IMPROVING THE PERFORMANCE OF POTATO CHIPS PRODUCTION LINE

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ABSTRACT

This study was carried out in potato chips production line to improve the performance of production line. The peeling device heat and control (Mod BP) potato batch peeler type was modified to suit the different varieties of potatoes were used and its performance was evaluated. Two different varieties of potato (Hermes and Lady Rosetta), harvested from two soil type (sand and clay), under using two peeling processes (conventional and modified). The measurements were taken before and after modified potato peeler to measure the performance of the peeling process and the quality of the final potato as chips. The results showed that when used modified potato peeler the peeling efficiency was increased by 3.1 %, the mechanical destruction of the potato tubers were decreased by 32.7 %, the peeling time of every batch decreased by 17.7 % so the peeler productivity per hour increased by 21.9 % and the water consumption decreased by 17.6 % . The properties of the final product were improved as the oil content percentage was decreased by 2.4 %. That means dropping of use oil and processing time addition to have more healthy product.

INTRODUCTION

Potatoes (*Solanum tuberosumL.*) are one of the essential food crops in the world and are grown in more than 100 countries under temperate, subtropical and tropical conditions. Its worldwide production in 2010 was close to 324 million tons and the plant was grown on approximately 19 million hectares**. FAO, (2011)**. **Maryam and Mohsen (2015)** reported that, the potato plant is a staple in the food diet of many people around the world and ranks second after rice in terms of widespread global distribution. Approximately 34% of the total potato crop is produced in Asian countries.

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Probably due to its high calorie content, potato has, throughout the years, been a main supplier of energy in people's food. The protein in potato is of a high biological quality, supplying 8 or 9 types of amino-acids which cannot be produced by human body. **Abdollah and Amir (2013)** pointed out that determination of physical properties of the potato, and their variations during long-term storage, is an important feature in achieving high product quality and consumer acceptance. Physical properties of potatoes (Agria, Satina, and Caesar cultivars), including surface area, volume, moisture content, weight, and three main diameters of tuber, were measured and then other properties, such as sphericity, roundness, geometric mean diameter, volume mean diameter, aspect ratio, effective diameter, and real density during storage time, were calculated **Trehan *et al.*, (2009)** mentioned that one of the main considerations during tubers selection as raw processing materials is the potato cultivar. Additionally, environmental conditions, cultivation methods, handling during harvesting and storage also play an important role in determining the quality of processed products**. Miranda and Aguilera, (2006)** noted that Potato slices for chips are commonly cut thin (1.27-1.78 mm thick) and fried until the water content is reduced from 75-80% to 1-2% wet basis . **Troncoso, *et al*., (2009)** found that vacuum frying significantly increased the oil content of potato chips, decreased color and texture parameters, and improved both flavor and overall quality.

One of the factors affecting the quality of potato chips is the physical characteristics of the potato from which it is made as not all potato varieties will produce high quality chips. Potato chips makers source potatoes from different locations during different seasons and thus may encounter substantial variability in the physical characteristics of the raw potatoes that could affect the performance of the production line and the final chip quality.

The objective of this study was to improve the performance of the production line by modifying the potato peeler to minimize peeling losses and amount of water spraying washes also maximize the total efficiency of the production line addition to evaluate the impact of the physical and mechanical characteristics of potato samples selection to suite potato chips production.

MATERIALS AND METHODS

The study was carried out in Special factory of making potato chips at Quesna, EL-Menofeya Governorate, Egypt during a period from JAN 2015 to JAN 2016. To evaluate and improve the performance of potato chips production line. Also to test the modifying of the potato peeler under different parameters processed to minimize peeling losses, peeling time and amount of water spraying washes, addition to maximize the productivity and total efficiency of the production line.

