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CRITICAL CONTROL POINTS FOR MEAT BALLS AND KIBBE PREPARATIONS IN A HOSPITAL KITCHEN

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ABSTRACT

Hazards and critical control points (CCP) associated with meat balls and kibbe preparations in a hospital kitchen were determined using flow diagrams and microbiological testing of samples collected along the production line. Microbiological testing included counts of mesophilic and psicrothrophic microorganisms, yeasts and molds, total and fecal coliforms, *C. perfringens*, coagulase positive staphylococci, bacteria of the *B. cereus* group and detection of *Salmonella*. Time/temperature binomial was measured in all steps of preparation. A decision tree was used to help in the determination of CCPs. The detected hazards were: contamination of raw meat and vegetables, multiplication of the microorganisms during meat manipulation, poor hygiene of utensils and equipment, and survival of microorganisms to the cooking process. Cooking and hot-holding were considered CCPs. The results stress the importance of the implementation of a training program for nutricionists and foodhandlers and the monitoring of CCPs and other measures to prevent foodborne diseases.

Key words: HACCP, microbiological quality of foods, meat, hospital kitchen

INTRODUCTION

Mishandling of foods in food service operations is frequently associated to outbreaks of foodborne diseases (7). In these establishments, the traditional method to control the quality of the food includes the inspection and microbiological evaluation of the end product. However, this method is not ideal because microbiological analysis results become available only after the food has been already eaten, leaving no opportunity for corrective measures.

In recent years, the hazard analysis and critical control point (HACCP) concept has been proposed as the best approach to assure food safety (6,10,13,20). HACCP includes identification, evaluation and control of potential hazards before they occur (14). HACCP is based on several principles, which are described in different ways. In March 1992, The National Advisory Committee on Microbiological Criteria for Foods (NACMCF) (12) published a document which defined hazard as "a biological, chemical or physical property that may cause a food to be unsafe for consumption". This document delineates the seven HACCP principles,

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gives the definitions of HACCP terms, and describes the initial steps to develop a HACCP plan. It also describes the use of a decision tree to aid the identification of critical control points.

The seven HACCP principles were summarized by Savage (14): (1) conduct a hazard analysis by preparing a list of steps in the process where significant hazards occur and describe the preventive measures, (2) identify the critical control points (CCP) in the process, (3) establish critical limits for preventive measures associated with each identified CCP, (4) establish CCP monitoring requirements, (5) establish corrective action to be taken when monitoring indicates that there is a deviation from an established critical limit, (6) establish effective recordkeeping procedures that document the HACCP system, and (7) establish procedures for verification that HACCP system is working properly.

In the application of HACCP, physical and chemical tests and even visual observations are used to monitor critical control points since microbiological testing is time consuming.

The objectives of this study were to evaluate the hazards associated with foods prepared with ground meat, and to determine the critical control points for preparation of these foods in a Brazilian hospital kitchen, using time/temperature measurements and microbiological testing. Foods prepared with ground meat were selected for this study because this type of foods has been implicated repeatedly as vehicle in reports of foodborne disease outbreaks.

MATERIALS AND METHODS

Food preparation place:

The study was done in the kitchen of a hospital that belongs to São Paulo University, São Paulo, Brazil. This hospital serves daily nearly 700 meals at lunch and 250 at dinner. The kitchen has an area for reception of goods, butchery and distinct areas for manipulation of vegetables and cooking.

Development of flow diagrams:

Flow diagrams of preparation of two ground meat based products (meat balls and kibbe) were constructed, in order to provide a clear, simple description of the steps involved in the process.

Determination of critical control points:

To determinate CCPs, the decision tree described by NACMCF was used (12).

Sampling procedures:

Portions of 100 g of meat were asseptically collected at each step of preparations of meat balls and kibbe. A pool of the seasonings and all other ingredients but eggs were also sampled.

