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INFLUENCE OF STORAGE UNDER CONTROLLED CONDITIONS ON COMPOSITIONAL AND PHYSIOLOGICAL PARAMETERS OF POTATO TUBERS AND QUALITY OF THEIR CHIPS PRODUCT

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ABSTRACT*: The influence of storage of potato tubers under controlled conditions of temperature, relative humidity and CO_2 on their compositional and physiological parameters and quality of their chips product was examined. The analyzed compositional parameters included moisture, dry matter, reducing sugars, starch, nitrogen substances. The physiological parameters included (A) External defects; greening, sun burnt secondary growth and mis shaped, bruising greater than 1cm^2 or 5mm deep, skin spot greater than 1cm^2 or 5mm deep, scab greater than 25%of surface area of tuber, growth cracks greater than 3cm long (in total), growth cracks containing soil and other disease and (B) Internal defects; include hallow heart greater than 1cm, black heart greater than 1 cm, pest & insect damage, compression bruising /blue spot (any dark + any light (white / pink), purple pigmentation, internal sprouting, rot ,rust spots, other discoloration . A reverse relationship was noticed (r=-0.849**) between starch (which decreased) and reducing sugars (which increased) of potato tubers during storage, while steadily significant reductions was observed in both non protein nitrogen (NPN) and fat contents. Generally, the total defects and total internal defects were less than 10% and 5%, respectively after 120 days of storage potato tubers belongs to the two cultivars which still less than the allowable limits. Although the external and internal defects of potato chips increased gradually in long storage period, the undesirable color level was more pronounced in chips of both unstored and that stored for 120 than tubers stored for 45 and 90 days. A reverse relationship (r=-0.705**) between moisture and fat contents of chips while a parallel relationship (r= 0.951**) between reducing sugars and NPN of chips were noticed during storage of potato tubers. Generally, the data demonstrated that the best storage conditions to keep potato very closed to fresh one are 9.5°C, 95% relative humidity, < 2500 ppm carbon dioxide, 10-20 cubic feet per minute (cfm) of air per ton, off light and in bulk for 120 days since it resulted in potato chips with accepted organoleptic properties .*

***Key words** : Potato tubers, storing conditions, compositional parameters, physiological parameters ,chips quality .*

INTRODUCTION

Advantages of storing tubers at low temperature include natural control of sprout growth, minimization of physiological weight loss (i.e., H_2O and dry matter) due to decreased respiration, and reduction in losses associated with bacterial and fungal pathogens (Gellert, 1986 and Hooker, 1995). Following exposure to low temperature (i.e., <9-10°C), potato tubers (*Solanum tuberosum L*) undergo a phenomenon knows as low temperature sweetening (LTS) (Bartsch, *et al*. 1990 and Bahman *et al*. 1995). LTS is a widespread but not universally occurring phenomenon in various parts of many higher plants which expose to lower than optimum growth or storage temperatures (Cargill, *et al.* 1989 and Brook, *et al*. 1995). In stored potato tubers, LTS results due to the accumulation of starch breakdown products, primarily sucrose and reducing sugars, glucose and fructose (Luis and Ronald *et al.* 1997). Despite extensive researches and numerous proposed mechanisms, there is still very little agreement with respect to the exact mechanism of LTS in potato tubers (Edwards and Cobb, 1999). Sugar accumulation associated with LTS in stored potato tubers develops within a few days of exposure to cold (Goodenough, *et al*. 1981 and Griffiths, *et al*. 1997).The cold causes accumulation of high levels of reducing sugars from starch. The resulted reducing sugars participated as substances in the Maillard browning reaction during frying and drying of potato. Dark- colored chips are unacceptable to the consumer due to their appearance and bitter taste (Atkin, 1981 and Luis, *et al*. 1997).This deterioration in chips color quality may be reversed by reconditioning the cold stored tubers at warmer storage temperatures (i.e.,>10°C) prior to processing. This will decrease reducing sugars content as some of these sugars are converted back into starch (Gurbuz, and Lee, 1997). To maintain low levels of sugars during long term storage, processing potatoes should be stored at temperatures around 9-10°C and treated with dormancy prolonging chemicals to prevent sprouting (Forbush, *et al*. 1993; Ereifiej, *et al*. 1997 and Eijck and Haverkort, 2002).

