*Sobhy. El-Shehemy*, [3]*Mousa A. Ayoub*, [4]*Safaa, H. Ghorbal and* [4]*A.K.A. Hozyen*

[1]Department of Food Hygiene, Faculty of Veterinary Medicine, Damanhour University, Egypt
[2]Food Technology Researches City, Borge El-Arab, Egypt
[3]Department of Animal Hygiene and Zoonoses,
Faculty of Veterinary Medicine, Damanhour University, Egypt
[4]General Authority of Veterinary Services Ministry of Agriculture

Abstract: The current study aimed to determine the effect of application of the hazard analysis and critical control point (HACCP) system on the quality of fresh meat slaughtered in Egyptian abattoirs especially on counts and incidence of some indicator microorganisms and isolation of pathogenic ones. It was achieved through sensory evaluation by examination of meat samples for the color, odor and consistency before and after application of the HACCP system. Also, total bacterial count (TBC), total coliforms count (TCC) and total Staphylococcus count before and after application of the HACCP system were performed. A total of 200 samples of beef meat randomly collected (100 samples before application of HACCP and 100 samples after application of HACCP) from different abattoirs located in Behera Province, Egypt. Based on the obtained results in the current study, it was concluded that the application of HACCP system in slaughter houses under Egyptian conditions improved the meat quality through improving the sensory characters of the meat as color, consistency and odor as well as decreasing the number of samples showing bacterial contamination that was indicated by decreasing the levels of Total Bacterial Counts, *E. coli* counts and Staphylococcal counts. Moreover, it was noticed that the previously mentioned bacterial counts were found to be matched with Egyptian standards of beef meat after application of HACCP.

Key words: HACCP · Meat abattoir · Sensory evaluation and Microbiological examination

INTRODUCTION

The primary purpose of meat hygiene practice is to prevent disease transmission to man and to provide a safe wholesome meat for his consumption especially after the meat is considered as an essential food and a kind of high quality animal protein [1, 2]. Hazard Analysis and Critical Control Point (HACCP) is a system which attempts to guarantee food safety and harmlessness, it ensures the protection of products and the correction of failures which decrease the costs for quality defects and practically eliminates the need for a final super control. The beef carcass surface are readily subjected to various sources of contamination mainly, hides, dust, water, stomach, intestinal or any inedible materials derived in the abattoir, in addition to, hands and clothes of the workers [3]. Live animal itself passes with long way from its farm until reach to consumer in form of meat. So, the meat may constitute a public health hazard either due to the presence of spoilage microorganisms responsible for objectionable changes or specific pathogens leading to infection and intoxication [4, 5]. Increased consumer awareness and concern about microbial foodborne diseases has resulted in intensified efforts to reduce contamination of raw meat, as evidenced by new meat and poultry inspection regulations being implemented in the United States. In addition to requiring operation of meat and poultry slaughtering and processing plants under the principles of the hazard analysis critical control point (HACCP) system, the new regulations have established microbiological testing criteria for *Escherichia coli* and *Salmonella spp*, as a means of evaluating plant

Corresponding Author: Mousa A. Ayoub, Department of Animal Hygiene and Zoonoses, Faculty of Veterinary Medicine, Damanhour University, Damanhour city, Behera, Egypt. E-mail: mousa.vet2007@yahoo.com.

performance [6]. Contamination of the meat surface with different organisms plays an important role in grading and classification of the meat in the world market [7]. The seven principles of HACCP system are analyze the hazards, determine critical control points, establish limits for critical control points, establish monitoring procedures for critical control points, establish corrective actions, establish verification procedures [8] and establish a record system [9]. The applications of HACCP in slaughter house includes, observations and examinations of sources of contamination of meat [10], Bacterial populations on carcasses surfaces [1] and finally, applications of HACCP principals in slaughter houses [9]. So, the aims of the current study was to determine the effect of application of the hazard analysis and critical control point (HACCP) system on the quality of fresh meat slaughtered in Egyptian abattoirs especially on counts and incidence of some indicator microorganisms and isolation of pathogenic ones. It was achieved through sensory evaluation by examination of meat samples for the color, odor and consistency before and after application of the HACCP system. Also, total bacterial count (TBC), total coliforms count (TCC) and total Staphylococcus count before and after application of the HACCP system were performed.