Samples of water were collected in screw cap sterile flasks. Equipment and utensils like basins, dishes, polipropilene chopping boards, wooden spoons, and blenders were also sampled before use by rubbing a known area with a sterile swab, previously moistened in sterile buffered water (3).

All samples were analyzed on the same day of collection. Samples collected along the preparation were examined three times. Equipments and utensils were tested five times.

Laboratory procedures:

For testing of solid products (raw meat, meat balls, kibbe), samples were homogenized with sterile buffered water, pH 7.2, in a Stomacher Lab Blender 400 for 2 minutes and then, decimal dilutions were made in the same diluent. The dilutions were used for microbiological analysis as described below.

For equipments and utensils testing, the tubes containing the swabs and Buffered Water were vortexed. This Buffered Water was used in the microbiological analysis.

Water samples were tested for total and fecal coliforms using the presence-absence test (1).

The microbiological analyses carried out in the samples are summarized in Table 1.

Aerobic mesophilic bacteria (AMB) were enumerated using pour plate in Plate Count Agar (Difco). Plates were incubated at 35ºC for 48 h (3).

Psychrotrophic microorganisms (APB) were enumerated by spreading 0.1 ml of the homogenates and their dilutions on Plate Count Agar (Difco) plates, which were incubated for 10 days at 7ºC (3).

Yeasts and molds were enumerated by spreading 0.1 ml of homogenates on Potato Dextrose Agar (Difco) (pH 3.5) plates, which were incubated for five days at room temperature (3).

The number of total and fecal coliforms was estimated by the most probable number method. Lauryl Sulfate Broth (Difco) was used in the presuntive test. After incubation at 35ºC for 48 h, total coliforms were confirmed in Brilliant Green Broth (Difco) incubated at 35ºC for 48 h, and fecal coliforms were confirmed in EC Broth (Difco), incubated at 44.5ºC for 24 h, as described by APHA (3).

Table 1 – Microbiological analysis of samples collected in a hospital kitchen

Samples	Microbiological analysis
Frozen meat Refrigerated meat Frozen ground meat Refrigerated ground meat Manipulated meat	Aerobic mesophilic colony count Aerobic psychrotrophic colony count Yeasts and molds colony count Enumeration of *B.cereus* group Enumeration of *Clostridium perfringens* Enumeration of *Staphylococcus aureus* Enumeration of total coliforms Enumeration of fecal coliforms Detection of *Salmonella*
Cooked meat Last meal to be served	Aerobic mesophilic colony count Yeasts and molds colony count Enumeration of *B.cereus* group Enumeration of *Clostridium perfringens* Enumeration of *Staphylococcus aureus* Enumeration of total coliforms Enumeration of fecal coliforms Detection of *Salmonella*
Pool of ingredients	Enumeration of *B.cereus* group Enumeration of *Clostridium perfringens* Enumeration of *Staphylococcus aureus* Enumeration of total coliforms Enumeration of fecal coliforms Detection of *Salmonella*
Eggs	Detection of *Salmonella*
Wheat	Enumeration of *B .cereus* group
Equipments and utensils	Aerobic mesophilic colony count

Bacteria of *B. cereus* group were enumerated according to the methodology described by APHA (3) with some modifications. Phenol-red-egg-yolk-polymixin agar plates were used for isolation of colonies, which were submitted to Gram staining and tests for catalase, motility, haemolysis in sheep blood agar and tyrosine decomposition.

Coagulase positive staphylococci were enumerated on Baird-Parker agar (Difco) plates. Gram staining, tests for coagulase, thermonuclease and catalase production tests were used to confirm suspected colonies (3).

Clostridium perfringens was enumerated by spreading 0.1 ml of the homogenates and their dilutions onto SPS agar (Difco) plates, which received an overlay of the same media. These plates were incubated at 43ºC for 48 h under anaerobic conditions. Gelatin-lactose and motility-nitrate tests were used for confirmation of suspected colonies (modification of APHA (3)).

