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Hazard Analysis Critical Control Points (HACCP) Application during Olive oil centrifugal extraction

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Abstract: *Olive fruit is considered as one of the most important fruit crops in Egypt. Olive fruits could be processed to produce olive oil which, consumed strongly these days as a results of its desirable biological effects. HACCP system is an international preventive system concerning with food safety. So, the present work was carried out to investigate the possibility of implementation of HACCP system during olive oil extraction using centrifugation system to improve the quality and safety of olive oil production. Hazard analysis was conducted to identify hazards that may be occur in the product cycle and to assess the preventive measures for controlling them, critical control points (CCPs) were determined to control the identified hazards. Critical limits were established at each CCP, appropriate monitoring system was established for each CCP to monitor its control , Corrective actions to be taken when monitoring indicates deviation or loss of control were established, Verification procedures were established to confirm that the HACCP system is working effectively, Documentation concerning all procedures and records were established. HACCP system can be also used to control the safety and quality of olive oil extraction plant.*

Key words: *GMP, Hazard, HACCP, Centrifugal Extraction, Quality, Olive oil, Safety*

I. Introduction

Olive tree (Olea europea L.) has been cultivated for thousands of years in The Mediterranean countries, these countries are still responsible for more than 90% of the world's olive oil, **(Bianchi, 2002)**. Virgin olive oil is defined as that the oil obtained from the olive fruit through physical procedures, which include washing, grinding, mixing, pressing, decantation, centrifugation or filtration, without being mixed with oils of another nature **(José and Yousfi, 2006)**. There are many factors affecting the quality of olive oil, which could be categorized as those which act during oil formation in fruits, collection of olive fruit, storage of olive fruits, extraction of oil and storage of extracted oil, **(Kiritsakis, 1990)**. Many investigations concerning these factors were carried out and, in particular, the influence of technological operations of olive processing on oil yields and quality was examined, **(Di Giovacchino et al., 2002)**.

Olive oil extraction process is affected by handling operation and various practices during manufacturing which may sometimes cause some risks and damage that effect the olive oil quality.

Food-borne illness is the major problem of food contamination. Microorganisms contaminating food may be nonpathogenic and yet may cause chemical changes that render food unit worthless for human consumption or may be pathogenic and cause infections or food poisoning and various gastrointestinal diseases when consumed, **(Anonymous, 1984)**. Food safety can be thought of as the set of conditions and practices during the production, processing, storage, distribution, preparation, and secondary storage of complementary foods (as olive oil) that are necessary to protect them from pathogenic microorganisms, exogenous chemical contaminants, naturally occurring toxic substances and newly formed toxic compounds produced during food storage, processing, or preparation, **(Motarjemi et al., 1993)**

HACCP system is an international preventive system concerning with food safety. Essentially, HACCP is a system that identifies and monitors specific food borne hazards (biological, chemical, or physical properties) that can adversely affect the safety of the food product **Codex, (1997)**.

So it was interest to follow HACCP system in the olive oil extraction processes to identify and control these risks to produce a high quality, healthy and safety product. So, the aim of the present work is investigate the possibility of application HACCP system in olive oil extraction by centrifugation system to improve the quality and safety of olive oil.

II. Materials And Methods

1- Study Area:

This study was performed in olive oil centrifugal extraction plant in Marsa Matrouh governorate, Egypt. The plant supplies the local markets in Matrouh and other Egyptian cities by olive oil.

2- Listing the prerequisite programs

The prerequisite programs (PRPs) represent the conditions and/or the necessary basic activities to develop the seven principles of HACCP system during olive oil extraction in the olive oil extraction plant under investigation were evaluated according to **(E.S., 2005b).**

3- Application of HACCP system

According to the **NACMCF (1992 and 1998),** HACCP system was applied during extraction steps of olive oil by centrifugation method based in the following seven principles: 1) Conduct a hazard analyses. 2) Identify the critical control points (CCPs). 3) Establish critical limits for preventive measures associated with each identified CCP. 4) Establish CCP monitoring requirements.5) Establish corrective actions to be taken when monitoring indicates then a deviation from an established critical limit. 6) Establish verification procedures. 7) Establish record-keeping and documentation procedures. The results were summarized with reference to CCPs and their monitoring on the HACCP control chart.