MATERIALS AND METHODS

Collection of Samples: It was done according to ISO, [11]. Samples were obtained from the side surface of 200 meat samples randomly collected from different abattoirs located in Behera Province (100 samples before application of the HACCP and 100 samples after application of the samples). They were collected from the different parts of the beef carcass (chest, neck, abdomen and shoulder) and the weight of each sample was about 250 g. The samples were placed separately in clean sterile plastic bags and transferred with insulated ice chambers with a minimum of delay to the laboratory of Food Hygiene Department, Faculty of Veterinary Medicine, Alexandria University. All samples were subjected to microbiological examination to ensure that the samples were apparently fit for human consumption.

Sensory Evaluation: It was done according to Wilson [12]. Samples were cut longitudinally and obliquely to reveal a maximum area for judging the inside color, odor and consistency. A group of 5 experienced veterinarians constituted the team of sensory evaluation to evaluate the quality of the meat samples concerning color, odor and consistency. Consumer considers the color of meat as an indicator of meat quality and freshness and often discriminates against discolored meat products. Thus any deterious effects on color attributes lead to negative economic impact [13].

Preparation of Samples and Microbiological Examination: Tenfold serial dilution was used for counting of microorganism. under complete aseptic condition, 5 g of each collected sample were transferred into a sterile homogenizer flask containing 45 ml of 0.1 % sterile peptone water, the contents were homogenized for 2 – 4 minutes at 14000 rpm and then stand for about 5 minutes at room temperature that to make the first serial dilution 10^{-1}. The contents of the flask were thoroughly mixed by shaking then 1 ml was transferred into a separate sterile tube containing 9 ml 0.1 % sterile peptone water to make the 2nd dilution 10^{-2} and so on to the dilution of 10^{-6}. Then total bacterial count, total coliforms count, total Staphylococcal count were carried out according to ISO, [11].

Statistical Analysis: Statistical analysis using analysis of variance (ANOVA) and Chi^2 was conducted using SAS software for determination the differences among sensory characters of the samples and among incidences of different bacterial isolates among different organs that the samples taken from it before and after the HACCP program applications [14].

RESULTS AND DISCUSSION

Sensory Evaluation: Consumers consider the color of meat as an indicator of meat quality and freshness and often discriminate against discolored meat products. Thus any deterioration affecting color attributes lead to negative economic impact [15]. Color is the most important sensory properties of the product because it strongly influence the consumers purchase decision. The tabulated data in Table (1) summarized the sensory evaluation of examined meat samples before and after the application of HACCP. Firstly, it was observed that 4 out of 100 meat samples collected before the application of HACCP showed abnormal color (4 %), while, there was no meat samples showed abnormal color among samples collected after the application of HACCP. This may be due to the fact that HACCP program steps decreased the contamination of the meat with deferent microorganisms, moreover good slaughtering steps (slaughtering, washing, cleaning, transportation and storage) and

Table 1: Sensory evaluation of samples of beef meat (n= 200)

	Before application of HACCP System				After application of HACCP System			
	Normal		Abnormal		Normal		Abnormal	
Organoleptic properties	No	%	No	%	No	%	No	%
Color	96	96	4	4	100	100	0	0
Odor	94	94	6	6	100	100	0	0
Consistency	96	96	4	4	100	100	0	0

$Chi^2 = 6.24^*$ *= Significant at ($P < 0.05$)

Table 2: Statistical analytical results of total bacterial count cfu/g of examined beef meat samples in relation to different parts of the carcass before and after application of HACCP System

	Before application of HACCP System			After application of HACCP System				
Parts of the Carcass	No.	+ve	Mean ± S.E.M	No	+ve	Mean ± S.E.M	Decreasing level of bacteria	EOS
Neck	25	10	$9.98 \times 10^6 \pm 1.14 \times 10^5$	25	5	$1.55 \times 10^3 \pm 0.14 \times 10^2$	8.43×10^3	1.60×10^3
Shoulder	25	13	$9.11 \times 10^6 \pm 1.15 \times 10^5$	25	8	$2.10 \times 10^2 \pm 0.15 \times 10^2$	7.01×10^4	1.70×10^3
Chest	25	12	$4.11 \times 10^6 \pm 1.11 \times 10^4$	25	7	$1.10 \times 10^2 \pm 0.11 \times 10^2$	3.01×10^4	1.20×10^3
Abdomen	25	15	$9.56 \times 10^8 \pm 1.17 \times 10^5$	25	10	$2.55 \times 10^3 \pm 1.11 \times 10^2$	7.01×10^5	1.90×10^3

Means within the same column of different litters are significantly different at ($P < 0.05$).