For isolation and identification of *Salmonella*, 25 g of food were homogenized in 225 ml of Buffered Peptone Water. Selenite Cystine broth (Difco) with novobiocin (100 µl/10ml) (Sigma) (35ºC/24h) and Tetrathionate Brilliant Green Broth (Difco) (43ºC/24h) were used as selective enrichment media. Broths were plated on Brilliant Green Agar and on SS Agar, and incubated at 35ºC for 24 h. Typical colonies were transferred to Triple Sugar Iron Agar (Difco) and to Phenylalanine Agar (Difco). The complete identification was done using the API20E system (BioMérieux) . Serological testing with somatic and flagella antibodies was also performed (modification of APHA (3)), using polivalent antisera supplied by Probac do Brasil Produtos Bacteriológicos Ltda.

Measurements of temperature:

The internal temperature of the food was measured in the geometric center using a thermocouple (Instrutherm TH200C). The temperature was taken at all steps from meat reception up to serving the last meal. The time of each preparation step was also registered, and a time-temperature binomial was determined. Thermometers for maximum and minimum temperatures were used to evaluate storage conditions of meat. The temperature of hot-holding devices was also measured.

RESULTS AND DISCUSSION

Flow charts and critical control points for the preparations of meat balls and kibbe are presented in Figs 1 and 2, respectively. Laboratory results are listed in Tables 2, 3 and 4.

Description of meat balls and kibbe preparations:

Frozen vacuum packaged meat was delivered to the hospital 10 days before use. After checking the temperature, the meat was introduced in a cold-chamber for thawing. Meat temperature ranged from – 9.0ºC to – 3.0º C at delivery. After thawing, temperature reached a maximum of 7.8ºC.

One day before planned use, thawed meat was transferred from the cold-chamber to the butchery, where it was ground by butchers wearing disposable gloves. This process was done in approximately 68 minutes. Before use, chopping board, blanches, knifes and mincer were disinfected with a solution of 2000 ppm sodium hipoclorite for 15 minutes and washed with hot water. After grounding, the meat was kept in the cold-chamber until the next day.

To prepare meatballs and kibbe, ground meat were mixed with vegetables and condiments. All vegetables were washed with tap water and chopped using the same knife and the same cutting board. Wheat used to prepare kibbe was soaked in water overnight at 7ºC. In the meat balls preparations, eggs and milk were also used.

All ingredients were mixed with a wooden spoon. While part of the mixture was transformed in balls by manipulators wearing disposable gloves, the remaining part was kept in the cold-chamber. Rolled meatballs and kibbe were kept in the cold-chamber until fried.

After frying, part of the meatballs and kibbe were served in a steam table and part was held in a hot pass-through until served.

Microbiological analysis and time/temperature measure:

Samples were collected 3 times in each step of the process and submitted to microbiological analysis. Results of pathogen enumeration are listed on Table 2.

It must be pointed out that in two occasions, no pathogens were detected in the samples.

All raw meat samples delivered to the kitchen were in accordance to specifications of the Ministry of Health of Brazil (Portaria nº 451/98) (11) since *Salmonella* was not detected in 25 g of any sample. However, considering the recommendation of Solberg *et al.* (17), 33.3% of the samples could not be considered acceptable due to the number of *S. aureus* (1.0×10^2 CFU/g) (Table 2). As shown in Table 2, these bacteria remained viable during the cold storage since they were also found in samples of thawed meat.

During cold storage, an increase of psychrotrophic microorganisms was detected (Table 3) which is not surprising since meat remained 10 days under refrigeration for thawing.

Table 3 shows that the number of some indicator microorganisms increased during grinding of meat. The process of grinding was done at room temperature and took about 68 minutes, leading to bacterial multiplication. Besides, the contact of the meat with the chopping board could introduce new contamination. Although desinfected, the chopping board contained a significant numbers of mesophilic microorganism (Table 4). Tebutt (19) described that it is not easy to clean and disinfect utensils made of polypropylene due to the irregular surface.

