FULL ARTICLE

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Assessment of frozen seafood good storage practices in the 21st Supply Deposit of the Brazilian Army

Avaliação das boas práticas de armazenagem de pescado congelado no 21º Depósito de Suprimentos do Exército Brasileiro

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ABSTRACT

The 21st Supply Deposit of the Brazilian Army (21st DSup), located in the city of São Paulo provides food raw materials for 16000 meals daily, and frozen fish is among the foodstuffs distributed. The objective of this study was to evaluate the good practices of seafood storage in the 21st DSup, identify issues of non-compliance that compromise food quality, and propose solutions. The system was evaluated, applying a checklist (RDC 275/2002) to evaluate the percentage of requirements in compliance with good practices. The 21st DSup was classified in Group 3, with 41% of items in conformance (< 50%), and we found that there is no hygienic-sanitary self-control program for storing cold seafood and other food supplies. The cold stores' temperatures are not able to maintain products within the required standards of conservation. The seafood cold storage protocol of the 21st DSup does not guarantee temperature conformity. It is necessary to implement a hygienic-sanitary self-control program for food supply storage, which should begin with the development of a food safety culture.

Keywords: Food safety. Hygiene-sanitary control. Good manufacturing practices. Cold seafood.

RESUMO

O 21º Depósito de Suprimentos do Exército Brasileiro, localizado na cidade de São Paulo fornece, diariamente, matérias primas para 16 mil refeições e, dentre os gêneros alimentícios distribuídos, está o pescado congelado. O presente trabalho avaliou as boas práticas de armazenagem de pescado congelado no 21º DSup e identificou as não-conformidades que poderiam comprometer a qualidade do produto e propoz soluções para as limitações encontradas. Foi utilizada uma o *check list* da RDC 275/2002 e o depósito foi classificdo quanto ao número de requisitos conformes em boas práticas. O 21º DSup foi classificado como Grupo 3, obtendo 41% de itens conforme (< 50%); não dispunha de programa de autocontrole higienicossanitário da armazenagem do pescado congelado e outros insumos alimentares. As temperaturas das câmaras de produtos congelados não eram capazes de manter o produto dentro dos padrões de conservação exigidos. O protocolo de armazenamento do pescado congelado no 21º DSup não garantia conformidade da temperatura para o produto. É necessário construir um programa de autocontrole higiênico sanitário do armazenamento de suprimentos alimentares, que deve ser iniciado com o desenvolvimento de uma Cultura de Segurança de Alimentos.

Palavras-chave: Segurança do alimento. Controle higienicossanitário. Boas práticas de produção. Pescado congelado.

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Introduction

A large quantity of meals is served daily in the barracks of the Brazilian Army (BA) (Brasil, 2014b). Until October 2016, the BA had 469 food and nutrition units (FNU) distributed throughout the country (Brasil, 2014b). In The Second Military Region (2nd MR), the 21st Supply Deposit of the Brazilian Army (21st DSup) provided food for the production of 18,000 meals.day^{-1} in various military organizations (MO), demanding approximately 168,000 kg. year^{-1} of seafood (Brasil, 2005). Like other food supplies, seafood is purchased through bidding in lowest price modality.

Food Inspection and Bromatology Laboratories (FIBL) is responsible for receiving, storing and distributing food to the MO. The inspection records of the FIBL located on the premises of the 21st DSup registered disapproval of seafood for non-compliance, (Andrade Lima & Corrêa, 2013; Campos et al., 2013; Ferreira et al., 2013; Gallotti et al., 2013) with respect to the maintenance of the cold chain, appearance, coloring, and other quality attributes, indicating the need to review and improve good practices – (GP) of purchase, storage and shipment of the products.