S.E.M = Standard error of mean. ** = Significant at ($P < 0.01$)

discarding of the abnormal meat products, storage time and temperature have a great effect on color stability [16]. Secondly, it was recorded in Table (1) that 6 out of 100 meat samples collected before the application of HACCP showed defects in meat odor (6 %), while, there was no meat samples showed abnormal odor among samples collected after the application of HACCP. The different odor smelt may be grouped under two main categories, acceptable, fleshy odor and unacceptable fermented, putrefied and fecal odors [17]. The flavor and a normal meat very widely differ according to types of lipids, atmospheric contamination, type of food, the variety of medical used, cold storage refrigeration period and sanitary condition under which the meat is prepared and stored [18]. The consistency of meat is a quality character not only depending on kind and age of animals, but also on meat, which directly affects meat quality and tenderness but it is mainly affected by the percentages of fat, moisture, connective tissue and texture [19]. Finally, data recorded in Table (1) showed that, 96 % of exmined samples were normal in consistency and 4 % of examined meat were tough and of abnormal consistency. There is a large amount of variation within and among muscles for tenderness traits which in turn increase our understanding of source of variation in tenderness in different muscles and provide basis for development of muscle specific strategies for improving the quality and value of muscle [20]. Muscle tenderness depends on quality grade and aging time. The postmortem aging should be managed with respect to individual muscle. The content, composition and quality of meat depend upon, sex and nutrition status [10]. So application n of the HACCP procedures improves the meat quality and consistency of the meat.

Microbiological Evaluation: Total bacterial count is used as an important index for the level of sanitation and hygienic quality of meat [21]. The obtained results in Table (2) clarified that the total bacterial count before application of the HACCP program was of a higher level in abdomen region carrying mean value $9.56 \times 10^8 \pm 1.17 \times 10^5$ of beef carcasses surfaces, while after application of the HACCP program the bacterial level in abdominal region decreased to a mean value of $2.55 \times 10^3 \pm 1.11 \times 10^2$. While in neck region, the mean value was $9.98 \times 10^6 \pm 1.14 \times 10^5$ and after application of the HACCP program its mean value was $1.55 \times 10^3 \pm 0.14 \times 10^2$. In shoulder region, the mean value was $9.11 \times 106 \pm 1.15 \times 10^5$ and $2.10 \times 10^2 \pm 0.15 \times 10^2$ while after application of the HACCP program its level ranged from 0.50×10^2 to 3.20×10^3 with a mean value of $2.10 \times 10^2 \pm 0.15 \times 10^2$. But the lower level of total bacterial counts before application of the HACCP program observed in chest region before application of the HACCP program it ranged from 0.50×10^5 to 3.20×10^7 with a mean value of $4.11 \times 10^6 \pm 1.11 \times 10^4$ and after application of the HACCP program the total bacterial count ranged from $0.60 \times 10^{2\text{ to}}$ 2.00×10^3 with a mean value of $1.10 \times 10^2 \pm 0.11 \times 10^2$. These results showed an increasing level of total aerobic bacteria count in beef cattle carcasses surfaces that can be attributed to the

Table 3: Statistical analytical results of total coliforms count cfu/g of examined beef meat samples in relation to different parts of the carcass before and after application of HACCP System

Parts of the Carcass	Before application of HACCP System No.	+ve	Mean ± S.E.M	After application of HACCP System No	+ve	Mean ± S.E.M	Decreasing level of bacteria	EOS
Neck	25	7	$3.40 \times 10^3 \pm 2.66 \times 10^2$	25	4	$2.40 \times 10^3 \pm 1.66 \times 10$	1.00×10	1.50×10
Shoulder	25	10	$3.58 \times 10^3 \pm 2.34 \times 10^2$	25	5	$2.55 \times 10^2 \pm 1.33 \times 10$	1.03×10	1.50×10
Chest	25	9	$2.58 \times 10^3 \pm 1.33 \times 10^2$	25	5	$2.54 \times 10^2 \pm 1.34 \times 10$	2.04×10	1.60×10
Abdomen	25	12	$4.30 \times 10^4 \pm 3.66 \times 10^2$	25	8	$3.30 \times 10^3 \pm 1.66 \times 10$	1×10	1.95×10