In general, a high number of *Enterobacteriaceae* or coliforms ($>10^4$ /g) is found in raw vegetables (18). In the present study, total (TC) and fecal coliforms (FC) were detected in the pool of ingredients (Table 3). This reveals an inadequate hygiene since samples were collected after their disinfection. The flora coming from the ingredients could be responsible for the increase in the MPN of total coliforms, determined in meat samples collected after mixing (Table 3).

During mixing, no increase in the counts of fecal coliforms, mesophilic microorganisms and yeasts and molds was detected (Table 3). Correct manipulation procedures, in which foodhandlers weared disposable gloves, and exposure of meat at room temperature for less than 30 minutes may explain the absence of microbial multiplication.

S. aureus are normally found in warm blooded

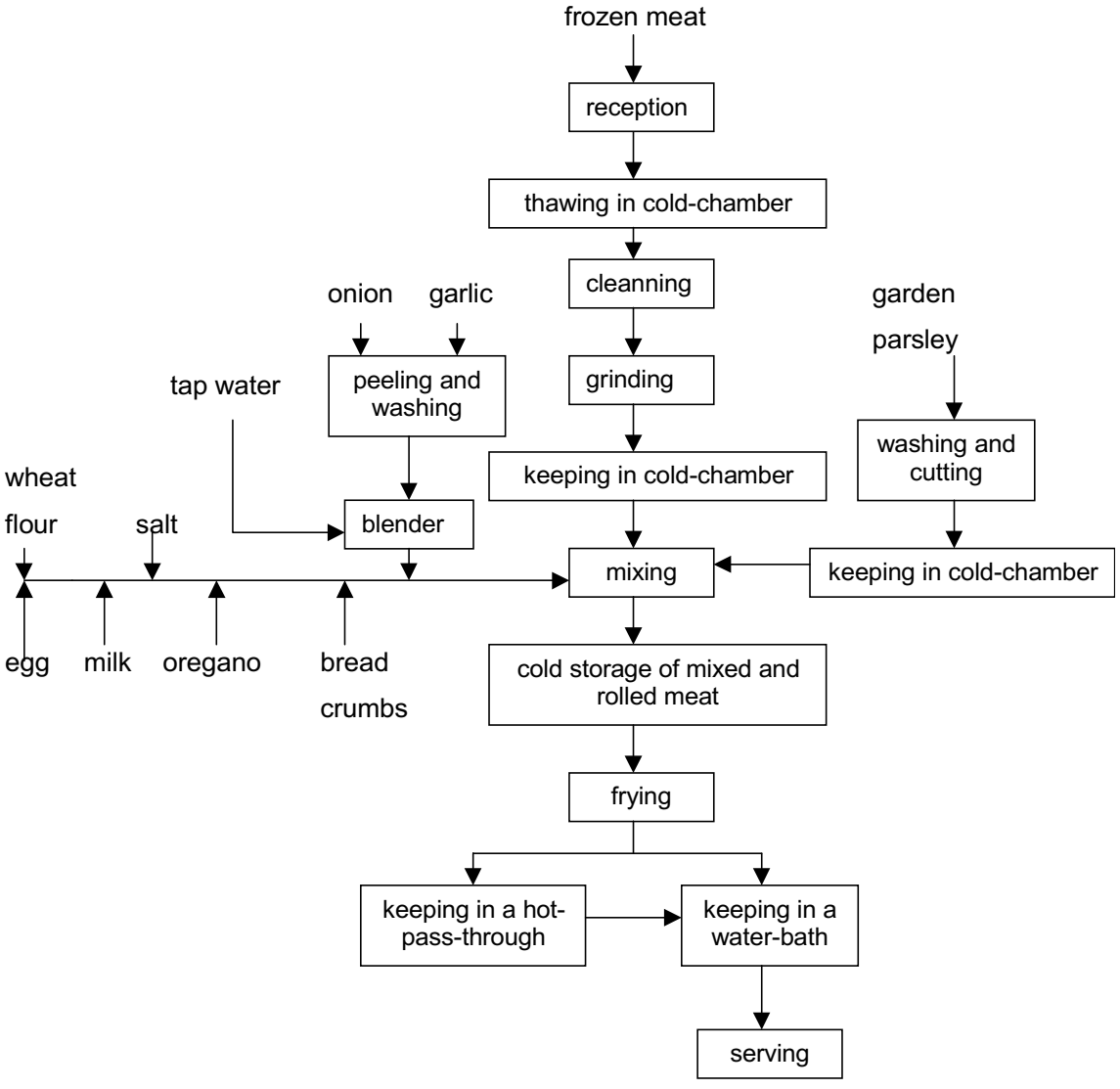

Figure1 – Flow diagram of meat balls preparation

animals and can be used as indicators of inadequate manipulation (9). These microorganisms were detected in two samples of meat delivered to the hospital. In one case (Table 2), coagulase positive staphylococci survived during refrigeration and mixing. These results agree with the literature which reports that these bacteria can survive for long periods in temperatures lower than the necessary for multiplication (21). However, the number of coagulase positive staphylococci found in the samples was not enough to produce toxin and cause a foodborne intoxication. According to Schmitt *et al.* (15), foods would represent a risk only if maintained at 14-15ºC for several days or at room temperature for many hours, which did not happen in the present study.

The average times for frying meat balls and kibbe were 4 and 6 minutes, respectively. The maximum temperature during frying was 82.3ºC and 95.0ºC, respectively. Meat balls remained in a temperature above 63ºC for 3.3 minutes and kibbe for 5,0 minutes. In both cases, the time/temperature binomial was enough to eliminate total and fecal coliforms and to reduce mesophilic bacteria and yeasts and