III. Results And Discussion

1- Prerequisite programs (PRPs):

Prerequisite programs (PRPs) are the basic environmental and operating conditions essential for the safe production of food. Unlike HACCP which is product and process specific, prerequisite programs are more general and apply to all areas in a food production facility. Examples of prerequisite programs include, but are not limited to, Good Manufacturing Practices (GMPs), Good Hygiene Practices (GHPs), Standard Operating Procedures (SOPs) and Sanitation Standard Operating Procedures (SSOPs). The design and construction of food premises are also part of the prerequisite programs.

HACCP is not a standalone system. Prerequisite programs are critical to the successful application of HACCP as they provide the foundations for developing effective HACCP systems. Prior to implementing HACCP and also after a HACCP plan is implemented, it is imperative that prerequisite programs are in place **(E.S.,2005b)**

It could be noticed that, Location of extraction plant, design buildings external, walls, doors, devices and machines and disposals tanks were satisfactory according to the criteria listed in **E.S., 2005b,** on the other hand, the following areas in the oil factory should be physically separated: olive reception, washing, oil extraction and separation, oil storage and packaging, **(Petrakis, 1994).** We observed also that, the grounds of building of the plant or store are not sloped and drained to prevent stagnant water and not free of waste and debris, in the same time the plant has good lighting and ventilation .

Quality control practices and its device were not applicable where the temperature of the olive oil extraction plant was not recorded and the microbiological characteristics of water used in the olive oil extraction plant were not evaluated then the safety of water used in the extraction plant was not determined this could be one of the major contamination sources during different extraction steps.

In the same time, operation control was not applicable, so, we suggested a simple HACCP system to operation control. Also, maintenance and sanitations were not applicable where program of pest control was not applicable and there is no program for waste management of wastes produced during extraction process. According to the results of observation of personal hygiene of workers in the extraction plant under investigation it could be noticed that, hygiene and sanitation practices of workers in the extraction plant were not enough and workers should learned more about personal hygiene especially washing their hand with soap and sanitizers after toilet, using gloves, covering their hairs and refraining from placing fingers in mouth, nose, ears and from eating, chewing, spitting and smoking during food handling operation .

Pest control program was to eliminate from rodent, insects and birds. Modern pest management programs are designed to allow pest prevention as well as control.

2- Implementation of HACCP system on Centrifugation mill:

The details of the flow diagram are shown in Figure 1. The process flow diagram was verified to establish that diagram accurately represents the actual activities and operations used in the manufacture of the product. This was done by observing each step of the manufacturing process.

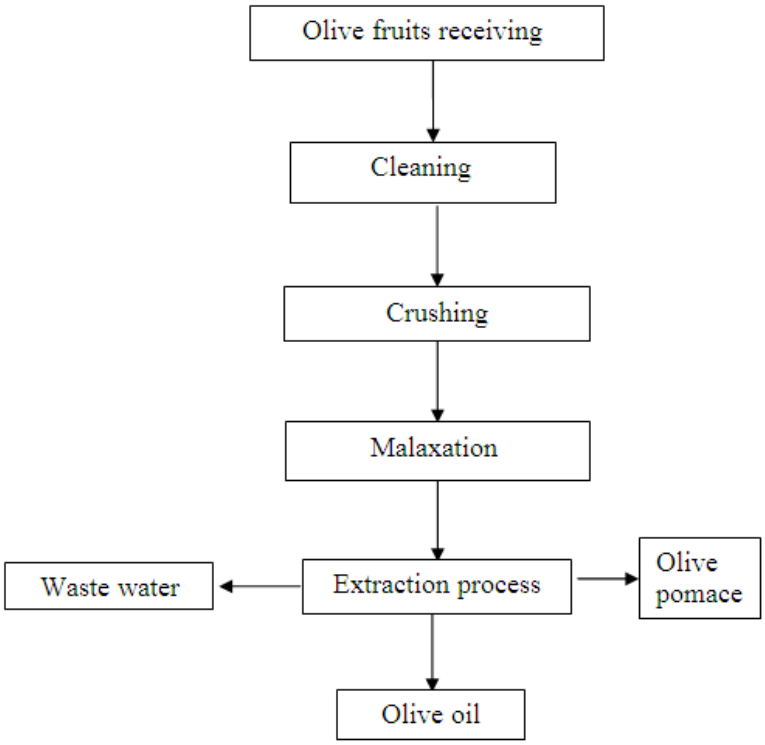

Figure (1): Flow diagram of olive oil extraction by Centrifugation method.