Means within the same column of different litters are significantly different at ($P < 0.05$).
S.E.M = Standard error of mean. ** = Significant at ($P < 0.01$)

different sources contamination especially the hides of animals [22] or pollution in the abattoirs from atmosphere [23] or visceral contents [24]. Also, the hands of meat handlers are considered as an important source of contamination, such as slaughter persons and butchers during cutting of meat may increase the bacterial load of meat [15]. The tabulated data in Table (2) also clarified that the decreasing level of total bacterial count after application of the HACCP program reached to 1.60×10^3, 1.70×10^3, 1.20×10^3 and 1.90×10^3 for the samples collected from neck, shoulder, chest and abdomen, respectively and these results were nearly similar to the bacterial counts of EOS.

The detection of coliforms is known as index for fecal contamination. Enterococci can induce undesirable changes in meat and meat products and when found in large numbers may be implicated in cases of food poisoning [25]. Table (3) showed that the total coliforms counts CFU / g of beef carcasses surfaces differ significantly among different parts of the carcass ($P<0.05$). the obtained results clarified that the total coliforms count before application of the HACCP program was of a higher level in abdomen region as its mean value $4.30 \times 10^4 \pm 3.66 \times 10^2$ CFU/g of cattle carcasses surfaces. While, after application of the HACCP program the bacterial level in abdominal region decreased to a mean value of $3.30 \times 10^3 \pm 1.66 \times 10$. In shoulder region, the mean value was $3.40 \times 10^4 \pm 2.66 \times 10^2$, while after application of the HACCP program its level decreased to a mean value of $2.40 \times 10^3 \pm 1.66 \times 10$. While, in neck region its level had a mean value of $3.40 \times 10^3 \pm 2.66 \times 10^2$, while, after application of the HACCP program its level decreased to a mean value of $2.40 \times 10^3 \pm 1.66 \times 10$. The lower level of total coliforms count observed in chest region as its level before application of the HACCP program was of a mean value of $2.58 \times 10^3 \pm 1.33 \times 10^2$ and after application of the HACCP program the mean value of total coliforms count was $2.54 \times 10^2 \pm 1.34 \times 10$. These results cleared that the beef cattle meat showed more coliforms count CFU / g on abdomen, neck, shoulder and chest. These results may be attributed to after evisceration which clearly added coliforms through opening the way of contamination by intestinal content and rumen especially with presence of evisceration faults at trunk, also the presence of digestive outlet added to coliforms load of hind quarter beside that un skinned tail in cattle until evisceration added to coliforms count in trunk and hind quarter by carrying of fecal matter. These results agreed with Nozha *et al.* [26] who evaluated the bacteriological quality of beef meat, offals and their results indicated that the counts of the aerobic plate counts and fecal coliforms were particularly high in all the analyzed samples, that may be attributed to the unsanitary conditions of offals collection after evisceration process through putting these offals on the floor between the fecal matter which the major source of contamination by coliforms beside delayed transportation of offals to special hygienic place leading to the same result. In addition, results recorded in Table (3) cleared that the number of samples showing contamination with coliforms decreased by a percentage of 42.86, 50, 44.45 and 33.34 % for the samples taken from neck, shoulder, chest and abdomen, respectively. While, the decreasing level of coliform counts in meat after application of the HACCP program reached to 1.00×10, $1.0^3 \times 10$, 2.04×10 and 1×10 for neck, shoulder, chest and abdomen, respectively and these results were nearly similar to the bacterial counts of EOS.