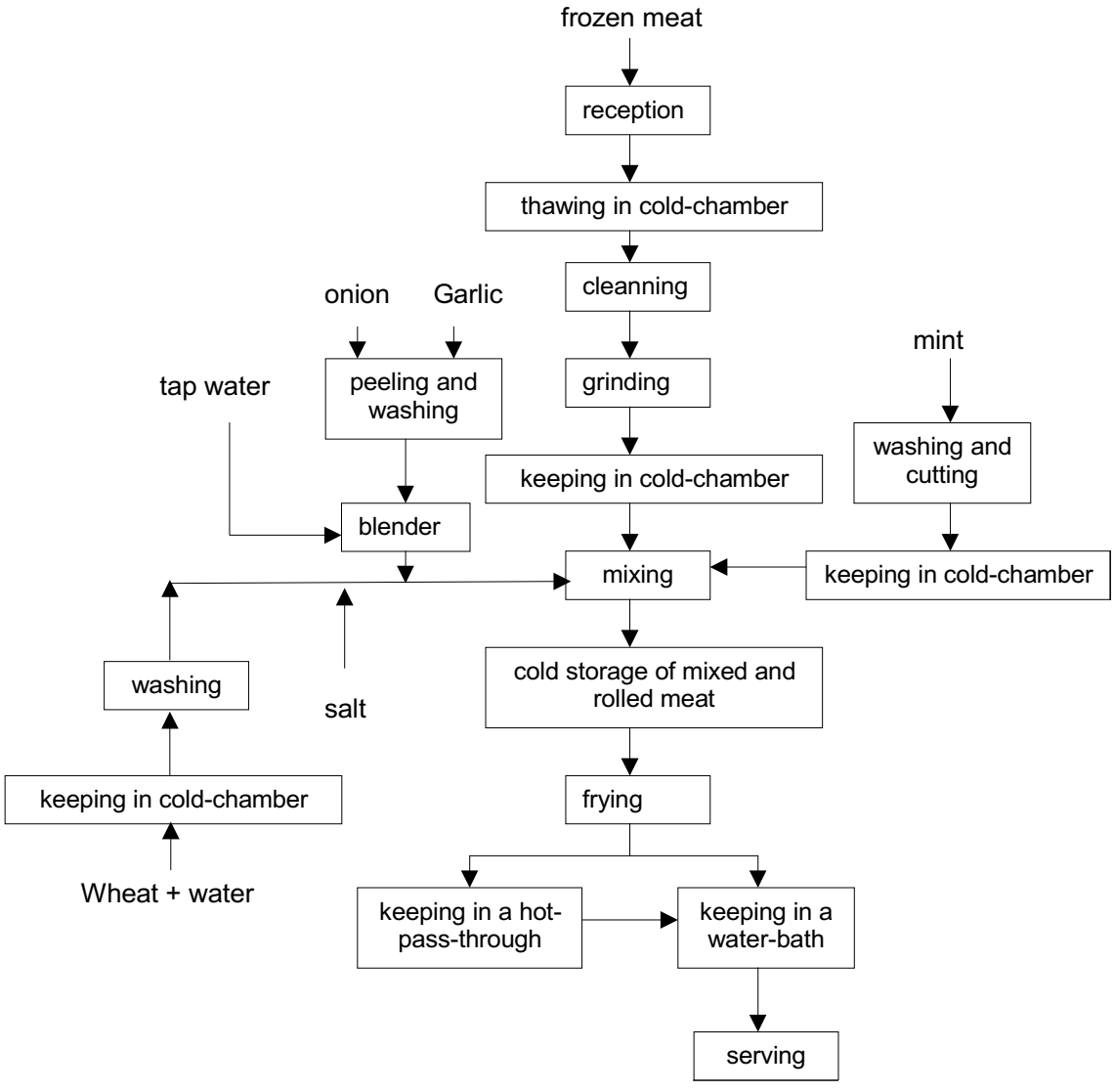

Figure 2 – Flow diagram of kibbe preparation

molds, as it can be observed in Table 3. It seems that the attained temperature was sufficiently high to kill the vegetative cells, but not enough for spores of pathogenic bacteria. Bacteria of the *B.cereus* group were not eliminated by frying (Table 2).

Between frying and serving, meat balls and kibbe were maintained hot in the steam table or in a hot pass-through for an average period of time of 135 and 108 minutes, respectively. The average temperature of the steam-table water was 92.5ºC , which is enough to maintain the food temperature above 60ºC (16). However, 33.3% of samples showed lower temperatures for a period of one hour. During this period, indicator microorganisms and pathogen levels did not increase (Tables 2 and 3).

C. perfringens was not detected in any analyzed sample.

Table 4 shows the average numbers of mesophilic bacteria detected in equipments and utensils. It seems that only dishes were efficiently cleaned. Wooden spoons presented the highest level of contamination, followed by blender and basins. These equipments and utensils could contaminate the food during preparation.

Hazard analysis:

According to NACMCF (12), to conduct a hazard analysis it is necessary to prepare a list of steps in the process where significant hazards occur, to list all identified hazards associated with each step, and to establish the preventive measures.

The steps with identified hazards and the preventive measures for both preparations were the following:

Reception: raw meat may present spores of *C. perfringens, Salmonella, S.aureus* and other pathogens (5). In the present study, coagulase positive staphylococci were detected in 33.3% of the incoming meat. To prevent these hazards it would be necessary to require periodical microbiological analysis of raw meat supplied by the butchery, and to change the meat supplier when the analysis shows an inadequate count of microorganisms. Raw vegetables and condiments may also have large numbers of bacteria, including bacterial spores (7).

Thawing: no important hazard was detected in the thawing step. The growth of *C.perfringens, Salmonella* and *S.aureus* during thawing in a refrigerator (5) under an adequate temperature is not expected. However, temperature higher than 4ºC was found once in this study which allowed an increase

Table 2 – Pathogens found in different steps of preparation of meat balls and kibbe.