Potato variety

Using different varieties of potato (Hermes and Lady Rosetta), (*Solanum tuberosumL.).* A comparison between the potato varieties used in the experiment as shown in Table 1 and Fig, 1 and 2

Table (1): The properties of potato varieties used in the experiment

Potato variety	*Lady Rosette*	*Hermes*
Tuber shape	round	round oval
Skin color	red	Yellow
Flesh color	pale yellow	Yellow
Eye depth	shallow	medium depth
Maturity	medium early	medium early
Yield	High	High
Dry matter	high	Reasonable
Cooking type	floury	Floury
Use	Chips	Chips

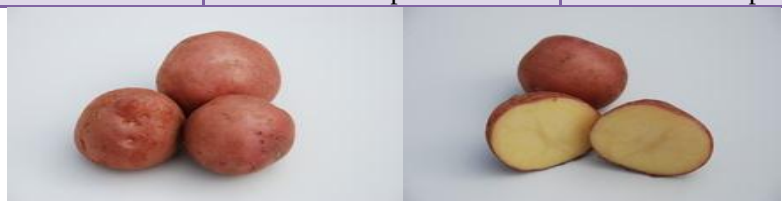

Fig. (1) Lady Rosetta potato variety

Fig. (2) Hermes potato variety

Potato chips production line

The production line consists of a dynamic system of interdependent stages linked together to convert the potato into a chip as showing in Fig.3

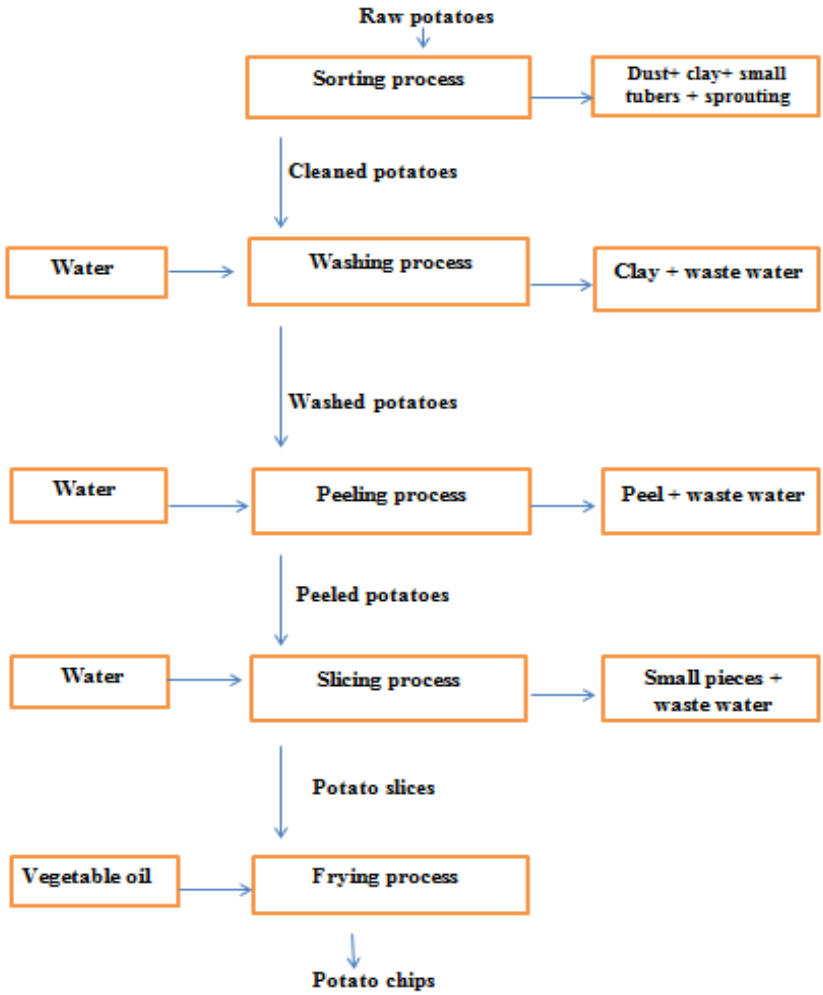

Fig. (3) Diagram of potato chips production stages

Modified peeling machine

For the processing of potatoes in to potato chips, removal of peel is an important unit operation. So, peeling device (Heat and Control Mod BP) potato batch peeler type was modified as showed in (Fig. 4) to suit the different varieties of potatoes and its performance was evaluated. The main parts of the machine are a peeling drum and a water spraying unit.

The peeling drum inside surface covered with emery paper to detach peel from potatoes by abrasion. The water spraying unit washes the potatoes and simultaneously peel is removed from the drum through the perforation along with the flow of water.

