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CONTROLLING OF POTENTIAL HAZARD IN POTATO CHIPS PROCESSING THROUGH FOOD SAFETY MANAGEMENT SYSTEM FSMS (ISO 22000)

Rasha A. M. Eissa[(1)], M. A. Salem[(1)] and S. Y. Elsanat[(2)]

[(1)] **Food Science and Technology Department, Faculty of Agriculture, Tanta University, Egypt**

[(2)] **Food Science and Technology Department, Faculty of Agriculture, Kafrelshiekh University, Egypt**

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ABSTRACT: ***The purpose of this study is to design Hazard Analysis and Critical Control Point (HACCP) plan for potato chips production through food safety management system F.S.M.S ISO 22000 based on actual conditions in the plant. A specific model has been developed to boost the safety and quality of potato chips product in this plant. The prerequisite programs (PRPs), operational prerequisite programs (OPRPs), hazards, critical control point (CCP), preventive measure, critical limits, monitoring procedure and corrective actions have been designed in this HACCP plan. Microbiological analysis for incoming flavors were within the acceptable limits and thus the incoming shipments were accepted and no acceptance from the supplier in case of out of the acceptable limits. The results showed that microbiological examination of raw potatoes before and after frying that frying process could significantly reduce all microorganisms in raw potatoes to the acceptable level on two processing lines. A program of cleaning and disinfection of production lines and a personal hygiene program for the workers and ensuring the effectiveness of them as well as the quality of the water entering the manufacturing process. Chemical, microbiological, physical and sensory tests were conducted to ensure the safety and quality of the finished product.***

Key word: ***Potato chips plant, ISO 22000, HACCP, Hazard, Critical limit.***

INTRODUCTION

Recently, consumers have focused on food safety, which does not contribute to disease, microbial infection or poisoning. Food safety has become an important and essential criterion for consumers to choose food regardless of its importance and nutritional value. A food safety-risk analysis: is essential not only to produce or manufacture high quality products to ensure safety and protect public health, but also to comply with international and national standards and market regulations. There are three types of food hazards: natural, biological and chemical in addition to allergens and radiological substance (Codex, 2009; Noble *et al*., 2009; Easdani *et al*., 2012 and ISO22000, 2018).

The ISO 22000 international standard specifies the requirements for a food safety management system that involves interactive communication, syste m management, prerequisite programs (PRPs), hazard analysis and critical control point (HACCP) principles (ISO 22000, 2018).

Potato chips is a food product prepared from potato tubers after cleaning, peeling, slicing and frying in suitable edible food oil (Zhang and Peterson, 2018). Potato chips are the most popular snack food in Egypt and are devoured at a rate of 100 million pounds annually. Potato chips are a predominant part of the snack food. According to the snack food association potato chips constitute 40% of snack

food consumption, beating out pretzels and popcorn in spite of the fact that hardly anyone thinks potato chips are nutritious and convenience food market (Majcher and Jelen, 2005; Abd-Elhak, 2005 and Dogan and Kokini, 2007).

The objective of this study is to ensure that all products manufactured by the company were safed and fit for consumption "our end customer expects that "so food safety as one of the highest priorities in doing business because it saves the business money in the long run, avoids you poisoning your customers and testing improves staff motivation and efficiency. In addition, design HACCP plan for potato chips production based on actual conditions in the plant to produce safe product.

MATERIALS AND METHODS

1. Materials:

The present study was carried out at processing and packaging Herms potato chips provided from a plant at Central Delta, Egypt, during the spring season of the year 2018. All chemicals, solvents, media in this study, were purchased from El-Gomhorea Company for chemicals and drugs, Tanta, Egypt.

2. Methods:

2.1. Chemical analysis of potato chips.

Moisture and oil were determined by NDS infrared engineering a device used to measure the moisture and oil ratio of the chips product in less than 10 seconds. The Micro-Kjeldahl method was used to determine the total nitrogen and thereafter its value was multiplied by the factor of 6.25 to get the crude protein content. Ash content was determined by ashing the samples in an electric muffle at 550˚C until constant weight was maintained. NaCl was determining by Mettler DL22 by titration via AgNo3. The amounts of total carbohydrates were determined by difference. The total energy was calculated using the Atwater factors; whereas 1.0g of each carbohydrate and protein provide 4.0 Kcal, and1.0g of fat provide 9.0 Kcal, as reported by (A.O.A.C., 2005). Free fatty acids (FFA) was determined according the method described by (A.O.C.S., 2005), by titration ethanolic oil extract with NaOH (0.1N) until appearance of the light pink color. Peroxide value was determined according to the method described by A.O.A.C. (2005), and the results were calculated as mill equivalent of oxygen absorbed by kilogram oil (meqO2 kg^{-1} oil).

2.2. Prerequisite programs (PRPs):

2.2.1. Factory zoning layout requirements.

This zoning plan is a mandatory part of a factory master plan. Based on the requirements of each area, the plant is divided into three zones high, medium, basic hygiene zone. Pathogen monitoring programs will be established in high hygiene zone. A full description of two potato chips (processing & packaging) lines starting from raw materials receiving, storage...etc. The flow diagram was constructed by HACCP team as shown in Figure (1).

2.2.2. Incoming raw materials.

Potato and flavors were examined. Samples were drawn by trained personnel for microbiological tests to ensure their safety based on specific criteria.

2.2.3. Cleaning and sanitation programs requirements

Material safety data sheets (MSDS) were maintained and available for all cleaning and sanitizing chemicals were clearly labeled and stored in secured areas with limited access. Cleaning process has done in place (CIP) every 2

weeks and cleaning out place (COP) was include all equipment and product contact surfaces.