Seafood has high perishability characteristics (Dehghani et al., 2018; Galvão & Oetterer, 2015; Huss, 1988; Ogawa & Maia, 1999), because the high water activity and free amino acid concentration (Deng et al., 2015; Luo et al., 2018; Oetterer, 2002) are ideal for spoilage and pathogenic bacterial proliferation (Huss, 1997a, 1997b; Huss et al., 2000; Huss, 2002; Huss et al., 2003). Consequently, seafood rapidly lose desirable sensory characteristics after capture and become pathogen carriers and histamine producers (Gozzi et al., 2011; Soares et al., 1998). Their lipid composition provides a favorable condition for oxidation and consequent rancidification (Arulkumar et al., 2018; Odeyemi et al., 2018; Soccol & Oetterer, 2003a, 2003b), contributing to the sensory quality loss.

The seafood supply chain needs rigorous practices for distribution, production and storage (Oetterer, 2002) to maintain desirable attributes, whether sensory, nutritional or sanitary (Brasil, 2017; Germano & Germano, 2013), that is, imposing a permanent cold chain control and hygienic practices.

In the "Agulhas Negras" Military Academy (AMAN), from 2010 to 2012, 2,816 tons of food was inspected, obtaining a 20% rate of non-compliance in animal origin products (Ferreira et al., 2013). Between 2008 and 2010, seafood was the product most often disapproved by the BA in the barracks of Manaus-AM (59.7%) because of temperature non-compliance (74%) and microbiologic contamination (62%) (Andrade Lima & Corrêa, 2013). Other studies about GMP in the BA showed non-compliance with water potability (Gallotti et al., 2013) and handler hygiene (Campos et al., 2013).

It is possible to reduce or avoid non-compliances through the application of self-control programs such as a "Resolutions of the Collegiate Board of the Ministry of Health RDC/MS 275/2002" (Brasil, 2002), or 216/2004 (Brasil, 2014a) and the Brazilian standards NBR 15635:2015 (Associação Brasileira de Normas Técnicas, 2015). These instruments provide technical regulation about good practices for food services, which carry out activities like storage and distribution at 21st DSup. The BA has self-standards (Brasil, 2015) named "Food Safety Regulations of the Armed Forces MD42 R01" (Brasil, 2015). No studies about the use of military food storage standards were found to-date.

Studies about the adoption of GMP are available to FNU (São José et al., 2011; Vidal et al., 2011), restaurants (Oliveira et al., 2016; Santini & Seixas, 2016; Souza Genta et al., 2005), bakeries (Guimarães & Figueiredo, 2010), free-markets (Patrícia et al., 2012) and meals production units (MPU) (Mariano & Moura, 2010). However, no studies about the adoption of GMP in storage places were identified. The logistics of perishable foods like cold seafood represent strategic elements of management and require the adoption of tools like traceability, document registration and Hazard Analysis of Critical Control Points (HACCP) (Giannoglou et al., 2014; Tsironi et al., 2008; Tsironi et al., 2009; Tsironi et al., 2016) and rigid control of the temperature (never up to -18ºC) (Brasil, 2017).

The aim of this study was to evaluate GMP of seafood storage in the 21st DSup, identify non-compliance, and propose solutions based on the standards of the current legislation.

Materials and Methods

This study was approved by the Research Ethics Committee of the School of Veterinary Medicine and Animal Science, University of São Paulo (FMVZ/USP), under the Protocol n.77150314, and it follows the ethical procedures established by resolution n. 466/2012 (Brasil, 2012).

This is a cross-sectional study performed in the 21st DSup of BA, in São Paulo State, between May and July 2017. According to Gil (2002), it is an empirical, exploratory and documental case study, performed in a real organizational context. We used primary and secondary data. From the records of non-compliance, seafood was chosen as the object of this research.

To evaluate the GMP, we used the checklist proposed in the Appendix II of the RDC 275/2002. This tool is composed of five topics: building equipment, furniture, handlers, production and transportation of food, and documentation.

The temperatures of three cold stores (8A, 8B and C3) were recorded during the period from 12 June to 12 July 2017 by analyzing the log sheets. The temperature monitoring was carried out daily at 5:30 AM, at 5:00 PM and at 10:00 PM, through the reading of the cold store displays. The records are of air temperatures.