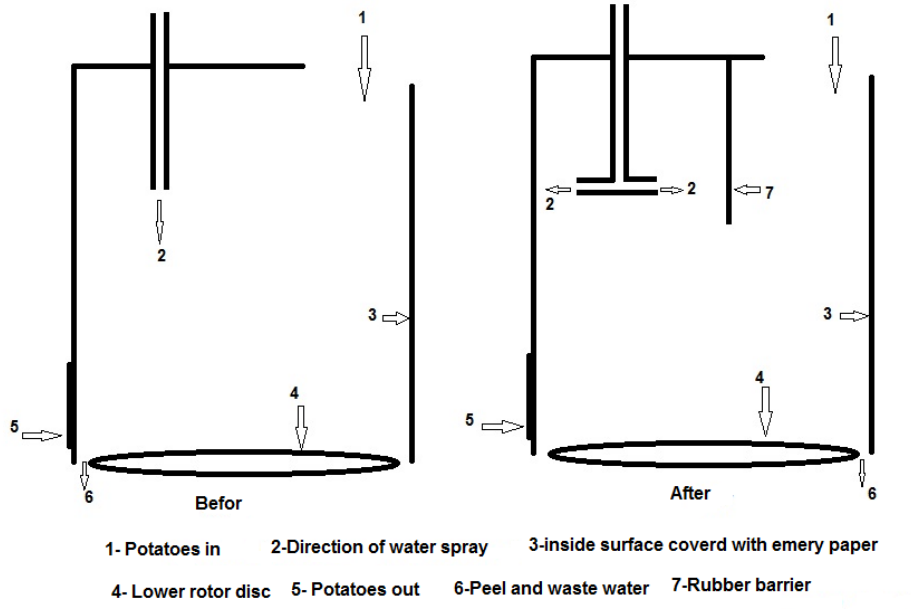

Fig (4). Peeling chamber before and after modifying

Experimental Procedures:

-Peeling processes (conventional and modified).

-Different varieties of potato (Hermes and lady Rosetta)

-Harvested from soil type (sand and clay) ,

Potato samples

In this study four potato samples comprising two potato varieties (Hermes, lady rosette) growing in two land type (clay and sand) were used. The samples were coded P1, P2, P3, and P4 as shown in Table 2. Physical properties of each sample (solid content, dust content, small tubers content were measured before used in processing.

Table.2. The coded potato samples were used.

Treatments	***P1***	***P2***	***P3***	***P4***
varieties	*Hermes*	*Hermes*	*Lady Rosette*	*Lady Rosette*
land type	*Clay*	*Sand*	*Clay*	*Sand*

Experimental measurements:

-Physical properties of potato tubers (Shape index, volume, the geometric mean diameter, sphericity and surface area of potato tubers)

-The potato chips processing stages (sorting efficiency, washing efficiency peeling performance)

- Quality of the potato chips production evaluated by oil content of final product

- Measuring physical properties of potato tubers

A digital slide caliper of accuracy of 0.01mm was used for measuring the three axis of tuber (the major axis as tuber length (L-mm), the intermediate diameter as tuber width (D-mm), and the thickness of tuber (T-mm). Shape index, volume, the geometric mean diameter, sphericity and surface area of potato tubers was taken according **(Mohsenin, 1986)**

Shape index: Shape index of the measured samples was calculated using the following formula: Shape index (I) = $\frac{L}{\sqrt{D\ T}}$

Volume of potato tubers: The nearest mathematical expression for the volume of potato tubers of the two varieties as follows:

$$V\,cal = (\pi / 6)\ (L\ D\ T).$$

Where: *V cal* = calculated volume of individual tuber, mm^3;

The geometric mean diameter (Dg): The geometric mean diameter was calculated by using the following equation:

$$Dg = (LDT)^{0.333}$$

Sphericity: of the tuber was determined by the following formula

$$\text{Sphericity (S)} = (Dg/\ L) \times 100$$

Where, Dg is the geometric mean diameter of the tuber

Surface area (A): Surface area was determined by the following formula:

$$A = \pi\ Dg^2$$

- Measuring the performance of the processing stages

-Sorting efficiency: Sorting efficiency can be calculated by using the following formula**.** Sorting efficiency = $\frac{W1-W2}{W1} * 100\ \%$

Where: W_1 Mass of the total sample, $W_{2:}$ Mass of the foreign matter which removed by sorting (dust-clay-spouting)**.**

-Washing efficiency: The washing efficiency was calculated by (**Scott et al., 1981)**.

$$WE = \frac{\mathrm{SR}}{\mathrm{SA}} * 100, \%$$

Where: WE = Washing efficiency, %.