2.2.4. Personal hygiene policy

Personal swabs were taken before and after cleaning hands to ensure that staff complies with person hygiene policy. Others programs, as appropriate and they are managed in PRPs list as shown in Table (1).

2.3. Sensory evaluation of finished product.

Potato finished products were sensory tested for their color, odor, texture (crispness), taste and overall acceptability on a 1 to 10 hedonic scale as described by El-Sheikh *et al*. (1999).

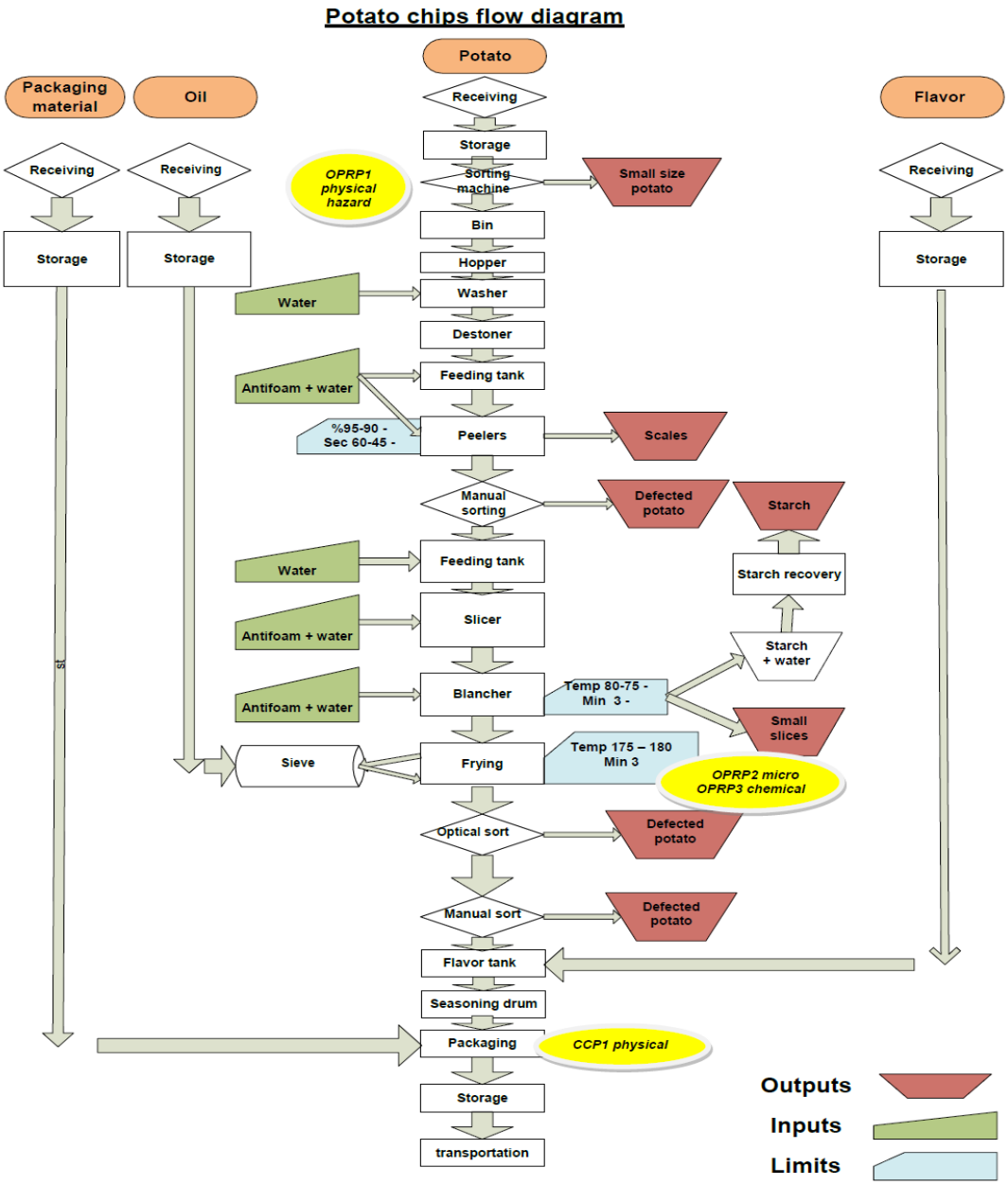

Fig. (1): Flow diagram a full description of two potato chips (processing & packaging) lines.

Table (1): Prerequisite programs (PRP) Listing.