All data collected were organized into worksheets and descriptive statistical analysis was performed considering the average and standard deviation of temperature, daily temperature variation and temperature amplitude. A Pearson's correlation (Bussab & Morettin, 2010) coefficient (Equation 1) was employed to measure the strength and direction of the linear relationship between the variables time (recorded per hour) and temperature, describing the direction and degree to which one variable is linearly related to another. A Student t-test was used to determine if the value of Pearson correlation coefficient was statistically significant, at a significance level of 5%. The IBM Statistical Package for the Social Sciences SPSS 20.0 was used.

$$r = \frac{\sum\left(Y_{m-i} - \overline{Y}_{m}\right)\left(Y_{est-i} - \overline{Y}_{est}\right)}{\sqrt{\left(\sum\left(Y_{m-i} - \overline{Y}_{m}\right)^{2}\right)\left(\sum\left(Y_{est-i} - \overline{Y}_{est}\right)^{2}\right)}} \quad (1)$$

Where:

Y_{m-i} is the value of the measured inhibitory activity for compound i (i = 1, 2, …, n)

is the average of the measured inhibitory activity

Y_{est-i} is the value of the estimated inhibitory activity for compound i

$\overline{Y}_{est}$ is the average of the estimated inhibitory activity.

Results and Discussion

According to the RDC 275/2002, the 21st DSup was classified in the Group 3 concerning GMP compliance (< 50%) (Table 1).

Non-compliance found in the item "Building" were mainly related to the structure. The 21st DSup was completed November 07, 1932.

Initially, two distinct units occupied the 21st DSup area: The Subsistence Regional Establishment II (ERS II) and the Intendency Material Regional Establishment II (ERMI II); both responsible to the Southeast Command (CMSE) barracks supply. The ERS II supplied the troops with foodstuff and the ERMI II with uniforms and equipment. The cold store buildings occupied today were poultry slaughterhouses between the 1940s and 1960s. Poultry were transported by rail from the BA farms, from the interior of the State of São Paulo.

On June 25, 1962, the Regional Establishment status was changed to Regional Deposit. In June 1991, the units were merged giving rise to the 21st DSup. Henceforth, the establishment received, apart from its traditional operations, the burden of supplying the troops with drugs. Operations before this date were carried out by the Regional Health Material Deposit (DRMS II). It partially adapted installations for this purpose, keeping up over several years, based on a model of occupation and preserving the original structure. This building was occupied prior to the publication of the legislation of GMP: Portaria nº 1428/1993 Ministério da Saúde, that approved the Technical Regulation of Food Safety.

The buildings are very important in GMP compliance, especially because the structural problems are directly related

Table 1 – Non-compliance percentage according to the RDC 275/2002 - Department of Experimental Epidemiology Applied to Zoonosis (VPS)/FMVZ/USP, São Paulo (SP) – 2018

Verification items	Nº of items	Non-compliance items	Compliance items	Non-applied items	% percentage of non-compliance
Building	78	51	22	5	65
Equipment and furniture	21	8	7	6	38
Handlers	13	6	7	0	46
Production and Transportation	34	13	9	12	38
Documents	18	18	0	0	100
TOTAL	164	96	45	23	59

Source: Elaborated by the authors.

to cross-contamination (Aplevicz et al., 2010), work accidents (Vidal et al., 2011) and difficulty to maintain satisfactory hygiene. Ferreira et al. (2011) demonstrated that the floor, among other structures of buildings, comprises the most recurring structure with non-compliance in FNU because of the intense transit of employees, equipment and goods. Improper cleaning of floors and walls contributes to the proliferation of micro-organisms, thereby compromising food quality and increasing the risk of occurrence of foodborne diseases (DTA) (Brasil, 2014a). Silva & Correia (2009) claim that food storage buildings should be easy to maintain and clean, thereby preventing access of insects, rodents, birds and other synanthropic animals. According to Fonseca et al. (2010), "buildings" was a critical item in GMP studies, as a similar situation was observed by Akutsu et al. (2005) and Araujo et al. (2016).