The description of product (Table 1) was used to alert the consumer of potential hazards in the final product.

Table (1): Olive oil product description

Product name	Olive oil
Important characteristics	Free fatty acids : less than 3.3 % Peroxide value : less than 20 K232 : less than 3.50 K270: less than 0.30
The intended use	Ready to use
Packaging	Dark glass bottles
Where it will be sold	Retail store
Labeling instruction	Keep in dry place
Distribution condition	Room temperature

2-1- Hazard analysis:

2-1-1- Product ingredient and incoming materials:

Table (2) shows the biological, chemical and physical hazards in the raw material and added water during centrifugal extraction of olive oil. The table also, includes the preventive measures for the hazards in each material.

Table (2): The hazard identified in olive oil ingredients and their preventive measures

Ingredient/ material	Hazards	Preventive measure
Olive fruits	BCP	Qualified fruits supply Proper personal hygiene and handling Transfer in suitable plastic pox
Water	BCP	Supply quality water

B: biological C: chemical P: physical

2-1-2- Olive oil extraction steps:

In table (3), the preventive measures are provided for hazards in each processing step. All the control situations were set up under the requirements of this line to produce safe and good quality product (olive oil).

Table (3): The hazard identified in olive oil processing steps and their control measures

Processing steps	Hazards	Control measure
Olive fruits receiving	BCP	Qualified fruits supply Good transportation handling Good washing process

Cleaning	BCP	Supply quality water Proper personal hygiene and handling
Crushing	BP	Proper personal hygiene and handling Proper unsuitable cleaning process
Malaxation	BC	Proper unsuitable cleaning process 35C/ 60 min
Extraction	BCP	Suitable extraction condition (time , sieving , added water) Supply quality water

B: biological C: chemical P: physical

2-2- Critical Control points (CCP) identification:

The critical control points were identified according to HACCP decision tree (Table 5) as recommended by **Pierson and Corlett, 1992; Codex, 1993 and Riswadkar, 2000**.

Table (4): The decision tree of olive oil centrifugal extraction line

Processing step	**Category and identified hazard**	Q1	Q2	Q3	Q4	CCP
Receiving of olive fruits	Microbiological infection (B)	No	No			CCP
	Suitability of olive (PB)	Yes	Yes			
	Mechanical damage (P)	No	Yes			
	Insect infection (B)	No	Yes			
	Foreign materials(P)	No	Yes			
	Pesticides residues (C)	No	Yes			
	Enzymatic reactions (C)	Yes	Yes			
Cleaning (leaves removal and washing)	Water quality (B)	Yes	Yes			CCP
	Reuse of excessive wash water (B)	Yes	No			
	Washing time (B)	Yes	Yes	Yes	No	
	Foreign materials (P)	Yes	Yes			
	Pesticides residues (C)	No	Yes			
Crushing	Microbiological infection (B)	No	No			
	Foreign materials (P)	No	No			
Malaxation	Microbiological infection (B)	Yes	Yes			CCP
	Emulsions formation (C)	Yes	Yes			
	Enzymatic reactions (C)	Yes	Yes			
Centrifugal extraction	Water quality (B)	Yes	Yes			CCP
	Oil degradation (C)	Yes	Yes			
	Emulsion formation (C)	Yes	Yes			
	Impurities (P)	Yes	Yes			

B: biological C: chemical P: physical

2-3- Details of HACCP control chart of centrifugal extraction line of olive oil:

In spite of the results of decisions tree **(Table, 4)** we proposed a HACCP plan summarized in **Table (5)**

2-3-1- Receiving of raw materials (olive fruits and water):

a. Hazards:

The received olive fruits must be free of damage olive fruits and at health statue. Chemical contamination (pesticides residues and heavy metal), microbiological infection, insect infection, enzymatic reactions, mechanical damage and foreign materials are the main hazards in this step.

b. Control measures:

Separate poor olive fruits and health olive fruits and good transportation handling (plastic box with suitable pores and olive fruits height must not be over than 25-30 cm) are the speed control measures at this step.

c. Critical limits:

The received olive fruits must meet the good manufacturing practice, **(Petrakis, 1994)**, mechanical damage should be minimized and fermentation or mold growth preventive, the direct contact of olive fruits with the soil should be avoided (suitability of olive fruits), good transportation handling to prevent undesirable enzymatic reactions and the growth of yeasts and molds and adequate sanitary conditions.

d. Monitoring actions:

We shall need regular visual inspection of different items, microbiological and chemical analysis of different samples (also, physical inspection may be important).

e. Corrective actions:

The plant manager must be rejected unsuitable items; poor quality olive fruits should be processed separately. Also, training of operators on good manufacturing practice must be conducted.

f. Verification procedures and documentation:

All entry items must be recorded and checks carried out on them, the rejection of unsuitable items, the list of approved suppliers and fitness of these items, developing particular specifications for the raw material, the results of physical, chemical and microbiological analysis of different samples, the rejected batches, the courses given to operators and any control measures.

2-3-2- Cleaning (leaves removal and washing):

a. Hazards:

The main purpose of this operation is to remove impurities which bear the fruits in the field.

The main hazard sources are excessive stresses reuse of washing water (since it produces the opposite effect, that is, the contamination of the raw materials by microorganisms), foreign material, pesticides residues, heavy metals and water quality.

b. Control measures:

The main preventive measure to ensure renewed frequently washing water (by physical inspection of water). It will be essential to apply effectiveness of cleaning and disinfection program to equipments. Microbiological and chemical analysis of different samples.

c. Critical limits:

The washing water must be renewed as often as necessary, the water used for washing must be potable in accordance with **E.S., 2005a** and national law. Leaves and small drenches that are normally collected with olives during harvesting should be removed (the weight of these materials should not exceed 1% of the total olives). Also, good hygiene practices are an important parameter for olive oil production during this step.

d. Monitoring actions:

The state of dirt's of washing water must be inspected periodically to ensure that it meet good manufacturing practice. Physical inspection of washing water (color – odor). Application of preventive program of cleaning and disinfection of equipments

e. Corrective action:

If the dirty olive reaches to plant, the rate of replacing washing water must be increase. Another corrective measure related to the preventive programs of maintenance, cleaning and disinfection of equipments is required.

f. Verification procedures and documentation:

Record frequency of water changes, temperature, preventive programs of maintenance, cleaning and disinfection of equipments and any corrective measures applied.

2-3-3- Malaxation process:

a. Hazards:

The main sources of hazard during malaxation process are microbiological growth, enzymatic reaction and emulsion formation.

b. Control measures:

One of the must important control measures is equipment state which affects the contamination degree. Malaxation temperature and time (≤35C , 60 min) are another important control measures which affect the microbiological growth, enzymatic reaction and emulsion formation. The emulsion formation is related to the oil loss which considers another control measure.

c. Critical limits:

Good manufacturing practice of olive oil production requires that the temperature of heating fluid in the jacket of malaxation machine should never exceed 45 C , **(Petrakis, 1994)**. Also, the temperature of olive paste should never exceed 35 C and malaxation time should never exceed 60 min, **(Tzia, et al., 1999).**

d. Monitoring actions:

The main important parameters which must be monitored are malaxation temperature and time, heating fluid temperature and oil loss. Also, the cleanness and integrity of containers as well as absence of extraneous material inset them should be guaranteed and carefully control.

e. Corrective action:

Visual inspection of malaxation temperature and time, heating fluid temperature**, (Petrakis, 1994)** (adjusting them to allowing range if they were out of range) and corrective programs of cleaning and disinfection of equipments. Also, microbiological analysis of different samples during malaxation process.

f. Verification procedures and documentation:

Record malaxation temperature and time, heating fluid temperature, cleaning and disinfection programs and any other control measures.

2-3-4- Extraction of olive oil:

a. Hazards:

The main sources of hazard related to extraction of olive oil by centrifugation are emulsion formation, enzymatic reactions, impurities and oil degradation.

Water contamination which may play an important role in oil separation is another hazard source.

b. Control measures:

The first control measure during extraction of olive oil by centrifugation is operation efficiency (by oil loss and processing time) and equipment state (cleaning program). The drinking water to be used must prevent microbiological contamination.