Pre-Requisite	Hazards		Control Measures	Target	Monitoring			Corrective Actions
	Hazardous Agent(s)	Origin(s)			Activity	Responsibility	Records	
Control of Personnel	Physical contamination by foreign bodies (jewelry, hair, clothes etc)	The personnel and its belongings	- Implementation of hygienic personal practices. - Full training on food safety and good hygienic practices. - Respect of the zoning plan and the restriction linked to each area (jewelry forbidden in green zone). - Temporary exclusion from production site of ill staff members. - Enough Washing and disinfection tools are provided.	Absence of foreign bodies due to personnel belongings	GMP inspection	Quality assurance (Q.A) department	GMP inspection records	- Retraining - Disciplinary action
	Microbiological contamination due to insufficient hygiene (dirty hands, illness (sneezing-coughing-fever), outdoor clothes,etc	The personnel and its clothes		All staff is aware of hygienic issues and comply with good manufacturing practices.				
Pest Control	Physical and microbiological contamination brought by pests (hair, excrement, body parts, bacteria, molds etc.)	Pests (Insects, rodents, birds etc…)	- Use of pest control devices and chemicals only by fully trained operators. - Use of approved authorized chemicals and devices fitted for food company. - Correct placement of control units. - No toxic baits inside the production area. - Clean and dry work areas.	Absence of foreign bodies and microbiological contaminations due to pests presence.	GMP inspection record	QA head	GMP inspection records	Notification of the company which provide service and Frequent assessment of it
	Chemical and physical contamination by pest control devices (baits, traps, insecticides, spraying etc..)	Misuse or storage of chemicals and poor management of devices used for pest control.		No contamination by pests control measures.				
	Microbiological	humidity, temperature environment			GMP inspection	QA or production	GMP Inspection record	
Maintenance of equipment	Physical contamination by loose equipment parts, forgotten tools, etc.	Poorly maintained equipment, technician's bad maintaining habits or mistakes.	- Maintenance by trained and experienced operators. - Only food-contact grade materials are used e.g. food grad lubricant. - Cleaning and verification after maintenance.	Absence of foreign bodies due to poor maintenance.	GMP inspection (maintenance plan inspection)	QA head	GMP inspection records	- Review maintenance plan - Retrain
	Microbiological contamination of parts in contact with food during maintenance.	bad habits, mistakes technician's during maintenance or insufficient cleaning.		Avoiding microbiological contamination due to maintenance.				
	Chemical contamination due to use of inappropriate material for maintenance, e.g. use of nonfood contact grade lubricant	Technician's bad maintaining habits or mistakes.		Use the right products and protocols for equipment maintenance.				

GMPs: (Good manufacturing practices) QA: (Quality assurance)

Table (1): Continued: Prerequisite programs (PRP) Listing.

Pre-Requisite	Hazards		Control Measures	Target	Monitoring			Corrective Actions
	Hazardous Agent(s)	Origin(s)			Activity	Responsibility	Records	
Maintenance of Buildings	Physical contamination	Degraded parts of the building (walls, ceiling)	- Buildings are designed and kept in good repair following the Good manufacturing practices. -No buildings maintenance at proximity of a production or during the production.	Buildings are not a source of foreign bodies.	GMP inspection	QA head	GMP inspection records	- Maintain buildings - Repair - Train staff
	Microbiological contamination	Presence of water leak, bad evacuation of wasted water, mishandling etc...		Buildings do not constitute ecological niches for pathogenic microorganism.				
	Chemical contamination	Building maintenance chemical products (paint, cleaning and repairing products etc.)		Chemicals used for buildings maintenance are isolated from food production.				
Cleaning and Sanitizing	Microbiological contamination	Insufficient cleaning and disinfecting, over use of water, insufficient drying, use of inappropriate tools	- Establishment of cleaning procedures. - Establishment of a clean plan for each equipment.	All staff in charge of cleaning has to fit to the cleaning procedures to avoid any microbiological contamination.	- GMP inspection (maintenance plan inspection)	- QA head	- GMP inspection records	- Review Cleaning plan - Retrain
	Chemical contamination by cleaning products	Wrong cleaning method, mis-use of cleaning chemicals, use of appropriate or unapproved cleaning products.		Use the right chemicals and methods for cleaning.				
Control of Visitors and Security	Physical accidental contamination by foreign bodies,(jewelry, hair, clothes etc...	Visitors and their belongings	Before entering the facility, Visitors receive information about Hygiene/ confidentiality/ safety rules and they must observe these rules during the visit. Visitors are accompanied permanently. They must follow Zoning plan requirements	All visitors comply with the rules of the facility and do not represent a safety risk for the production or for them selves.	Sign-in for visitors by security	QA or production department	Sign-in	- Review visitor's booklet - Advise staff to report visitors
	Microbiological contamination due to contact with any process-related material	Visitors and their clothes						
	Deliberate contamination or degradation	Intruders	Security systems, e.g. Restricted access by a temporary badge with limited access and they are accompanied permanently.	Absence of intruders	signature book - security system	QA or production department	signature book - security system	

GMPs: (Good manufacturing practices) QA: (Quality assurance)

Table (1): Continued: Prerequisite programs (PRP) Listing.

Pre-Requisite	Hazards		Control measures	Target		Monitoring			Corrective actions
	Hazardous Agent(s)	Origin(s)				Activity	Responsibility	Records	
incoming Raw and packaging materials	Physical Chemical Microbiological	Supplier	- Reception criteria - Release of incoming material COC, COA, declaration (certification of compliance-analysis) - Use of approved suppliers and audited	- No contamination coming from incoming material at supplier level		- GMP inspection - Internal audit	QA head	GMP inspection records	- Rejection or holding on defective material - Supplier audit - Changing supplier
raw and Packaging material (stored)	Physical contamination by damaged parts of the packaging	Mishandling	Inspection, release of incoming raw and packaging material Following of good hygienic storage practices.	Absence of foreign bodies due to non-conform packaging.	- GMP inspection - Internal audit	QA head		- GMP inspection records - Internal audit report	- Reject damaged packaging material - Retrain - Review release procedure
	Microbiological contamination	Operators, storage conditions (pest contamination).		All staff are aware of hygienic issues and comply with good working practices when manipulating packaging's.					
	Chemical contamination	Migration of Raw material in the product		Only food grade materials are used for packaging					
Waste disposal	Physical	Incorrect Waste disposal	Waste are identified, collected and disposed of. Packaging waste are grinding and disposed of Waste container are closable	Waste does not represent a vector of physical, attraction for pest activity, microbiological and chemical contamination		GMP audit	QA department	GMP inspection records	- Re identify waste container, - make the responsibility of disposed of clear, change damaged waste container
	Chemical	Chemical Waste not properly stored disposed-of							
	Microbiological	Waste not properly stored							
calibration	Chemical	over / under dosage of ingredients	verification, calibration activities on equipment	Device for measure are working properly		GMP audit	QA department	GMP inspection record	- Review verification and calibration plan, apply verification and calibration on device for measuring
	Microbiological	Product parameters monitored with a non-compliant device	used to monitor, produce, store product for consumption						
Storage conditions	Physical	product not properly closed, non integrity of packaging raw materials	- Control of temp in raw material, finished product storage area - Monitoring of ambient air - FiFo is observed - Only electric forklift is used - cleaning activities in storage area - chemical and lubricant are stored separately - segregated non conform material - training of operator- Zoning rules	Storage of raw materials, equipment, and lubricants does not represent a vector of chemical, microbiological and physical contaminations for finished product		GMP audit hygiene monitoring	QA department	GMP inspection records	- Cleaning of storage area - Adjust humidity and temperature parameters - established new zoning rules
	Chemical	Storage of chemicals-environmental							
	Microbiological	Humidity, temperature of environment							