In recent years, there has been great interest in the development of potato cultivars that can be processed into chips with acceptable color directly from low temperature storage (e.g., 4°C) (Hanson, 1975 and Hardenburg, 1986). Egypt is considered one of the largest producers and exporters potatoes in Africa (Hassan, 1991). Potatoes are cropped continuously in Egypt from August to June. The bulk of the potato crop stores in the traditional store structures in Nawallas which made of mud bricks. Losses in tubers during storage in such stores ranged from 20 to 50% and may reach to 70% due to moth infestation, dehydration, excessive sprouting and other causes (EL-Dawoudi, 1999). Therefore there is a need for improving storage facilities and practices. The two basic elements control potato stores are the system and the structure. The system is responsible or moving the air and includes humidification, refrigeration, and overall air distribution. The system must be

able to accommodate potato loads and to maintain the environmental conditions require keeping tuber quality (Nouri, and Toofanian, 2001).

In this study the influence of storage under controlled conditions on compositional and physiological changes of two cultivars of potato tubers and the quality of their chips product was investigated.

MATERIALS AND METHODS

Materials:

Two cultivars of fresh full mature potatoes (*Solanum tuberosum* L) namely Lady Rosetta and Herms were brought from the private farm of Societe Nationale Du Commerce "SONAC Co." Alsalhia ,EL-Sharkia governorate, Egypt after harvesting in the middle of May, 2002. The harvested potatoes were packed on Jumbo bags and placed on a shaded place before transported by trucks to the cold store. Potatoes were cured at 16°C ±2 °C and 85-90% relative humidity for 15-21 days, then graded mechanically according to their size using grader model 900-1750-1, Bijlsma Hercules BV, Holland, sorting by hand and packed in wooden boxes. The boxes were stored under controlled conditions of 3300 ppm of CO_2, 95 % relative humidity and 9.5°C for 120 days in four rooms of Sonac Co., Damanhour, Behaira governorate, Egypt. Each room has 17.10 x 29.90 x 7.00 meter dimensions, 2 perforated ducts with 70 cm diameter, 1140 box capacity per each room (228 box x 5 boxes height) containing around 5000 tons of potatoes. Samples of stored potatoes were withdrawn after 0.0, 45, 90, and 120 days of storage to evaluate the changes in their quality, before and after frying to chips. The Chloro-Isopropyl n-Phenyl Carbamate (CIPC) was used as anti sprouting agent, after 45 days of storage. The stored potatoes were sprayed with CIPC solution at the rate of 60 gm CIPC / Ton of potatoes to inhibit the germination of potatoes buds. Fresh palm olein oil was used for frying potato slices. It was obtained from local market at Alexandria, Egypt. It has 0.03% free fatty acids as oleic acid, zero peroxide value and 2.2 red Lovibund color using 5 ¼ inch cell.

Technological methods:

Potato chips were prepared from stored tubers using three kilograms sample. The tubers were manually sorted then washed and cleaned by running water for four minutes, peeled using carbarundum mechanical potato peeler model No20 Fimar Co., Italy, with size14 lbs, grit size1-1.5 mm for 1.5 to 2 minutes. Washed peeled potatoes were trimmed by hand using stainless steel knives, mechanically sliced into slices with 1.3 to 1.5 millimeters thickness by Lama 220 slicer model Shedco, Italy. The resulted slices were washed to remove the released starch forming during slicing by washing in a 50 liter pot containing 25 liter of water. The weight of washed slices was determined after sorting to discard discolored or irregular shaped slices. Slices were placed on perforated trays at a rate of one pound per

square foot, dried in a cabinet dryer for 12 minutes at 60°C to decrease their moisture content to about 24 % before frying. The slices were immersed in palm olein vegetable oil at a temperature of 185°C until fried, using pilot fryer with capacity 8 liter, model Bartlett D11E30, Italy. When the oil in the fryer heated to 185°C, power to the fryer was immediately switched off then the basket containing potato slices was placed in the oil. The basket was moved vigorously after 3 minutes from frying in the oil to prevent the sticking of slices together. Potato chips were drained, cooled, turned onto a white tray, and the weight of the fried sample was recorded to calculate the chips yield. Samples of chips were inspected for green, undesirable color, external and internal defects.

Chemical Analysis:

The AOAC (1995) methods were followed to determine the most chemical constituents of potato tubers and chips. Otherwise, the reference was mentioned. All analysis were carried out in triplicates.