SR = Mass of foreign materials removed by washing = Mass of sample before washing - mass of sample after washing, g/ kg.

SA = Mass of foreign material attached, which was estimated by, hand washing of 50 samples of fruits to full cleaning and weighing the foreign materials attached with one kg of fruits (g /kg).

-The peeling efficiency: were determined by using the following formula **(k.singh and shukla 1994)**

$$Peeling\ efficiencey = \frac{\mathrm{F1} - \mathrm{F2}}{\mathrm{F1}} * 100$$

F1 = fraction of peel in raw potatoes

F2= fraction of peel in peeled potatoes

-Mechanical destruction of potato tubers: can be calculated by using the following formula**.**

$$Mechanical\ destruction = \frac{W2}{W1} * 100$$

Where: W_1 Mass of the total sample of potatoes.

W_2: mass of small pieces of tubers, which destroyed by peeling.

-Measuring the potato chips quality

Quality of the potato chips production evaluated by determine the oil content of final product.

-The oil content of potato chips: can be determine by using Soxtec System HT extraction unit (Pertorp, Inc., Silver Spring, MD, USA) with petroleum ether as the solvent **(AACC, 1986)**.

RESULTS AND DISCUSSION

The discussion will cover the obtained results under the following heads.

-Physical properties of potato samples

The physical properties of potato samples which used to evaluate the potato chips production line such as length (L) , width(D) ,thickness (T) ,shape index(I), Sphericity (S), Geometric mean diameter (DG) ,surface area(A) and

calculated volume(V) where discussed the results obtained from measuring 100 potato tuber from each sample was showed in Table (3) .

Table (3):Some physical properties of potato samples

Treatmen	*L, mm*	*D, mm*	*T, mm*	*I*	*S*	*DG, mm*	*A, mm²*	*V.mm³*
P1	94.87	53.33	44.62	1.98	63.77	60.37	11737.63	124749.92
P2	93.34	64.00	56.09	1.69	74.30	67.50	14695.29	173961.12
P3	79.47	62.69	60.98	1.32	84.46	66.13	14319.91	169391.44
P4	83.83	72.51	62.32	1.26	86.34	72.05	17143.77	225795.62

- Sorting efficiency evaluating

Fig (5) showed the relationship between the potato samples and sorting efficiency it was showed that the highest value of sorting efficiency was 61.72 % in p1 and the least value was 44.45 % in p2.

-Washing efficiency evaluating

Fig (6) showed the relationship between the potato samples and washing efficiency it was showed that the highest value of washing efficiency was 100% in p2 and p4 were the least value was 80% in p1.