GMPs: (Good manufacturing practices) QA: (Quality assurance) FIFO: (first in first out) Raw materials that are stored first are released first.

RESULTS AND DISCUSSIONS

1. Prerequisite programs (PRPs):

Steps or procedures that control the operational conditions within the food establishment, allowing for environmental conditions that are favorable for safe and wholesome food manufacturing. Systems that are normally in place before the HACCP plan is developed to ensure the business is operating according to Codex general principles of food hygiene, relevant codes of practice and relevant food safety legislation (ISO 22004, 2014).

1.1. Factory zoning (Layout).

The air in the high hygiene area was filtered and monitored by air sampling which as one of the applied microbiological programs to measure the air conditions efficiency. Air sampling test was used to evaluate the microbiological load of the high hygiene area air surrounding different locations of packaging line (seasoning area). The obtained results are shown in Table (2).

Results revealed that the air after implementing hygienic requirements of seasoning area by filtrated air was free from any pathogenic bacteria and has low microbial load of bacteria and mold & yeast counts but the air of the same area before implementing hygienic requirements were having high loads of bacteria, mold and yeast counts. In in in Case of devition, corrective action must be taken by checking air filter, maintain or change filter if necessary and the retest again is required. Our results were in agreement with (Khateb Heba, 2014).

1.2. Incoming flavors

Conducting microbiological analysis on the incoming flavors to ensure their food safety and compliance with the specifications. The samples were withdrawal according to ISO 5928. From the results shown in Table (3), we can find that samples flavors were within the limits and thus incoming shipments were accepted. In case of deviation from the limits, it is holded, rejected and returned back to the supplier.

Table (2): Microbiological analysis of high hygiene zone before and after implement hygienic requirements (air sampling).

Seasoning area	Test time	Microbial count (cfu / plate)				
		Total plate count	Mold &yeast	*Staphylococcus aureus*	*E. coli*	*Bacillus cereus*
Limit	----	< 50	< 30	Nil	Nil	Nil
Front	Before	200[a]	100[a]	Nil	Nil	Nil
	After	33[de]	20[d]	Nil	Nil	Nil
Middle	Before	150[b]	70[b]	Nil	Nil	Nil
	After	20[e]	20[d]	Nil	Nil	Nil
End	Before	75[c]	45[c]	Nil	Nil	Nil
	After	15[e]	15[d]	Nil	Nil	Nil

***cfu / plate = colony forming unit / plate.**

***The limits are according to internal specifications.**

*** Values followed by different letter in columns are significantly different at p <0.05.**

Table (3): Microbiological analysis of cheese, kebab and ketchup flavors samples.

Microbiological tests (cfu/gm)	limits	Flavors		
		Cheese	Kebab	Ketchup
Total plate count	≤100000	5.3×10^{2c}	7.3×10^{2b}	8.6×10^{2a}
mold& yeast	≤1000	1.2×10^{2c}	1.4×10^{2b}	1.5×10^{2a}
Bacillus cereus	≤1000	Nil	Nil	Nil
Salmonella	Nil	Nil	Nil	Nil
Staphylococcus aureus	Nil	Nil	Nil	Nil
E. coli	Nil	Nil	Nil	Nil
Coliform group	≤10	Nil	Nil	Nil

***cfu/gm = colony forming unite/1gm and Salmonella only/25 gm:**
***The limits are according to internal specifications as per agreement with supplier.**
*** Values followed by different letter in rows are significantly different at p <0.05.**

1.3. Cleaning and sanitation program.

For all cleaning operations, a visual inspection was performed after cleaning. The effectiveness of cleaning was monitored and results documented. Table (4) shows the results of the microbiological tests of the swabs were taken from different equipment from the processing and packaging lines before and after the implementation of the cleaning and sanitation programs (C&S). The significant decrease in total plate count can be observed clearly, with no pathogens microorganisms (*Staphylococcus aureus, Bacillus cereus, Enterobacteriaceae) and* all microorganisms have been reduced to safe level after implementing (C&S) programs. In case of deviation and the results out of the limits corrective action should be taken by re-clean, re-use of sanitizer (devosan) again, training, awareness of employees and re-swabbing and retest again. The production will not start working unless the results within the acceptable limits.