Potato tubers were cleaned, peeled and sliced. Part of these slices was immediately analyzed for the moisture, sugars, while the rest was dried at 110°C, then crushed, finally ground in a stainless steel hammer mill, mixed and stored in an air tight glass container for subsequence determinations of the total nitrogen, non –protein nitrogen and crude fat.

Moisture content of potato tubers and chips were determined by drying method at 110 °C and the dry matter (%) was calculated by difference. Reducing sugars were extracted with 80% ethanol, rotary evaporated at 50°C water and diluted extract was subjected to determine reducing sugars using Lane and Eynan method. Starch was determined by the direct acid hydrolysis method using concentrated HCl for 2.5 hr. The resultant reducing sugars were determined by Lane and Eynan method. Starch was calculated by using a 0.9 conversion factor. The crude protein content was assessed by semi-micro Kjeldahl method using a factor of 6.25. NPN was determined in the supernatant after precipitation of protein by 10% trichloro acetic acid as described by Singh and Jambuthan(1981) using microKjeldahl method. Protein nitrogen was calculated by subtracting the NPN from total nitrogen. Crude oil was determined by Soxhelt extraction method using petrolium ether (boiling point 40-60°C) for 16 hours. Ash was estimated at 550 °C in muffle furnace.

Examination of physiological defects:

A- Fresh potato inspection:

Ten Kilograms of fresh and stored potatoes were inspected to sort the tubers according to their content of external and internal defects. The potatoes having the same an external defect were weighted in each category and expressed as percentage of the total sample weight. Also each tuber was cut along the longitudinal axis (rose to heel) to examine its internal

defects. As mentioned before potatoes have internal defectives were weighted and expressed as percentage of the total sample weight. The following are the main external and internal examined defects (Brinkman, *et al*.1996, Frito Lay Company. 1999 and Eijck, and Haverkort,2002).

-External defects include:

greening, sun burnt supportive stolons, sprout, embedded stones and grit, secondary growth and mis shaped, bruising greater than 1cm^2 or 5mm deep, any damage (e.g. mechanical, shatter cracking) greater than 1cm^2 or 5mm deep, rot greater than 1cm^2 or 5mm deep, skin spot greater than 1cm^2 or 5mm deep, scab greater than 25%of surface area of tuber, growth cracks greater than 3 cm long (in total), growth cracks containing soil and other disease.

-Internal defects include:

hallow heart greater than 1cm, black heart greater than 1 cm, pest & insect damage, compression bruising /blue spot (any dark + any light (white / pink), purple pigmentation, internal sprouting, rot ,rust spots, other discoloration.

B-Fried potato chips inspection:

The prepared chips were inspected for the following defects; 1. Green discoloration on the edges of the slices. 2. Purple discoloration at some distance from the slice edge.3.Undesirable color include any brown, white, gray, pink, black and purple color covering at least 50% of the chip slices. 4. Internal defects; they can be differentiated from undesirable color by their size, and from external defects by their location inside the chips slices. 5. External defects; any defect touches the edge of the chip and greater than 0.5 cm diameter.

Organoleptic methods:

The potato chips were subjected for sensory evaluation using ten panelists of Food Science and Technology Department staff, Agriculture College, Alexandria University. Panelists were asked to evaluate the sensory properties (Color, Texture, Odor and Taste). Panelists were asked to evaluate the sensory properties according to the following sheet:

SENSORY EVALUATION SHEET

Name :
Date :
Sample No.:
Please rate color, texture, Odor, and Taste of these samples according to the following scheme

Property	Description	Final score	Sample score	Comments
1-Color				
Pale yellow	Excellent	20		
Yellow	Good	16		
Dark yellow	Fair	12		
Yellow red	Poor	8		
Yellow brown	Very poor	4		
2-Texture				
Crispy	Excellent	20		
Slightly firm	Good	16		
Firm	Fair	12		
Softy	Poor	8		
Oily & softy	Very poor	4		
3- Odor				
Flat	Excellent	20		
Normal odor	Good	16		
Slightly burned	Fair	12		
Slightly rancid	Poor	8		
Rancid	Very poor	4		
4-Taste				
Flat	Excellent	20		
Slightly oil	Good	16		
Moderately oil	Fair	12		
Oily	Poor	8		
Starchy &bitter	Very poor	4		

Signature:……

Statistical analysis: Results were analyzed using analysis of variance of the SAS package (SAS, 1985).