The building non-compliance of 21st DSup also occurs in the toilets and changing rooms. This non-compliance is frequent in the food industry, supermarkets and small shops as reported by Valente & Passos (2004), where the researchers studied 58 supermarkets in southeastern Brazil and found that 79.3% had inadequate toilets and poor hygienic conditions. Toilets and changing rooms should comply with technical specifications regarding sizing, flow and use of specific materials, respecting the users' status (collaborator or visitant) and their gender (Brasil, 2002; Brasil, 2014a).

Electrical installations or other operations specific to the food industry in the old buildings constantly exhibit undesirable conditions such as those identified in the 21st DSup. Food safety and hygiene are directly related to these conditions and must be considered extremely important. According to Guimarães & Figueiredo (2010), electrical installation problems were observed in 100% of the investigated food establishments in the Federal District of Brazil. This non-compliance made sanitation difficult and increased the risk of work accidents (Akutsu et al., 2005; Aplevicz et al., 2010; Brasil, 2014a).

Equipment and furniture had non-compliance in cold store operations. From local information, we found that there were no standard operating procedures (SOPs) and preventive equipment maintenance in the 21st DSup. SOPs are a prelude to Hard Analysis and Critical Control Point (HACCP) (Lee et al., 2007). A self-control program requires a SOP deployment and preventive equipment maintenance for chilling and freezing equipment, ensuring correct and continuous operation.

Without the practice of periodic preventive maintenance of the equipment, there would be no safety or correct operation of compressors and evaporators, even in monitoring temperatures. Temperature monitoring is only reliable when the correct operation of the refrigerated equipment is guaranteed (Othmane et al., 2011).

Soldiers who work in cold stores do not use appropriate uniforms and disposable accessories. Even worse, there are no hand antiseptic supplies. Soldiers handle food wearing military uniforms, without disposable caps and masks, and they are not educated on good food safety practices (Mutisya et al., 2016) during the military period. We did not observe any posters containing instruction about personal hygiene. It must be highlighted that food hygiene should be promoted through military training programs (Abidin, 2013; Griffith et al., 2010a; Yiannas, 2009; Griffith et al., 2010b), and corrective actions should be taken during the workout routines (Griffith, 2010).

Similarly, Campos et al. (2013) reported poor personal hygiene through research about *Escherichia coli* on 10th t RM (Ceará and Piauí State) barrack kitchens. They demonstrated that the behavior of food manipulators is essential to prevent food contamination and spoilage. Almeida et al. (1995) in 1990s, evaluating GMP in university restaurants, found the same non-compliance, highlighting the importance of food security education.

The 21st DSup has no GMP formal document, and these results support and confirm the non-compliances observed, highlighting the need for a protocol to guide food handling. In the agrifoods industry, Girelli et al. (2015), and Fonseca et al. (2010), evaluating restaurants, found several non-compliance issues related to the absence of GMP programs. Costa et al. (2011) supported the previous claims after showing that GMP was absent in 48 establishments in the Paraíba State. Furthermore, Oliveira et al. (2016) showed that, in 16 restaurants around the Federal University of Sergipe, 93.7% of non-compliance was represented by absence of GMP programs. The monitoring and verification of these attributes and parameters should not be optional or sporadic, but must be permanent and carried out by competent personnel (Germano & Germano, 2013). Food safety management systems (FSMS) are ineffective if people fail to promote good food safety behavior (Yiannas, 2009).

Oliveira et al. (2016) found non-compliance in food stores and restaurants, mainly in transport, storage, handling and delivery. The authors concluded that behavioral deficiency is likely to render FSMS obsolete (Brasil, 2014a), caused mainly by ignorance of the importance of food safety.

According to Vidal et al. (2011), there are only a few studies regarding GMP in military organizations in Brazil, making it impossible to confront these results with other problems experienced in the BA.

The analysis of cold store temperature records (Figure 1) (Table 2), carried out between June 12 and July 12, 2017, demonstrated that the temperature does not comply with the standards (-18º C or less) (Brasil, 2017).