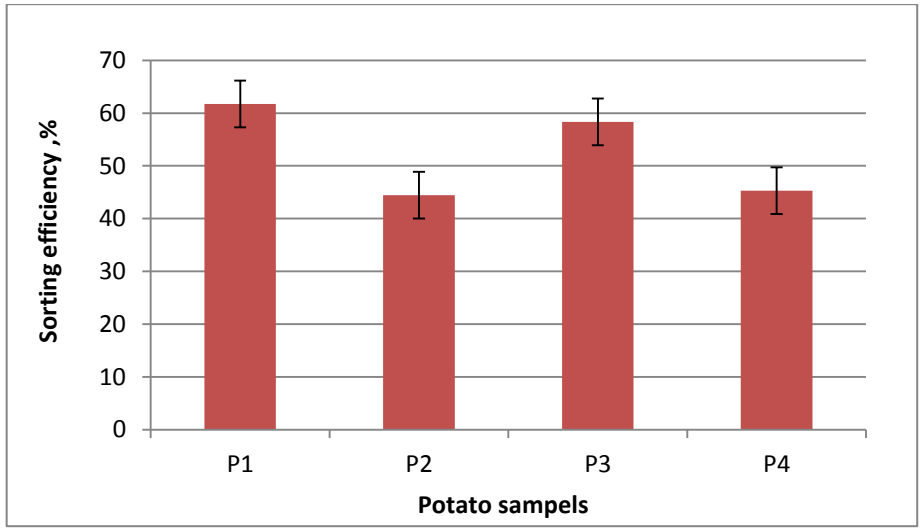

Fig. (5) The relationship between potato samples and sorting efficiency.

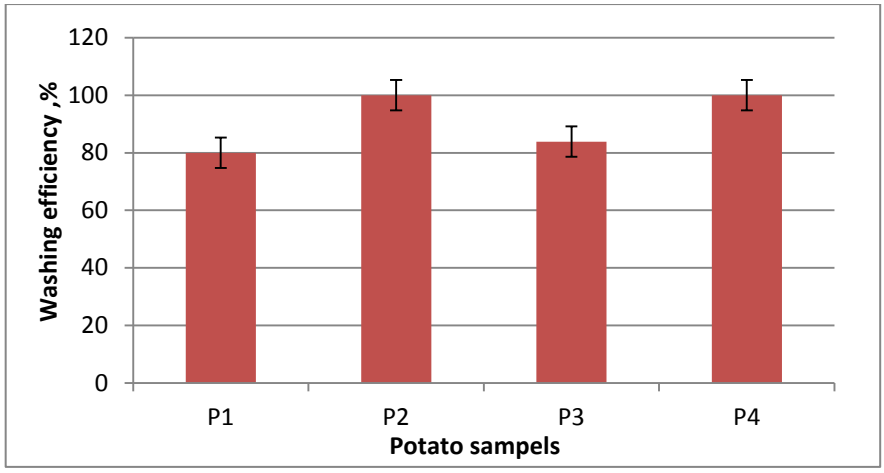

Fig. (6) The relationship between potato samples and washing efficiency

- Effect of modifying the peeler on peeling performance

-Peeling efficiency

Fig (7) showed the effect of modifying the potato peeler on the peeling efficiency of potato samples it shows that peeling efficiency increased after modifying the peeler by 2%,3%,4and 3% in p1,p2,p3,and p4 respectively.

- Mechanical destruction percentages during peeling

Fig (8) showed the effect of modifying the potato peeler on mechanical destruction of potato tubers during the peeling process it shows that the mechanical destruction decreased after modifying the peeler by 37.9 %, 38.6 %, 34.07%, and 20.4 % in p1, p2, p3, and p4 respectively.

-Peeling time

Fig (9) showed the effect of modifying the potato peeler on the peeling time per one batch of potatoes (25 kg) to reach the required peeling efficiency it shows that the peeling time decreased by 10 seconds in P2 and 5 seconds in the other samples.

- Peeler productivity

Fig (10) showed the effect of potato peeler modifying on the peeler productivity the amount of peeled potatoes per hour increased by 321.4 kg in p1, 750 kg in p2, 600 kg in p3 600 and kg in p4. The peeler productivity for all samples increased by average 567.8 kg potatoes per hour with average percentage by 21.9 %.

