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### The Influence Of The Halal Concept On The Microbiological Correctness Of Meat And Meat Products

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#### ABSTRACT

##### **Keywords:**

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Halal food is permissible food for Muslims. Whether something will be halal largely depends on the primary production process as well as processing, which must be in accordance with halal standards. Production chains must have a halal certificate, and final products must be marked with the halal logo. Halal food safety criteria are largely in line with the health criteria of the HACCP concept. Therefore, the aim of this paper was to examine the microbiological status of meat and meat products in establishments with implemented Halal and HACCP concept and to compare them with establishments that are not certified, i.e. in which the specified control concepts are not implemented. For this purpose, a total of 600 (300+300) samples of meat and meat products from two production chains were analyzed in accordance with international and national standards. The largest number of positive samples came from facilities without an implemented Halal concept with a total number of aerobic mesophilic bacteria (21/300, 7%), *Listeria monocytogenes* (6/300, 2%), *Escherichia coli* (17/300, 5.66%), *Staphylococcus aureus* (16/300, 5.33%), while *Salmonella* and *Clostridium* were not isolated. The application of Halal criteria for food in combination with the HACCP concept contributes to better microbiological correctness of products in the Halal meat industry.

#### INTRODUCTION

According to Islamic law, the food eaten by Muslims must be Halal (permissible/lawful), and it bears the label "Tayyib", which means that Halal food must be correct, of good quality and safe (Najmi et al. 2023; Wilson 2014). Muslims are allowed to consume only halal food. Some

foods are completely prohibited. The opposite of halal is non-halal or haram (forbidden) food. For Muslims, the animals that are forbidden to eat are pork, corpses, blood, blood products, carnivores, birds of prey, reptiles, insects, etc. Islamic messages apply to all countries of the Islamic world (Annisa et al. 2023; Beik et al. 2021). Halal and tayyib meat is a guarantee for Muslims that halal food meets the halal food

criteria for food: that it does not contain parts or substances taken or extracted from animals that are prohibited for consumption by Muslims, that it does not contain substances declared as impurities, that halal food is not prepared, processed, produced using utensils, equipment and/or machines containing impure substances according to Islamic laws, and that during preparation, processing or storage it did not come into contact with haram food and haram products (Aghwan 2018; Bujang et al. 2018).

Halal requirements are based on Islamic law/Sharia, and all regulations are found in the Holy Quran. Every aspect of the food chain (from farm to table) must comply with halal requirements, including procurement, processing and serving of food (Rusydiana et al. 2023). Whether certain food will be halal or haram, produced in different food industries, also depends on the production method followed in the production chain, which is defined by halal standards. The problem with halal standards is that they are not consistent in all countries of the Islamic world (Demirci et al. 2016). Meat production has the most requirements that must be respected in accordance with Islamic laws. Halal requirements are largely universal in all Islamic countries when it comes to animal welfare. Animals must be treated as humanely as possible during housing, transport and slaughter (Aini et al. 2022). Also, halal meat industries must have a halal certificate, which is a guarantee for a halal product (Wannasupchue et al. 2023).

Halal meat is defined as meat obtained from the slaughter of a halal animal and processed in accordance with Islamic dietary criteria for food (Hadith no. 668 of Sahih Bukhari, ed. 3, book 44). Taking halal is Allah's command and the basic practice of all Muslims (Alzeer et al. 2018). However, the Holy Qur'an addresses all people regardless of religion, not only Muslims, to seek halal food, because it is for their benefit, because the Islamic criteria for food includes both the hygienic (health) aspect of food safety and medicinal properties (Baharuddin et al. 2015). The Halal industry is one of the fastest growing industries in the world. The main factor driving the halal industry is the high demand from Muslim consumers and the community for halal food. According to Abdullah et al. (2021) what Muslim consumers want is halal food that is made according to halal requirements in accordance with the Shariah and that is healthy. The primary concept of halal (permissible), that