There are other important control measures which related to olive oil quality such as FFA, TBA, PV, K_{232}, K_{270} and polyphenols.

c. Critical limits:

The critical limits will be marked by good manufacturing practice (cleaning and disinfection programs) and olive oil specification (FFA (3.3), PV ($\leq$ 20), K_{232} (3.5) and K_{270} (0.2)).

Making sure that process water must be potable in accordance with **E.S.,2005a** and national law, **(Petrakis, 1994)**.

d. Monitoring actions:

We shall need to monitor regular visual inspection of processing efficiency, water quality, FFA, TBA, PV, K_{232}, K_{270}, polyphenols, equipment stat and good hygiene practices.

e. Corrective action:

The corrective preventive is, maintenance, cleaning and disinfection programs of equipments. If necessary, there will be training the operators to improve handling practices

f. Verification procedures and documentation:

Recorded preventive maintenance, cleaning and disinfection programs of equipment, training courses if they were necessary and any control measure

IV. Conclusion

As a result of development and improvements in food industry and international trade, consumers are demanding safe and wholesome food products, so, many food industry companies are planning to use food safety management systems to insure the production and distribution of safe foods. The HACCP system in this study for centrifugal extraction of olive oil is developed step by step based on the seven principles of HACCP. By answering the questions in decision tree, the critical control points were determined. Then the HACCP control chart was developed to include critical limits, monitoring and corrective action. Further research is needed to design HACCP plans for other olive oil extraction methods.

Table (5): HACCP Control Chart of olive oil extracted by Centrifugal system

Critical control point (CCP)	Hazard	Control measures	Critical limits	Monitoring action	Corrective action	Verification procedures and documentation
Receiving of raw materials (olive fruits and water)	*Microbiological infection *Insect infection * Mechanical damage *Pesticides residues *Trace elements *Enzymatic reactions *Foreign materials	*Separation of ground of flight and health olives *Separate ground of flight and health olives *High quality drinking water *Good transportation handling	*Suitability of olive *Meeting the specifications of drinking water *Adequate sanitary conditions *Good transportation	*Visual inspection of each items *Microbiological and physicochemical analysis of water *Microbiological and chemical analysis of samples	*Reject unsuitable items *Poor quality fruits must processed separately *Switch point water supply *Conduct training for operators	*Develop particular specifications for the raw materials *Corrective measures *Recording raw materials
Cleaning (leaves removal, washing)	*Water quality *Foreign materials *Washing time *Reuse of excessive wash water *Pesticides *Heavy metal	* Microbiological analysis of samples * Effectiveness program of cleaning and disinfection *Renew frequently wash water	*Adequate renewal of the washing water *Incr ease wash time *Good hygiene *Good performance of equipment	*Visual inspection of wash water dirt *Correct application of the programs preventive cleaning and disinfection of equipment *Physiological inspection of washing water (color – odor)	*Increase the rate of replacing the washing water *Correct programs preventive cleaning and disinfection of equipment	*Frequency of changes water * Programs preventive cleaning and disinfection of equipment *Corrective measures
Malaxation process	*Microbiological infection *Enzymatic reactions *Emulsions formation	*Equipment (state, cleaning) * Malaxation temperature and time (<35ºC, 60min) *oil loss	*Good performance of equipment *Suitable malaxation conditions (35 ºC, 60 min)	* Malaxation temperature and time	*Visual inspection of malaxation temperature and time *Correct preventive programs of cleaning and disinfection of equipment	* Cleaning and disinfection programs of equipment *Visual inspection of malaxation temperature and time
Extraction of olive oil by Centrifugation	*Enzymatic reactions *Emulsions formation *Water quality *Impurities *Oil degradation	*Operations (time, efficiency, oil loss) *Equipment (state, cleaning) *Cleaning program and adequate disinfections *Oil loss *FFA, PV, TBA, K232, K270, poly phenols	* Processing time *Minimum oil loss *FFA, PV, TBA, K232 , K270, poly phenols *Olive oil specification *Good performance of equipment	*Visual inspection of processing time, water quality *Visual inspection of FFA, PV, TBA, K232, K270, poly phenols *Good hygiene practices *Periodic visual inspection of equipment	*Correct preventive programs of maintenance, cleaning and disinfection of equipment *Training program	*Preventive programs for cleaning and disinfection of equipment *Visual inspection of FFA, PV, TBA, K232, K270, poly phenols

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