Two out of three cold stores lack maintenance of the cold chain, with fluctuating temperatures between -5.6 ºC and -21.2 ºC. This compromises the quality of sensual nutritional parameters (Galvão & Oetterer, 2015; Ogawa & Maia, 1999), thereby damaging seafood and increasing the potential for health hazards. Storage of fish at this temperature (up to -18ºC) is known to cause extensive quality loss (Burgaard & Jorgensen, 2011).

The Pearson's correlation (Table 3) showed a strong correlation between the period of cold store activities (5:30 pm) and the temperature rise. This is indicative of food safety errors. During the application of the checklist, long periods of open doors were observed. Another piece of relevant information was the number of workers going through cold stores. The insulation and the number of workers are the important variables in the balance of energy and the thermal load calculation (Evans et al., 2014; He et al., 2014; Johnston, 1994). Failure to observe these characteristics compromises the proper functioning of the equipment, causes excessive consumption of energy and compromises the quality of seafood (Johnston, 1994).

The weak correlation observed at the C3 cold store demonstrates that the lower door opening (this cold store is less accessed) does not cause a linear relationship between

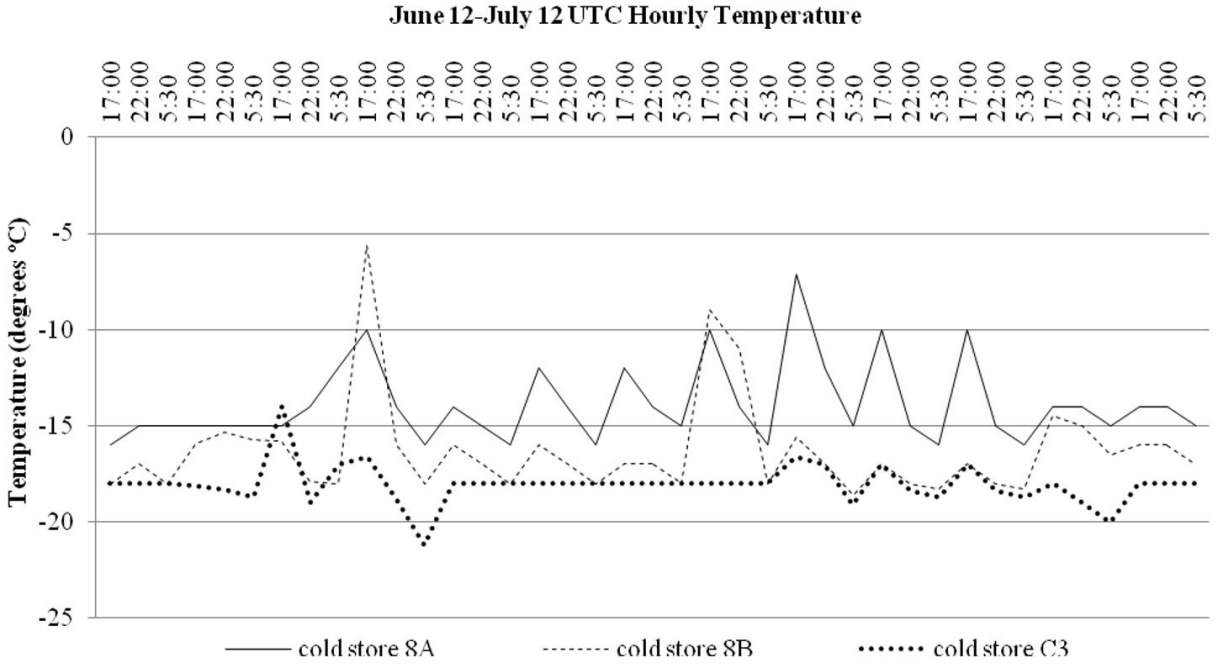

Figure 1 – Cold store temperature time series during the period
Source: Elaborated by the authors.