is, food that Muslims can consume in accordance with Islamic laws, is zero tolerance for non-halal products (forbidden) along the entire food chain (Lestari et al. 2023). There is a noticeable demand for halal food among non-Muslims who recognize the quality of halal products (Ambali & Bakar 2014). According to Sthapit et al. (2023) non-Muslims see the motives for consuming halal food in the quality and hygienic-health correctness of halal food. According to Abdullah et al. (2021) the combination of hygiene and health principles of the HACCP concept in the production of halal food contributes to better quality and safety of halal products. Critical points in the production of halal meat can be determined in accordance with the health principles of the HACCP concept in order to improve the quality and safety of halal food. Therefore, the aim of this work was to examine the microbiological integrity of meat and meat products in establishments with implemented Halal and HACCP concept and establishments that are not certified, in order to find the connection between halal food criteria, halal certification and the HACCP concept, which contributes to greater safety and health correctness of halal meat and meat products.

## **MATERIAL AND METHODS**

### **Research area**

Samples of meat and meat products were collected from two production chains located on the territory of Bosnia and Herzegovina, from processing units (slaughterhouse/meat processing), certified according to Quality management systems – Requirements BAS EN ISO 9001:2017 (ISO 9001 2017) and Environmental Management Systems – Requirements with instructions for use of BAS EN ISO 14001:2017 (ISO 14001 2017) and national Bosnian halal standards Halal food - requirements and measures BAS 1049:2010 and HACCP requirements for food quality and safety management facility "A", as well as those that are not certified/registered facility "B". Microbiological analysis was carried out in the Laboratory for microbiological testing of food products, animal feed and items of general use of the Veterinary Faculty, University of Sarajevo, according to BAS EN ISO 112901/A:2005 (ISO 112901 2002).

### **Samples of meat and meat products**

The research collected a total of 600 (300+300) different samples of meat and meat products: prepared meat (n=100; 50+50), minced meat (n=100; 50+50), chopped, shaped meat (kebabs, hamburgers and fig.) (n=100; 50+50), sausages (Bosnian sudžuk) (n=100; 50+50), smoked products-semi-permanent (smoked beef) (n=100; 50+50), dried meat products-permanent (beef prosciutto) (n=100; 50+50). Therefore, the sampling was carried out in such a way that 300 samples of meat and meat products were taken in facility "A". Then the same sampling procedure of 300 samples was repeated in facility "B". The samples were appropriately labeled and stored under vacuum in sterile bags at a temperature of 4°C with variations of  $\pm 2^{\circ}\text{C}$  and delivered to the laboratory for further analysis.

### Methods for determining the number of bacteria

Preparation of samples for microbiological analysis was done in accordance with Preparation of test samples, initial suspensions and decimal dilutions for microbiological tests - Part 1: General rules for the preparation of initial suspensions and decimal dilutions BAS EN ISO 6887-1:2005 and 6887-3:2005 (ISO 6887 2005). All microbiological analyzes were performed according to the methods of the BAS EN ISO standard: Microbiology of the food chain – Horizontal method for the detection and enumeration of *Listeria monocytogenes* and of *Listeria* spp. – Part 1: Detection method BAS EN ISO 11290-1:2018 (ISO 11290-1 2018); Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of *Salmonella* – Part 1: Detection of *Salmonella* spp. – Amendment 1 Broader range of incubation temperatures, amendment to the status of Annex D, and correction of the composition of MSRV and SC BAS EN ISO 6579-1/A1:2022 (ISO 6579-1 2022); Microbiology of food and animal feeding stuffs – Horizontal method for the detection of *Escherichia coli* O157 – Amendment 1: Annex B: Result of interlaboratory studies BAS EN ISO 16654/A1:2018 (ISO 16654-1 2018); Microbiology of the food chain – Horizontal method for the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species) – Part 1: Method using Baird-Parker agar medium BAS ISO 6888-1:2022 (ISO 6888-1 2022); Microbiology of food and

animal feeding stuffs – Horizontal method for the enumeration of sulfite- reducing bacteria growing under anaerobic conditions BAS ISO 15213:2008 (ISO 15213 2008); Microbiology of the food chain – Horizontal method for the detection and enumeration of *Enterobacteriaceae* – Part 2: Colony-count technique BAS EN ISO 21528-2:2018 (ISO 21528-2 2018); Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 1: Colony count at 30 degrees C by the pour plate technique BAS EN ISO 4833-1:2014 (ISO 4833-1 2014).