Our results in agreement with (Forsythe and Hayes, 1998 and Khatab Heba, 2014) who reported that standard number of good microbial load of spoilage microorganisms of food contact surfaces ranged between 2-10/cm^2 while the safe microbial load number is less than 1/cm^2. It was clear also that there was no control in this place already before implementing C&S programs. We had poor cleaning system in food contact equipment and control has not been effective so that is why it was important that corrective action was taken to insure safety food product.

1.4. Personal hygiene.

Table (5) presents the microbiological analysis results of swabs were taken before and after implement workers hygiene CSPs from two processing line (sorting area after frying) and two packaging line (additive flavoring area) to evaluate personal hygiene and ensure the effectiveness cleaning and disinfection program for workers. The results were indicated high contamination with total plate count with the presence of pathogenic microbes (*Staphylococcus aureus, Enterobacteriaceae*) before cleaning & disinfecting of hands.

Table (4): Microbiological analysis of swabs taken from Equipment of two processing and packaging lines before and after implementation of C&S programs.

Location	Tests & limits	Line	Before C&S	After C&S
Bucket (A)	Total plate count (1000 cfu / swab)*	1	2.2×10^{5a}	$4.7\times10^{2\ b}$
		2	9.1×10^{3a}	$4.3\times10^{2\ b}$
	Mold & yeast (Nil / swab)	1	2.1×10^{3a}	Nil
		2	4×10^{2a}	Nil
	Staphylococcus aureus (Nil / swab)	1	Detected	Nil
		2	Nil	Nil
	Bacillus cereus (Nil / swab)	1	Detected	Nil
		2	Nil	Nil
	Enterobacteriaceae (Nil / swab)	1	Detected	Nil
		2	Nil	Nil
Drums (B)	Total plate count (1000cfu / swab)	1	6.6×10^{5a}	3.5×10^{2b}
		2	7.8×10^{3a}	3.8×10^{2b}
	Mold & yeast (Nil / swab)	1	1.9×10^{4a}	Nil
		2	2.1×10^{3a}	Nil
	Staphylococcus aureus (Nil / swab)	1	Detected	Nil
		2	Detected	Nil
	Bacillus cereus (Nil / swab)	1	Detected	Nil
		2	Detected	Nil
	Enterobacteriaceae (Nil / swab)	1	Nil	Nil
		2	Detected	Nil
Vibrators (C)	Total plate count (1000cfu / swab)	1	1.2×10^{4a}	$2\ .9\times10^{2b}$
		2	3.1×10^{4a}	5.3×10^{2b}
	Mold & yeast (Nil / swab)	1	8.1×10^{2a}	Nil
		2	3.6×10^{3a}	Nil
	Staphylococcus aureus (Nil / swab)	1	Detected	Nil
		2	Nil	Nil
	Bacillus cereus (Nil / swab)	1	Detected	Nil
		2	Detected	Nil
	Enterobacteriaceae (Nil / swab)	1	Detected	Nil
		2	Detected	Nil
Ishida (D)	Total plate count (1000cfu / swab)	1	9.3×10^{4a}	2.5×10^{2b}
		2	8.9×10^{5a}	3.3×10^{2b}
	Mold & yeast (Nil / swab)	1	$2{,}1\times10^{3a}$	Nil
		2	1.2×10^{3a}	Nil
	Staphylococcus aureus (Nil / swab)	1	Detected	Nil
		2	Detected	Nil
	Bacillus cereus (Nil / swab)	1	Detected	Nil
		2	Nil	Nil
	Enterobacteriaceae (Nil / swab)	1	Detected	Nil
		2	Detected	Nil

***The limits are according to American public health association. cfu / swab = colony forming unite / swab. 1000 cfu / swab = 1 cfu/100Cm^2**

*** Values followed by different letter in rows are significantly different at p <0.05.**

***A, B, C, D comparison of means by location.**

Table (5): Microbiological analysis of swabs taken from workers for two processing line (sorting area after frying) and two packaging(flavoring area) lines before and after washing and disinfecting the hands.

Location	Worker	Tests & Limits	Total plate count 1000cfu/swab*	Mold & yeast Nil / swab	*Bacillus cereus* Nil / swab	*Staphylococcus aureus* Nil / swab	*Enterobacteriaceae* Nil / swab
Processing (Sorting) (A)	1	Before	3×10^{3i}	50×10^{2a}	Detected[a]	Detected[a]	Nil[b]
		After	9×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	2	Before	9.6×10^{3e}	64×10^{h}	Nil[b]	Detected[a]	Detected[a]
		After	4×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	3	Before	2.8×10^{3k}	72×10^{g}	Nil[b]	Detected[a]	Nil[b]
		After	5×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	4	Before	9.1×10^{3f}	50×10^{i}	Detected[a]	Nil[b]	Detected[a]
		After	4×10^{o}	Nil[l]	Nil	Nil[b]	Nil[b]
	5	Before	4.2×10^{4a}	87×10^{f}	Detected[a]	Detected[a]	Nil[b]
		After	3×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	6	Before	6.2×10^{4b}	90×10^{f}	Nil[b]	Detected[a]	Detected[a]
		After	7×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
Packaging (Flavoring) (B)	1	Before	2.9×10^{3j}	4×10^{2b}	Detected[a]	Detected[a]	Detected[a]
		After	7×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	2	Before	4.8×10^{3h}	2.5×10^{2d}	Detected[a]	Detected[a]	Detected[a]
		After	1.2×10^{2o}	Nil[l]	Nil[b]	Nil	Nil[b]
	3	Before	8.5×10^{3g}	8×10^{k}	Detected[a]	Detected[a]	Detected [a]
		After	2×10^{2m}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	4	Before	1.7×10^{4d}	22×10^{j}	Detected[a]	Nil[b]	Detected[a]
		After	3×10^{2l}	Nil[l]	Nil[b]	Nil[b]	Nil[b]
	5	Before	3.2×10^{4c}	99×10^{e}	Nil[b]	Detected[a]	Nil[b]
		After	2.9×10^{3j}	5×10^{k}	Detected[a]	Nil[b]	Nil[b]
	6	Before	1.4×10^{2n}	3.2×10^{2c}	Detected[a]	Detected[a]	Detected[a]
		After	6×10^{o}	Nil[l]	Nil[b]	Nil[b]	Nil[b]