Staphylococci are commonly found on the skin and in the upper respiratory tract of man and animals and can easily contaminated the carcasses. The presence of *Staphylococcus aureus* on carcass surface may be due to contamination during dressing and evisceration in slaughter house, contaminated equipment, butcher's hand with abrasions and wounds, slaughter of animal beside dressed one in the same area in the slaughter hall, contaminated air from over crowdness of workers and their aerosols which contaminated air with *Staph. aureus* during slaughtering so some contamination of carcasses with *Staph. aureus* could be expected [27, 28]. The presented data in Table (4) showed that the

Table 4: Statistical analytical results of total Staphylococcal counts cfu/g of examined beef meat samples in relation to different parts of the carcass before and after application of HACCP System

	Before application of HACCP System			After application of HACCP System				
Parts of the Carcass	No.	+ve	Mean ± S.E.M	No	+ve	Mean ± S.E.M	Decreasing level of bacteria	EOS
Neck	25	5	$1.80 \times 10^3 \pm 0.66 \times 10^2$	25	3	$0.55 \times 10^2 \pm 0.03 \times 10$	1.25×10	1.00×10
Shoulder	25	6	$1.03 \times 10^3 \pm 0.34 \times 10^2$	25	4	$1.00 \times 10^2 \pm 0.34 \times 10$	0.03×10^2	1.00×10
Chest	25	5	$0.58 \times 10^3 \pm 0.33 \times 10^2$	25	3	$0.55 \times 10^2 \pm 0.02 \times 10$	0.03×10^2	0.50×10
Abdomen	25	8	$4.30 \times 10^3 \pm 0.66 \times 10^2$	25	5	$3.30 \times 10^2 \pm 1.66 \times 10$	1×10	3.00×10

Means within the same column of different litters are significantly different at ($P < 0.05$).

S.E.M = Standard error of mean. ** = Significant at ($P < 0.01$)

staphylococcal counts CFU / g of beef carcasses surfaces differ significantly among different parts of the carcass ($P<0.05$). The obtained results cleared that the Staphylococcal counts before application of the HACCP program were of a higher level in abdomen region with a mean value of $4.30 \times 10^3 \pm 0.66 \times 10^2$ CFU / g of cattle carcasses surfaces. While, after application of the HACCP program the mean value in abdominal region was $3.30 \times 10^2 \pm 1.66 \times 10$. In neck region, the mean value of the staphylococcal count was $1.80 \times 10^2 \pm 0.66 \times 10$ while after application of the HACCP program its mean value decreased to $0.55 \times 10^2 \pm 0.03 \times 10$. In shoulder region before application of the HACCP program, the mean value was $1.03 \times 10^3 \pm 0.34 \times 10^2$ and after application of the HACCP program the mean value of the total staphylococcal count was $1.00 \times 10 \pm 0.34 \times 10$. The lower level of the total staphylococcal count was observed in chest region before application of the HACCP program with a mean value of $0.58 \times 10^3 \pm 0.33 \times 10^2$ while after application of the HACCP program its mean value was $0.55 \times 10 \pm 0.02 \times 10$. It was clear that by application of the HACCP program there is a decrease in the number of *Staphylococci* of either the samples contained *Staph. aureus* or the number of staphylococci in the samples examined. Results found in Table (4) also clarified that the number of samples showing contamination with *Staphylococcus* decreased by a percentage of 40, 33.34, 40 and 37.55 % for the samples that were taken from neck, shoulder, chest and abdomen, respectively. While the decreasing level of Staphylococcal count in meat after application of the HACCP program reached 1.25×10, 0.03×10^2, 0.03×10^2 and 1×10 for neck, shoulder, chest and abdomen, respectively. These results were nearly similar to the bacterial counts of EOS 1.00×10, 1.00×10, 0.50×10 and 3.00×10 for neck, shoulder chest and abdomen, respectively.

CONCLUSION

In the present work, the microbiological examination revealed the presence of high microbial counts on the surfaces of beef during slaughtering, skinning and evisceration process which have a clear influence in increasing the microbial load on carcasses surfaces. In order to ensure a maximum safety and lowering the carcasses contamination, the following recommendations are suggested through application of the HACCP control program through application of the following steps; including abattoirs should be of high sanitation level, periodical cleaning and disinfection of the abattoir, abattoirs should be closed at regular intervals to provide enough time for sanitation and preventing cross contamination between carcasses, campaigns hygiene education for all persons handling meat from point of slaughtering until selling of meat, application of mechanical technique in slaughtering to minimize human intervention, carcasses should be washed in the abattoirs with running water under pressure to reduce surface contamination, stomach and intestine and all inedible materials derived from the slaughtering and dressing of animals should be removed as soon as possible to avoid the contamination of the abattoirs floor or walls or carcasses surfaces and periodical checkup for all persons and meat handlers and must be have health certificates to avoid contamination of meat.

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