### RESULTS

The results of research on the presence of *Listeria monocytogenes*, *Salmonella* spp., *Escherichia coli*, *Staphylococcus aureus*, *Enterobacteriaceae*, sulfite-reducing clostridia and the sum of aerobic mesophilic bacteria from samples of meat and meat products in a facility with implemented Halal and HACCP concept (facility "A") and in a facility without Halal and HACCP concepts (facility "B") are shown in Table 1. The largest number of positive samples was in group "B" facilities that did not meet the microbiological criteria with the total number of positive samples for the presence of aerobic mesophilic bacteria (21/300, 7% ), *Listeria monocytogenes* (6/300, 2%), *Escherichia coli* (17/300, 5.66%), *Staphylococcus aureus* (16/300, 5.33%), while *Salmonella* and *Clostridium* bacteria were not isolated. The largest number of positive samples for aerobic mesophilic bacteria was recorded in shredded meat, kebabs, hamburgers and in samples from establishments without implemented Halal and HACCP concepts (16/50, 32%). A greater number of positive samples for *Listeria monocytogenes* were recorded in samples of ready-made meat (2/50, 4%), sausages (Bosnian sudžuk) (2/50, 4%), while a smaller number was recorded in samples of smoked products-semi-permanent (smoked beef meat) (1/50, 2%), dried meat products-permanent (beef prosciutto) (1/50, 2.00%). *Escherichia coli* was detected in all samples of meat and meat products, and the largest number of positive samples was in chopped shaped meat, kebabs, hamburgers in establishments without implemented Halal and HACCP concepts (9/50, 18%). *Staphylococcus aureus* was detected in all samples from establishments without implemented Halal and HACCP concepts, with the exception of one

positive sample of meat from an establishment with implemented Halal and HACCP concepts (1/50, 2%) from chooped shaped meat gabbers, hamburgers and processed meat (Table 1).

PROCESSED MEAT																		
	TESTED BACTERIAL SPECIES																TOTAL NUMBER/SAMPLES	%
	Enterobacteriaceae				Coagulase positive staphylococci				Listeria monocytogenes				Aerobic mesophilic bacteria					
	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%		
FACILITY WITH HALAL/HACCP	48	96	2	4	49	%	1	2	50	100	0	0	50	100	0	0	50	100
FACILITY WITHOUT HALAL/HACCP	43	86	7	14	47	%	3	6	48	96	2	4	45	95	5	10	50	100
MINCED MEAT																		
	TESTED BACTERIAL SPECIES																TOTAL NUMBER/SAMPLES	%
	Escherichia coli				Coagulase positive staphylococci				Listeria monocytogenes				Aerobic mesophilic bacteria					
	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%		
FACILITY WITH HALAL/HACCP	49	98	1	2	50	100	0	0	50	100	0	0	50	100	0	0	50	100
FACILITY WITHOUT HALAL/HACCP	42	84	8	16	47	94	3	6	50	100	0	0	43	86	7	14	50	100
CHOPPED SHAPED MEAT (GABBERS, HAMBURGERS)																		
	TESTED BACTERIAL SPECIES																TOTAL NUMBER/SAMPLES	%
	Escherichia coli				Coagulase positive staphylococci				Listeria monocytogenes				Aerobic mesophilic bacteria					
	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%		
FACILITY WITH HALAL/HACCP	49	98	1	2	49	98	1	2	50	100	0	0	50	100	0	0	50	100
FACILITY WITHOUT HALAL/HACCP	41	82	9	18	46	92	4	8	50	0	0	0	42	84	8	16	50	100
SAUSAGE (BOSNIAN SUZDUK)																		
	TESTED BACTERIAL SPECIES																TOTAL NUMBER/SAMPLES	%
	Enterobacteriaceae				Coagulase positive staphylococci				Listeria monocytogenes				Aerobic mesophilic bacteria					
	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%		
FACILITY WITH HALAL/HACCP	49	98	1	2	50	100	0	0	50	100	0	0	50	100	0	0	50	100
FACILITY WITHOUT HALAL/HACCP	48	96	2	4	47	94	3	6	48	96	2	4	49	98	1	2	50	100
SMOKED PRODUCTS - SEMI-DURABLE (SMOKED BEEF)																		
	TESTED BACTERIAL SPECIES																TOTAL NUMBER/SAMPLES	%
	Enterobacteriaceae				Coagulase positive staphylococci				Listeria monocytogenes				Aerobic mesophilic bacteria					
	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%		
FACILITY WITH HALAL/HACCP	49	98	1	2	50	100	0	0	50	100	0	0	50	100	0	0	50	100
FACILITY WITHOUT HALAL/HACCP	47	94	3	6	48	96	2	4	49	98	1	2	50	100	0	0	50	100
DRY MEAT PRODUCTS - PERMANENT (BEEF PROSCIUT)																		
	TESTED BACTERIAL SPECIES																TOTAL NUMBER/SAMPLES	%
	Enterobacteriaceae				Coagulase positive staphylococci				Listeria monocytogenes				Aerobic mesophilic bacteria					
	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%	NEGATIVE	%	POSITIVE	%		
FACILITY WITH HALAL/HACCP	50	100	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100
FACILITY WITHOUT HALAL/HACCP	50	100	0	0	49	98	1	2	49	98	1	2	50	100	0	100	50	100
Salmonella spp. and Sulfite-reducing clostridia were not detected in the tested samples																		