The limits are according to American public health association: 1000/swab for total plate count Nil/swab for *Mold & yeast Bacillus cereus, Staphylococcus aureus and Enterobacteriaceae.

***cfu/swab = colony forming unite/swab. 1000 cfu/swab = 1 cfu/100Cm^2.**

*** Values followed by different letter in columns are significantly different at p <0.05.**

*** A, B comparison of means by location.**

But after implementing effective hand washing program we found all results of swabs taken within the acceptable limit and high contamination was reduced to the acceptable level for all workers awareness, (Easdani *et al*., 2012).

2. Efficiency of potato frying

Many types of spoilage and pathogenic microorganisms exist on fresh, minimally processed, and fully processed potato products. The microbiological quality of finished potato products is influenced by the natural micro flora, processing, handling, and human contact. The natural micro flora of potatoes is influenced by soil and airborne inoculate, agricultural practices, harvesting methods, and storage conditions (Dona and Davidson, 2000). Frying temperature was set in the range of 175 -180°C and time of fryer is 3 min. in which was efficient and effective for moisture reduction and microorganism destruction. Table (6) shows the data of practical experiment of two potato-processing lines to determine the efficiency of the frying process. The results indicated a high microbial load of raw potato slices before frying in two processing lines. Results showed very high contamination by *(Total plate count*, *Mold & yeast count*, *Staphylococcus aureus*, *Bacillus cereus, E. Coli).* After frying the results indicated that frying process could significantly reduce all microorganisms in raw potatoes to the acceptable level on two processing lines according to (E.S: 1629:2017).

Table (6): Microbiological analysis of potato slices before and after frying for two processing lines.

Microbiological tests (cfu/gm)	processing line	Result before frying	Result after frying	Specification
Total plate count	1	3.6×10^{6a}	10×10^{b}	≤50000
	2	2.7×10^{6b}	7×10^{c}	
Mold &yeast	1	9.0×10^{5c}	1×10^{d}	≤500
	2	6.6×10^{5d}	20×10^{a}	
Staphylococcus aureus	1	Nil^{h}	Nil^{e}	Nil
	2	Nil^{h}	Nil^{e}	
Bacillus cereus	1	3.2×10^{3e}	Nil^{e}	≤10000
	2	5.2×10^{2f}	Nil^{e}	
E. Coli	1	1.2×10^{2g}	Nil^{e}	≤10
	2	2.7×10^{2g}	Nil^{e}	

***cfu/1gm = colony forming unit/1gm.**

***The limits are according (E.S: 1629:2017).**

*** Values followed by different letter in columns are significantly different at p <0.05.**

3. HACCP plan

3.1. Product description and intended use

A full description of the product should be drawn up, including relevant safety information such as: composition, physical/chemical structure, microbiological characteristics and nutritional value. Ingredients and materials used for potatoes chips manufacturing and the intended use of the product are described in Table (7). The intended use should be based on the expected uses of the product by the consumer. As considered against the following headings and recorded as HACCP study notes (SCV, 2006).

Table (7): Product description and intended use.

Item	Product description	
Product name	Fresh slice potato frying in vegetarian oil	
Product description	Potato slices 8 flavors (chili- cheese-salt - salt &vinegar - spicy cheese - kebab- chicken - ketchup)	
Physical properties	Product should be free from rancidity, undesirable odor and slices color ≥55L	
Chemical characteristics	Moisture (3%), Oil (40%), salt before seasoning (3%), Ash (4%) and Free fatty acid (FFA) (1.5%) as oleic oil.	
Microbiological characteristics	Product should be free from microorganisms and pathogenic microbes which causing poisoning and their toxin, bacteria count 50000 cfu, Bacillus count maximum 10000 cfu.	
Nutritional value /10gm	Parameters	Amount (gm)
	Fat	3.94
	Protein	0 .67
	Carbohydrate	4.27
	Saturated fat	1.22
	Un Saturated fat	2.72
	Cholesterol	0.0
	Fiber	1.12
	Vitamin A	0.0
	Vitamin C	0.003
	Sodium	0. 05
	Calcium	0.003
	Iron	0.003
	Calories /10g	65.27 kcal
Raw& packing material	Potato – palm oleic oil - flavor - film PPM 40µ - Carton single B - printing rolls - adhesive rolls - a starch roll.	
Stock keeping units SKUs	13-17 mg , 24-28gm, 62-72gm.	
Storage conditions	Store in a cool and dry place away from sunlight.	
Distribution method	Malls - supermarkets - restaurants - retails - big markets.	
Shelf life	6 months.	
Customer requirements	Direct consumption.	
Intended Use/target group	Ready for consumption for all ages.	

According to Egyptian standard E. S 1629 / 2017, PPM: Polypropylenemetalize.

3.2. On-site verification of flow diagram: and process step

All processes steps activities are described in details to explain the purpose of each step in the process.