Preparation	Date	Sample	Pathogen	CFU/g
Meat balls	11/12/95	Thawed meat	*B. cereus*	$1.0x10^2$
	1/22/95	Received meat	*S. aureus*	$1.0x10^2$
		Thawed meat	*S. aureus*	$1.6x10^2$
		Mixed meat	*S. aureus*	$1.0x10^2$
Kibbe	8/24/95	Received meat	*S. aureus*	$1.0x10^2$
		Mixed meat	*B. cereus*	$2.0x10^2$
		Cooked meat	*B. cereus*	$1.0x10^2$
	11/20/95	Mixed meat	*B. cereus*	$1.0x10^2$

Table 3 – Enumeration of total (TC) and fecal (FC) coliforms, aerobic mesophilic bacteria (AMB), aerobic psichrotropic bacteria (APB), and yeasts and molds at each step of the preparation of meat balls and kibbe.

Preparation	Food sample	TC (MPN/g)*	FC (MPN/g)*	AMB (CFU/g)*	APB (CFU/g)*	Yeasts and molds (CFU/g)*
	Received meat	4.7x10	1.6x10	$4.5x10^4$	$1.2x10^4$	$7.5x10^3$
	Thawed meat	$4.4x10^2$	$3.7x10^2$	$7.9x10^6$	$4.7x10^7$	$1.5x10^6$
	Ground meat	$2.1x10^3$	$3.8x10^2$	$3.6x10^6$	$6.1x10^7$	$1.8x10^6$
Meat balls	Mixed meat	$3.8x10^4$	$2.2x10^2$	$5.7x10^6$	$3.3x10^7$	$1.6x10^6$
	Cooked meat	< 3.0	< 3.0	$3.2x10^3$	NT	$2.7x10^2$
	Served meat	< 3.0	< 3.0	$2.3x10^3$	NT	$2.3x10^3$
	Pool of ingredients	$4.2x10^3$	6.0	NT	NT	NT
	Received meat	$6.8x10^2$	4.7x10	$9.1x10^4$	$1.9x10^5$	$8.0x10^2$
	Thawed meat	$1.9x10^2$	8.0x10	$5.8x10^4$	$2.2x10^7$	$1.6x10^4$
	Ground meat	$1.9x10^2$	1.1x10	$1.7x10^6$	$1.3x10^7$	$1.5x10^6$
Kibbe	Manipulated meat	$1.5x10^3$	6.0x10	$7.5x10^6$	$4.0x10^6$	$3.5x10^5$
	Cooked meat	< 3.0	< 3.0	$2.2x10^4$	NT	$4.6x10^3$
	Served meat	< 3.0	< 3.0	$7.2x10^2$	NT	$2.0x10^2$
	Pool of ingredients	$3.8x10^2$	2.6	NT	NT	NT

NT – not tested.

* average of three determinations;

Table 4 – Enumeration of aerobic mesophilic microorganisms (AMB) in utensils.

Utensils	AMB (CFU/cm^2)*
Basin	$2.0x10^4$
Wooden spoon	$4.9x10^6$
Flat cake tin	$4.8x10^2$
Blender	$5.5x10^4$
Dish	$< 1,0 \times 10^2$
Chopping board	$2.3x10^3$

* average of five determinations

of the meat temperature to 7.8ºC. So, it would be necessary to monitor the cold-chamber temperature.

Manipulation: during manipulation, thawed meat was ground, mixed with vegetables and condiments, and transformed in meat balls and kibbe. As humans may carry foodborne pathogens on the skin, they can transfer these pathogens to the food during handling (7). However, all foodhandlers worn gloves. So this source of contamination was not considered significant. On the other hand, poorly-cleaned surfaces of utensils and equipments that harbor and promote microorganisms spread like wooden spoons and chopping board were used (Table 4), being a new source of contamination.