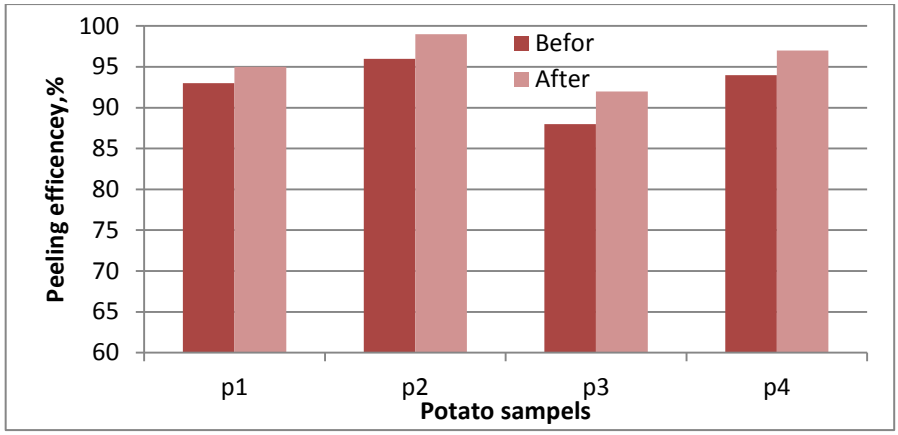

Fig. (7) Effect of modifying the peeler on peeling efficiency

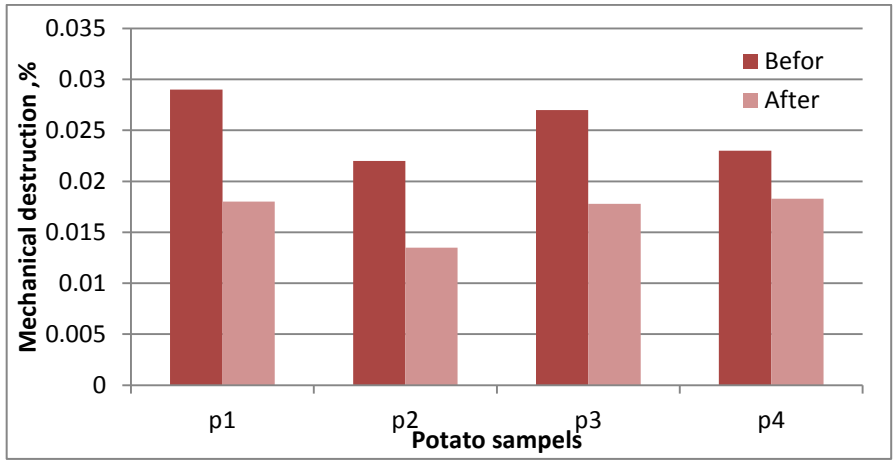

Fig. (8) Effect of modifying the peeler on mechanical destruction

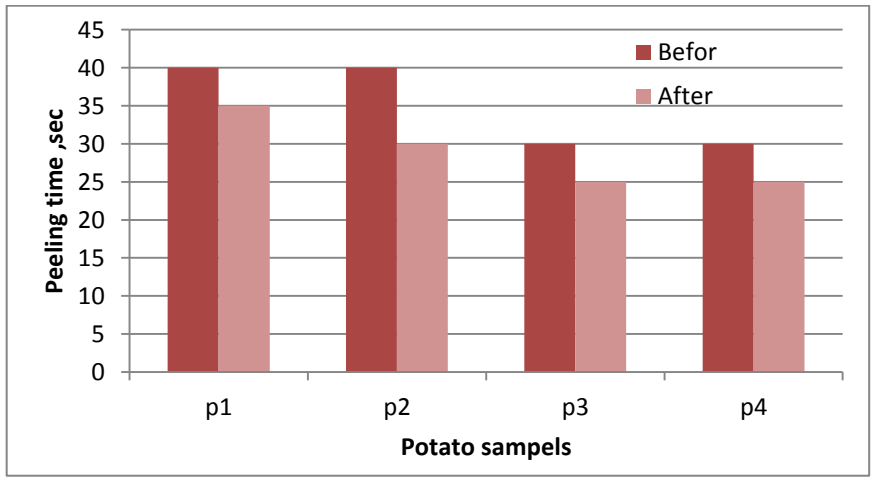

Fig. (9) Effect of modifying the peeler on the peeling time

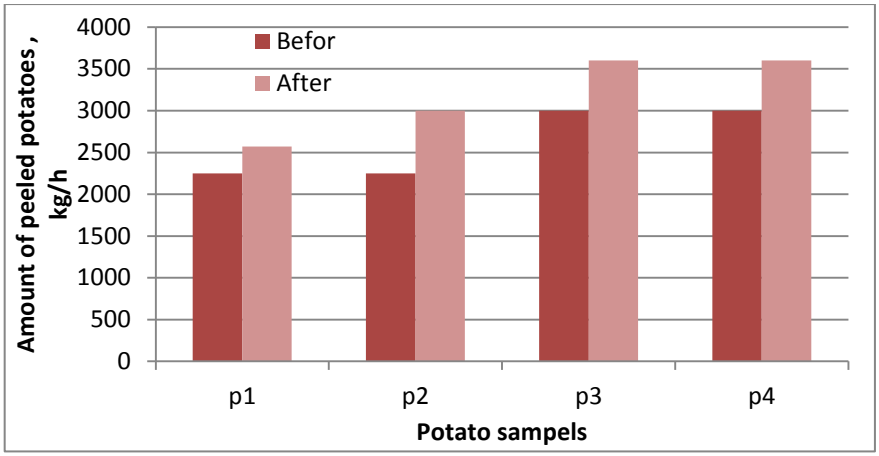

Fig. (10) Effect of the peeler modifying on the productivity

-Water consumption

Fig (11) showed the effect of modifying the potato peeler on the water consumption before and after modifying it shows that the water