3.3. Hazard analysis (List hazards, conduct hazard analysis, consider control measures)

Collect information about hazards and evaluating hazard analysis and hazard assessment is being done for each step of potatoes chips manufacturing starting from receiving till finished product storage.

3.4. Determining CCPs and it is critical limits:

Decision tree to determining CCPs must be done for each identified significant hazard (CAC/RCP-4, 2003). To determine the critical limits for each CCP by using list of supporting documents and as well as OPRP are necessary. To differentiate between the control measure classifications either CCP or OPRP for each identified significant hazard using (ISO 22004, 2014) as shown in Table (8).

Easdani *et al*. (2012) included hazard description, critical limit, observation procedure, responsible person, monitoring procedure and corrective action in his HACCP control chart for production of potato chips plant in Bangladesh. Metal detector was only CCPs found in the processing of potato chips its represent physical hazard and three OPRP were found in the processing of potato chips. It is receiving potato "Physical hazard", frying potato "Chemical hazard" and frying potato "microbiological hazard ". Records of monitoring must be kept to ensure the effectiveness of the HACCP system.

All CCPs, OPRP points identified should be monitored and verified as shown in Table (9).

4. Finished products control:

After the implementation of the food safety program and ensuring its effectiveness. According to the HACCP plan, samples were taken from the finished product and the results obtained from Table (10) showed that microbiological tests carried out on the finished products were within the permissible limits and that the product is completely free of pathogens. Also the results of chemical tests and physical properties includes packaging quality evaluation (scrap breakage, greening, peel removal and defects) showed that the product is within the permitted limits and of high quality according to the Egyptian standards. Physicochemical properties including moisture content, oil, salt, color, and absolute density in three types of potato chips are listed in Table (10). There was no difference in moisture content among the three types of potato chips. It was observed that fried potato chips (FPC) contained the highest oil content. Finally, sensory parameters (color, taste, odor, texture and acceptability). Sensory acceptability scores differed depending on the salt concentrations used for the preparation of potato chip samples which affects the liking of food products. Results of the sensory tests of the product also showed that it is acceptable according to consumer taste and marketing requirements. All above mentioned elements are considered the release criteria of the product. Our results are in agreement with Dona and Davidson (2000); Krokida *et al*. (2000) and Pedreschi and Aguilera (2002).

Table (8): Consider control measure and classification it into (CCP or OPRP).

Step and Hazard			Control measures	To Categorization of control measures in OPRPs and CCPs. Answer questions.						
Transferred hazards which considered as significant from the hazard assessment			Select and describe a control measure or combination of control measures capable of preventing, eliminating or reducing the hazard to an acceptable level.	Q1: Based on the likelihood of occurrence and the severity of adverse health effects, is this hazard significant? (see hazard assessment table) YES: This is a significant hazard. Go to Q2. NO: This is not a significant hazard.						
					Q2: Will subsequent steps alone or in combination guarantee the removal of this significant hazard, or its reduction to an acceptable level? YES: Identify and name subsequent step. NO: Go to Q3.					
						Q3: Are control measures or practices in place at this step and do they exclude, reduce or maintain this significant hazard as necessary? YES: Go to Q4. NO: Modify the process or product and go to Q1.				
							Q4: Is it necessary to establish critical limits for the control measure at this step? YES: Go to Q5. NO: This hazard is managed by an OPRP.			
								Q5: Is it necessary to monitor the control measure in such a way that action can be taken immediately when there is a loss of control? YES: This hazard is managed by control measures at a CCP. NO: This hazard is managed by an OPRP.		
S.N	Step	Hazard	Description of control measures	Q1	Q2	Q3	Q4	Q5	CCP / OPRP	Justification for decision
1	Receiving	physical hazard (foreign bodies)	Perforated conveyer	Yes	No	Yes	No	No	OPRP1	Perforated conveyor is the step to manage and control the physical hazards by trapping of (Foreign bodies≤2cm, dusts, stones, and sprout …etc.) followed by washing process step.
2	Frying	Microbiology hazard (temperature)	monitoring temperature	Yes	No	Yes	Yes	No	OPRP2	Frying at (175-180°C) kills microorganisms present in potatoes and this step ensure that fried slices are within safe limits.
3	Frying	Chemical Hazard (FFA %)	matrix oil management	Yes	No	Yes	Yes	No	OPRP3	Frying is the step to manage and control the content of free fatty acids in the acceptable limits and this step is designed for this purpose.
4	Packaging	Physical hazard (ferrous/non ferrous /steel)	In line metal detector	Yes	No	Yes	Yes	Yes	CCP1	Metal detector is specially designed and it is the last step for physical hazard elimination.

Table (8): Monitoring and verification for CCPs and OPRPs.