Table 1. Microbiological integrity of meat and meat products from facilities with and without implemented Halal/HACCP concept (facilities A, B)

## DISCUSSION

The aim of this work was to examine the microbiological correctness of meat products and meat products in establishments with implemented Halal and HACCP concept and in establishments that are not certified, in order to

find the connection between Halal food criteria, Halal certification and the HACCP concept, for the sake of a better understanding of this issue. Products from facility "A" showed a significantly better microbiological status of the final products. Also, it is generally noticeable that fresh meat has a higher presence of bacteria

compared to processed smoked meat. *Listeria monocytogenes* was not detected in any product from the facility with the implemented Halal and HACCP concept, in the products from facility "A". In products originating from facility "A", the number of aerobic mesophilic bacteria corresponded to legal norms and the number of these bacteria is generally lower compared to products from facility "B". *Salmonella* species as well as sulfite-reducing clostridia were not detected in any production plant. The potential of the HACCP concept, which includes *Good Manufacturing Practice* (GPP) and *Good Hygienic Practice* (GHP), has long been recognized in international standards as a good food safety concept. The halal concept related to halal food is not significantly different from the HACCP concept, but the halal food criteria are unknown to many when it comes to the world food market. It is considered that the application of the HACCP concept in the Halal meat industry improves the safety of Halal products and opens the door to the world food market (Abdullah et al. 2021; Demirci et al. 2016). Halal traditional food in Bosnia and Herzegovina can also increase gastronomic tourism. In addition, having a Halal certificate increases the guarantee for a Halal product. According to Žunić & Nezirović (2022), Halal national gastronomy, especially the autochthonous dishes of Bosnia and Herzegovina and Sarajevo, can be an important segment of tourist offer and culture.

Bujang et al. (2018) in their systematic review study, with the help of various literature, studied published articles on the microbiological status of meat and meat products for the presence of indicator microorganisms: *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp. and more important food contaminants *Clostridium* spp., where they came to the conclusions that some elements of tayyib differ from the rules of halal certification that define a halal product. They also state that Halal tayyib meat includes better quality, hygiene and safety of Halal products. Halal must include sanitary procedures as a form of food safety, with a guarantee of halal and tayyib quality (Raheem & Demirci 2018). In a systematic review study on the impact of the HACCP concept on halal food safety, Wahyuni et al. (2019) included a review of 120 articles from 1990 to 2018 to present their findings on Halal food safety, as well as the possibility of developing more rigorous Halal

food safety assurance solutions so that Halal food meets all criteria in the world market. Sani & Dahlan (2015) in their research on Halal food criteria for food produced in Malaysia found that international measures that include the HACCP concept improve the safety of Halal products, which is consistent with our results.