consumption decreased by 12.5% in p1 , 25% in p2 , 16.6 % in p3,and 16.6 in p4 . The average percentage of saving water in all samples was 17.6 %.

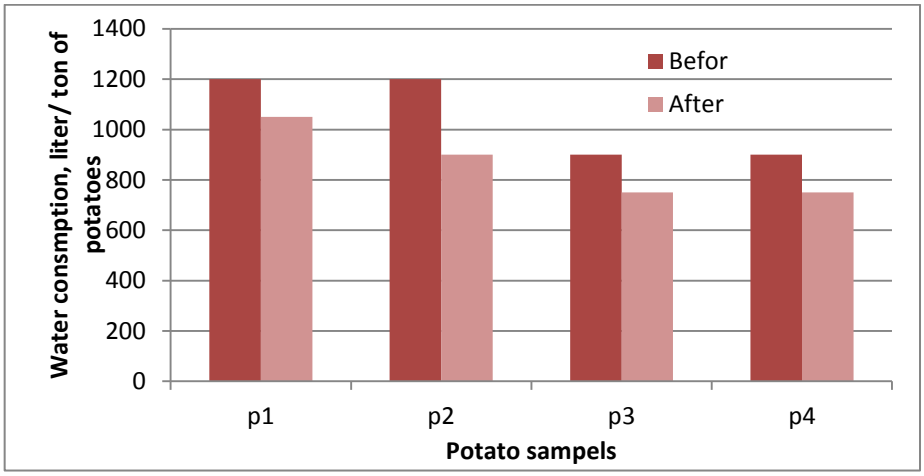

Fig. (11) Effect of modifying the peeler on water consumption

-The potato chips oil content

Fig (12) showed the effect of modifying the potato peeler on the oil content percentage of the potato chips as a final product it shows that oil

content percentage decreased by 2.8%, 2%, 3.1%, and 1.8% in p1, p2, p3, and p4 respectively under the same condition of slicing and frying process.