Table 2 – 21st DSup seafood cold stores temperature records - Department of Experimental Epidemiology Applied to Zoonosis (VPS)/FMVZ/USP, São Paulo (SP) - 2018

Cold stores	Daily temperature average ºC	Daily temperature amplitude ºC	Min value ºC	Max value ºC
8A	-14,3 ± 1,2	-3,0 ± 0,9	-13	-16
8B	-16,3 ± 2,4	-13,0 ± 3,3	-5,6	-18,6
C3	-18,0 ± 1,1	-6,8 ± 1,0	-14	-21,2

Source: Elaborated by the authors.

Table 3 – 21st DSup seafood cold stores temperature amplitude average and correlation – Department of Experimental Epidemiology Applied to Zoonosis (VPS)/FMVZ/USP, São Paulo (SP) – 2018

Period	Cold Store 7		Cold Store 8B		Cold Store C3	
	Average of TA*	Pearson's Correlation	Average of TA*	Pearson's Correlation	Average of TA*	Pearson's Correlation
05:30 am-5:00 pm	4,5 ± 1,7	0,985**	3,8 ± 4,3	0,961**	0,6 ± 0,7	-0,205**
05:00 pm-10:00 pm	3,2 ± 1,9		2,3 ± 3,8		0,9 ± 1,8	
10:00 pm-5:30 am	1,5 ± 1,1		1,6 ± 1,9		0,6 ± 1,0	

*TA - temperature amplitude; **p < 0,05. Source: Elaborated by the authors.

the period of cold store activities and temperature rise. According to Evans et al., (2014), normal temperature rise occurs because of air flow resulting from doors opening, but several amplitudes are characteristic of food safety errors or equipment malfunction.

The temperature increase of frozen and chilled products reduces their shelf life, compromises the original desirable characteristics and encourages spoilage and multiplication of pathogenic microorganisms, thereby increasing the risk of food loss and the occurrence of FBDs (Germano & Germano, 2003). Daily temperature amplitude is related to equipment malfunction in cold stores or operation inefficiency during the load and unload operations (Moraga & Medina, 2000).

Ronnow et al. (1999) related improper maintenance of cold store structures such as roof and wall panels, associated with food safety mistakes during load and unload operations, promotes air change and causes moisture and temperature variations. Door opening impairs the efficiency of the system for the following reasons: it increases the energy demand and total cold refrigeration load (Borderias, 1996), causes overloading of equipment (Pereira et al., 2010), increases loading cost and seafood weight loss (Pigott & Tucker, 1990), and increases lipid oxidation and seafood vitamin loss (Huss, 2002; Huss et al., 2003; Sorensen, 1992).

The lack of a FSMS is a strong indication that critical control points of the process such as a storage temperature or water tank contamination are not controlled and corrected when necessary (Barker & Mckenzie, 1997; Khandke & Mayes, 1998; Organização Pan-Americana de Saúde, 2001). The World Health Organization, in the late 1990s, predicted the difficulty that the food industry would have in the 21st century, caused by food safety skilled work deficit (World Health Organization, 1999). Several researchers (Griffith et al., 2010a; Harvey et al., 2002; Nayak & Waterson, 2017; Taylor, 2011; Yiannas, 2009), defend the adoption of food safety culture educational programs.

Conclusion

Non-compliance was found in five of five items on the checklist used in this study. This result highlights the need for the development of a seafood safety program as a primary program after which it can be extended to other foods. The non-observance of this need would lead to foodborne outbreaks and increase health costs.

The behavior of workers needs special attention because they are key to the effectiveness of the food safety program application.

Basic rules about cold storage needs should be respected. The good storage practices are intrinsically related to seafood nutritional and sanitary characteristics.

The employment of GMP will add value to the experience of young military recruits. By experiencing the work with GMP, these individuals will return to society with distinguished values, making them better suited for the labor market. Promoting food safety culture represents an improvement of the quality of food products. It further improves the lives of people because is a form of education and social promotion.

Conflict of Interest

The authors state that they have no conflicts of interest to declare.

Ethics Statement

This study was approved by the Research Ethics Committee of the School of Veterinary Medicine and Animal Science, University of São Paulo, under the Protocol n.77150314, and it follows the ethical procedures established by resolution No. 466/2012.

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