In a study conducted in the United States of America examining the microbiological status of halal beef in two American slaughterhouses, Al-Mahmood et al. (2021) state that out of a total of 432 beef carcass samples (before and after evisceration) and 59 working surfaces were tested for the presence of indicator microorganisms. The number of aerobic bacteria, the number of bacteria from the *Enterobacteriaceae* family, the total and generic number of coliform bacteria-*Escherichia coli* were analyzed and all samples were negative. The number of microorganisms in the carcasses of Halal beef was within the limits allowed in accordance with the microbiological guidelines prescribed by the United States Department of Agriculture (USDA) for food safety, and all of the above supports the excellent microbiological status of Halal beef, which is also our research ready-made Halal meat confirmed.

In another study from the United States, Al-Mahmood (2023) reports on food safety and sanitation practices in small-scale halal and non-halal beef slaughterhouses. Data were collected on hygiene practices in 45 halal slaughterhouses and 51 non-halal slaughterhouses that agreed to participate in the research. Research has shown that international food safety criteria do not differ significantly from criteria for halal food safety. In ensuring hygiene, halal and non-halal slaughterhouses used similar hygiene and sanitation procedures. Halal slaughterhouses most often used a combination of cold and hot water (180°C) and organic acid (31.1%), while non-halal slaughterhouses used only hot water (180°C). In all halal and non-halal slaughterhouses, a microbiological examination of the beef carcass was performed for the presence of indicator pollutants: generic number of *Escherichia coli* (100%). The results of the mentioned survey can be informative, but also applicable in finding ways to improve food safety. The above data also indicate that there are no deficiencies in sanitary practice that would problematize the microbiological status of halal food from the world market.

## CONCLUSION

Based on the obtained results, it can be concluded that products produced in plants with implemented Halal and HACCP concepts are microbiologically more correct than products produced in plants without implemented Halal and HACCP concepts. The application of Halal nutritional criteria for food in combination with the HACCP concept contributes to better microbiological correctness of products in the Halal meat industry.

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## Uticaj halal koncepta na mikrobiološku ispravnost mesa i mesnih prerađevina

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Naučni rad

### PODACI O RADU

### SAŽETAK

#### ***Ključne riječi:***

*halal koncept,  
higijenska ispravnost  
proizvoda,  
mikrobiološka  
sigurnost, legislativa*

Halal hrana je dozvoljena hrana za muslimane. Da li će nešto biti halal u velikoj mjeri zavisi od primarnog procesa proizvodnje kao i prerade što mora biti u skladu sa halal standardima. Proizvodni lanci moraju imati halal certifikat, a finalni proizvodi moraju biti označeni halal logom. Kriterijumi bezbjednosti halal hrane su u velikoj mjeri u skladu sa zdravstvenim kriterijima HACCP koncepta. Stoga je cilj ovog rada bio ispitati mikrobiološki status mesa i mesnih prerađevina u objektima sa implementiranim Halal i HACCP konceptom i uporediti ih sa objektima koji nisu certificirani, tj. u kojima nisu implementirani navedeni koncepti kontrole. U tu svrhu analizirano je ukupno 600 (300+300) uzoraka mesa i mesnih prerađevina iz dva proizvodna lanca u skladu sa međunarodnim i nacionalnim standardima. Najveći broj pozitivnih uzoraka poticao je iz objekata bez implementiranog Halal koncepta sa ukupnim brojem aerobnih mezofilnih bakterija (21/300, 7%), *Listeria monocytogenes* (6/300, 2%), *Escherichia coli* (17/300, 5.66%), *Staphylococcus aureus* (16/300, 5.33%), dok *Salmonella* i *Clostridium* nisu izolovane. Primjena Halal prehrambenih kriterija za hranu u kombinaciji sa HACCP konceptom doprinosi boljoj mikrobiološkoj ispravnosti proizvoda u industriji Halal mesa.