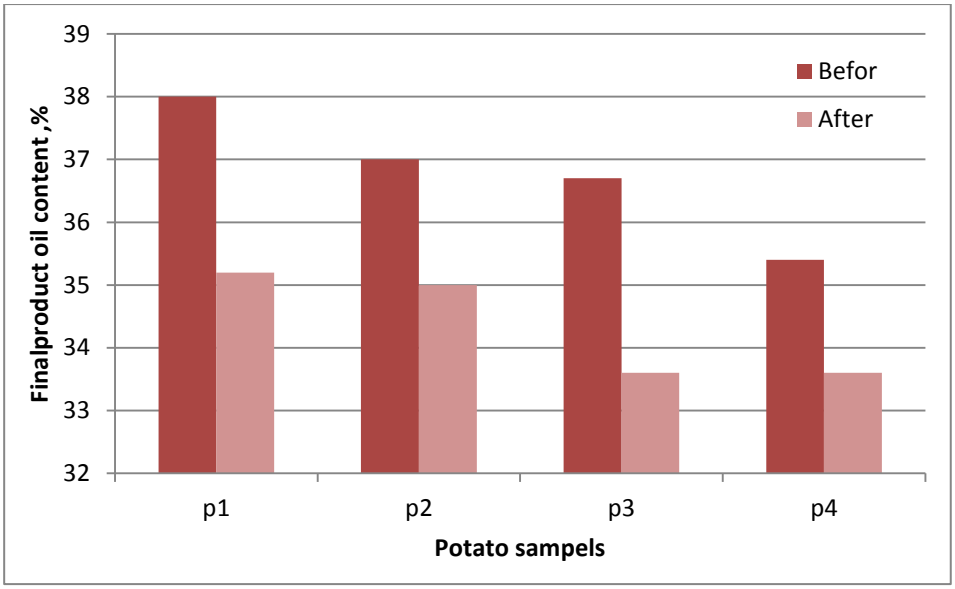

Fig. (12) Effect of modifying the peeler on oil content of the final product

CONCLUSION

The experimental work was executed in Special factory of making potato chips. The performance of the production line and modifying the potato peeler leads to maximize the peeling efficiency by 3.1 %, minimize the mechanical destruction of potato tubers during the peeling process by 32.7 %, minimize the peeling time per one batch by 17.7 % Which led to maximize the productivity of the peeling device by 21.9 % and minimize the amount of needed water consumption for peeling by 17.6 % , also the quality of the final product was improved as the oil content percentage was decreased by 2.4% .that mean reducing the raw materials, reducing processing time and have more healthy product.

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الملخص العربى

تحسين اداء خط إنتاج شرائح البطاطس

أ.د/ طارق فوده* د/ أسعد دربالة د/ محمد درويش** م/ محمود الخضري*****

أجريت هذة التجربة فى أحد المصانع الخاصة بتصنيع بطاطس الشيبس فى قويسنا بمحافظة المنوفية فى الفترة من يناير ٢٠١٥ وحتى يناير ٢٠١٦ لتقييم أداء خط انتاج شرائح البطاطس ورفع كفاءة خط الانتاج حيث تم تعديل ماكينة تقشير البطاطس *(Mod BP)* لتناسب استخدام جميع درنات البطاطس حيث تم دراسة بعض الخواص الفزيائية لصنفين من البطاطس واجريت الدراسة تحت العوامل التالية:

العوامل تحت الدراسة

١- صنفين من البطاطس ذات المواصفات التصنيعية العالية (هيرميس – ليدى روزيتا).
٢- نوعين من الارض المزروع فيها البطاطس (أرض طينية – أرض رملية).
٣- استخدام ماكينة تقشير البطاطس قبل وبعد التعديل.

القياسات

- قياسات للمواصفات الهندسية للدرنات المستخدمة فى التصنيع : وتشمل الطول والعرض والسمك والشكل والاستدارة ومساحة السطح والحجم المحسوب .
- قياس كفاءة مرحلة التنظيف والفرز.
- قياس كفاءة مرحلة غسيل الدرنات.
- قياس أداء ماكينة التقشير قبل وبعد التعديل.
- قياس خواص الجودة للمنتج النهائى بعد القلى ودراسة تأثير تعديل ماكينة التقشير على خواص المنتج النهائى .

النتائج :يمكن تلخيص النتائج المتحصل عليها كالاتى

١- تأثير الخواص الفزيائية للدرنات علي كفاءة التنظيف والفرز وكفاءة الغسيل و أداء ماكينة التقشير وخواص المنتج النهائي .
٢- وأظهرت النتائج أن استخدام الآلة المعدلة أحدث تأثيرا ايجابيا على كفاءة التقشير حيث زادت بنسبة ٣.١% . وانخفضت نسبة الفاقد من الدرنات بسبب التدمير الميكانيكى أثناء التقشير بنسبة ٣٢.٧ % .
٣- كما أدى تعديل الماكينة الى خفض زمن التقشير بنسبة ١٧.٧ % .
٤- كما أدى التعديل الى زيادة الانتاجية الخاصة بالماكينة بنسبة ٢١.٩ % .
٥- كما تم تقليل كمية الماء اللازمة للتقشير بنسبة ١٧.٦ % .
٦- وأظهرت النتائج أن خواص المنتج النهائي تأثرت بالايجاب مع تعديل آلة التقشيروضبط عوامل التشغيل الأخري حيث قلت نسبة الزيت ٢.٤% تحت نفس ظروف التقطيع والقلى .

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