To prevent these hazards it would be necessary to implement Good Manufacturing Practices (GMP), like better hygiene of utensils and equipments and reduction of exposure time to room temperature.

Frying: Two hazard were detected in this step. One is the microbial survival, mainly of sporeforming bacteria due to insufficient heating and survival of resistent microorganisms (7). The other is the presence of preformed toxins, like staphylococcal toxins, which are not destroyed by heat. These hazards indicate that it is important to control the time/temperature binomial during storage because meat balls and kibbe are fried for few minutes only. To prevent theses hazards it should be necessary to promote adequate cooking through reduction of the size of meat balls and kibbe, and setting correctly the time of frying and the oil temperature.

Hot-holding: microorganisms which were not destroyed during frying multiply during hot-holding if temperature is not high enough. Kibbe remained for up to 50 minutes in a temperature below 60ºC (data not shown).

Service: there was no apparent hazard during service because ready foods were distributed by cookers wearing disposable gloves and the dishes were adequately hygienized (Table 4).

Determination of Critical Control Points:

Using the NACMCF decision tree (12), two steps in the preparations of meat balls and kibbe were considered CCPs: cooking (frying) and hot-holding, where the time/temperature binomial should be controlled.

During cooking, temperature should reach 80ºC for 5 minutes in the geometric center of food.

During hot-holding food temperature should be at least 60ºC. To maintain this temperature, the water temperature in the water bath should be higher than 85ºC and pass-through temperature should be at least 60ºC. Besides, the bottom of the pans should be in contact with the steam table water.

Hazards analysis was also applied in a hospital kitchen by Bryan and Lyon (8) in the cook/freeze, cook/chill, assemble/serve and cook/hot-holding operations. CCPs were detected in each operation. In the cook/freeze and cook/chill operations, the identified CCPs were cooking, cooling and handling after cooking. In the assemble/serve operation, the CCP was the incoming food, and in the cook/hot-hold operation the CCPs were cooking and hot-holding. No hazard was observed during thawing.

Working in hospital kitchens with cook/hot-hold, cook/chill and cook/freeze systems, Bobeng and David (4) considered ingredients, foodhandlers and equipments hygiene and time/temperature control as CCPs.

Due to several hazards determined during meat balls and kibbe preparations it seems that training programs for nutritionists and foodhandlers are necessary. This training program shoud contain principles of food microbiology, food safety, microbiological hazards, food processing, determination of critical control points, practical control measures and monitoring procedures which are important to prevent foodborne diseases.

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RESUMO

Pontos críticos de controle na preparação de almôndegas e kibes em uma cozinha hospitalar

Foram determinados os perigos e os pontos críticos de controle (PCC) associados a preparações de almôndegas e kibes em uma cozinha hospitalar, baseados em fluxogramas de preparo e análises microbiológicas de amostras coletadas ao longo da preparação. As análises microbiológicas incluíram a contagem de microrganismos mesófilos, psicrotróficos, bolores e leveduras, *C. perfringens,* estafilococos coagulase positiva, bactérias do grupo *B. cereus*, número mais provável de coliformes totais e fecais e pesquisa de *Salmonella*. Foram medidos o tempo e a temperatura em todas as etapas da preparação. Para a determinação dos PCCs foi utilizada uma árvore decisória. Foram detectados os seguintes perigos: a contaminação da carne e vegetais crus, a multiplicação dos microrganismos durante a etapa de manipulação da carne, a falta de higiene dos utensílios equipamentos, a sobrevivência de microrganismos ao processo de cocção. A cocção e a manutenção à quente foram considerados PCCs. Os resultados indicam a importância da implantação de um programa de treinamento de nutricionistas e cozinheiros e de um sistema de monitoramento dos PCCs, assim como de medidas para a prevenção de doenças de origem alimentar.

Palavras-chave: HACCP, qualidade microbiológica de alimentos, carne, cozinhas hospitalares.

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