	Step	Hazard description	Control measure (s)	Critical Limits / Targets (or Limits if applicable)	Monitoring			Corrections/ Corrective actions Responsibilities	Records	Verification details
					How	Frequency	Who			
OPRP1	Receiving potato	Physical hazard	Perforated conveyor	(Mud, stones, sand, wood, plastic or Any small foreign bodies (F.B) ≤2cm	Remove dust, stones, and,...etc. through perforated conveyor	Very discharge of potato	Agriculture technician	Repair or replace conveyor and Identify the root cause	Potatoes receiving sheet	Frequent checking of the pored conveyor and ensuring frequent removal of the trapped (F.B)
OPRP2	Frying	Microbiological	Frying temperature	175-180°c	Measuring temperature and microbiolog analysis before and after frying	Temp monitoring every hour and micro analysis every month	Quality engineer & Technician	Stop the line and reject the defected product, check heat exchanger and Identify the root cause	Processing monitoring sheet	External calibration of temperature sensors
OPRP3	Frying	Chemical	Hygienic design of fryer	FFA ≤ 0.24 % as oleic oil	FFA % content measuremen t by titration with NAOH	according to matrix oil manageme nt if FFA ≤0.12 every 4 h >0.12 ≤0.15 every 2h >0.15 every h	Quality Technician	Mix with fresh oil according to matrix oil management. (If FFA≤0.18 feed 50%fresh oil& 50% if FFA 0.19-0.24feed 80%fresh oill&20%used oil if FFA >0.24 feed 100% fresh oil) Identify the root cause and confirm from FFA %	Processing monitoring sheet	FFA test
CCP1	Metal detector	Physical hazard (ferrous/ nonferrous /steel)	Sensor efficiency	Absence of all F.B metals even for less than 1.5mm	Metal detector sensor verification by a metallic identified sample	Every 2 hour	Lab technician	Stop the machine automatically (immediately) and reject the defected product. Identify the root cause and restart the line	Metal detector monitoring sheet	External calibration for sensor

Table (10): Microbiological, chemical analysis, physical properties and sensory evaluation of finished products.

Parameters	Limits	Products		
		Cheese	Kebab	Ketchup
Microbiological tests (cfu/gm)				
Total plate count	≤ 50000	2.5×10^{2c}	3.7×10^{2b}	4.5×10^{2a}
mold& yeast	≤ 500	1.1×10^{2c}	1.4×10^{2b}	1.8×10^{2a}
Bacillus cereus	≤ 1000	Nil	Nil	Nil
*Salmonella**	Nil	Nil	Nil	Nil
Staphylococcus aureus	Nil	Nil	Nil	Nil
E. Coli	Nil	Nil	Nil	Nil
Coliform group	≤10	Nil	Nil	Nil
Chemical analysis				
Free Fatty Acids content (%)	≤ 1.5	0.22	0.22	0.22
Moisture content (%)	≤ 3%	1.35	1.35	1.35
Oil content (%)	≤40%	33.43	33.43	33.43
Peroxide value (mEq/Kg)	≤10	5.3	5.3	5.3
Salt content after seasoning (%)	(4.5-5.5)	4.8	4.9	5.1
Ash	≤ 4%	3.55	3.59	3.45
Physical properties				
Breakage	≤ 15%	6%	7%	9%
Complete - In bag	≥ 60%	85%	80%	75%
Greening	≤ 3 %	1.9 %	1.8 %	1.9 %
Peel removal	90% - 95%	90%	92%	94%
Defects	≤ 12%	7.8%	7.9%	7.8%
Sensory evaluation				
Color	≥5	8	7	6
Taste	≥ 5	7	8	6
Odor	≥ 5	8	7	6
Texture(crispness)	≥ 5	7	7	6
Overall acceptability	≥ 5	7.50	7.25	6.00

*** cfu/1gm = colony forming unit/1gm * Salmonella only cfu/25 gm.**
***The limits are according Egyptian standard for fried potato (E.S: 1629:2017).**
*** Values followed by different letter in rows are significantly different at p<0.05.**

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السيطرة على المخاطر المحتملة في تصنيع رقائق البطاطس من خلال نظام إدارة سلامة الأغذية (FSMS ISO 22000)

رشا عبد الحليم محمد عيسى[١]، موسى عبده سالم[١] ، سمير يوسف السناط[٢]

[١] قسم علوم وتكنولوجيا الاغذية، كلية الزراعة جامعة طنطا، مصر

[٢] قسم علوم وتكنولوجيا الاغذية، كلية الزراعة جامعة كفر الشيخ، مصر

الملخص العربي

تهدف هذه الدراسة إلى تصميم خطة تحليل المخاطر ونقاط التحكم الحرجة (HACCP) لإنتاج رقائق البطاطس من خلال نظام إدارة سلامة الأغذية FSMS ISO22000 بناءً على الظروف الفعلية في المصنع. تم تطوير نموذج محدد لتعزيز سلامة وجودة منتج رقائق البطاطس في هذا المصنع. تم تصميم برامج المتطلبات الاشتراطية الأولية (PRP) وبرامج المتطلبات الاشتراطية الاولية التشغيلية (OPRPs) والمخاطر ونقاط التحكم الحرجة (CCP) والاجراءات التحكمية والحدود الحرجة وإجراءات المراقبة والإجراءات التصحيحية ضمن خطة HACCP . التحليل الميكروبيولوجي للنكهات الواردة كانت ضمن الحدود المسموحة، وبالتالي تم قبول الشحنات الواردة ولن يتم القبول من المورد في حالة الخروج عن الحدودالمسموح بها. أظهرت نتائج الفحص الميكروبيولوجي للبطاطس الخام قبل وبعد القلي أن عملية القلي خفضت بشكل كبير جميع الكائنات الحية الدقيقة في البطاطس الخام إلى المستوى المقبول على خطي المعالجة. تم وضع برنامج نظافة وتطهير خطوط الانتاج وبرنامج النظافة الشخصية للعاملين والتأكد من فاعليتهم. تم اجراء الاختبارات الكيميائية، الميكروبيولوجية، الفيزيائية والحسية للتاكد من سلامة وجودة المنتج النهائى.

السادة المحكمين

أ.د/ أحمد محمد فتوح جعفـــــــر مركز بحوث تكنولوجيا الأغذية

أ.د/ السيد حلمى عبدالسلام رحمه كلية الزراعة – جامعة المنوفية