RESULTS AND DISCUSSION:

1-Fresh and stored potato tubers:

- Compositional parameters :

A) Dry matter: Data in Table 1 revealed that a slight change occurred in dry matter during the 1st 45 days of storage. The slight loss in moisture content of tubers was due to the evaporation with the heat resulting from the respiration mainly at the 1st stage of storage. These losses were associated with slight increase of potato tubers dry matter. The controlled conditions used during potato storage reduced from their respiration rate and sequentially the losses in their dry matter.

Table (1): Compositional parameters of fresh and stored tubers for 120 days under controlled conditions [*].

Storage period /day	Potato cultivar	Compositional parameter (On dry weight basis)					
		Dry Matter	Starch	Reducing sugars	Crude Protein	Non protein Nitrogen	Crude fat
0.00	Lady Rosetta	22.18^{c*}	71.55^{a}	9.51^{d}	10.69^{C}	1.75^{a}	0.46^{a}
45		22.53^{b}	66.27^{b}	10.03^{c}	12.12^{b}	1.51^{b}	0.40^{b}
90		22.68^{b}	65.69^{b}	10.41^{b}	13.39^{a}	1.41^{c}	0.35^{c}
120		23.81^{a}	61.27^{c}	11.09^{c}	12.09^{b}	1.30^{d}	0.32^{d}
0.00	Herms	21.20^{b}	70.85^{a}	10.33^{c}	10.65^{c}	1.74^{a}	0.42^{a}
45		21.92^{a}	65.69^{b}	10.67^{bc}	12.77^{a}	1.55^{b}	0.36^{b}
90		22.24^{a}	64.30^{b}	10.84^{b}	12.77^{a}	1.44^{c}	0.32^{c}
120		22.36^{a}	58.77^{a}	12.25^{a}	12.20^{b}	1.28^{d}	0.28^{d}

[*] Means in a column not sharing the same superscript are significantly different at P< 0.05 (right, between storage periods within Lady Rosetta; left between storage periods within Herms)

B) Starch and reducing sugars: Reverse relationship was noticed (r=-0.894[**]) between the starch and reducing sugars of potato tubers during storage. Results in Table (1) illustrate that a significant steadily reduction in starch content associated with a gradual rise in reducing sugars were occurred during storage of the tubers of both potato cultivars. The reduction in starch was mainly due to its breakdown into reducing sugars through respiration process. The formed sugars cause darkness to potato processed products. Also, the results in Table (1) showed that the high reduction in starch and formation of reducing sugars in potato tubers was mainly occurred in the first and last 45 days of storage (Fick, and Brook, 1999).

C) Protein and non protein nitrogen: Data in Table (1) showed that there is an apparent rise in protein of potato tubers of both potato cultivars during storage up to 90days followed by a slight decrease. This may be due to the reduction in their starch content. On the other hand a steadily significant reduction was noticed in non protein nitrogen of tubers during storage. This may result from the reaction between such components with reducing sugars; such reaction causes an internal discoloration of tubers. Generally, the change in protein and non protein nitrogen through storage period in the tubers of the two cultivars was generally more or less the same.

D) Fat content: Results in Table (1) indicated that however the presence of low fat content in potato tubers, it is an ignorantly steadily declined with extended storage period. This decline was mainly due to respiration process. The breakdown of lipids supplies the tubers with some of there energy needs. The problem arises from the resulted products of the hydrolysis or the breakdown of the fats, such as peroxides, aldehyde, ketones, fatty acids, etc. and their influence on the sensory quality of fresh and processed

products. Generally, the declines in fat content during storage were relatively more observed in Herms and Lady Rosetta tubers through the first 45 days of storage.

Physiological defects:

A) External defects: Data in Table (2) showed the development of an external defects in potato tubers during storage. The results in this table reveal that; 1. Storage of potato tubers under the conditions described in materials and methods section prevented the development of greening, the increase of embedded stone, grit, supportive stolons, secondary growth and mis shapped, sun burnt, scab, growth cracks, and growth cracks containing soils as well as diseases.2. Slight but significantly P< 0.05 gradual increase in the development of rot, sprout, skin spot and bruising were observed with extending storage period particularly after 90 days of storage and also relatively more in tubers of Lady Rosetta cultivar than Herms one. Generally the total external defects were less than 10% after 120 days of storage in both cultivars. It is increased gradually during storage period. Generally most of the external defects can be removed during processing.

Table: (2): Development of external defects in potato tubers during storage [*].

Potato cultivar	Herms				Lady Rosetta			
Storage period / days	0.00	45	90	120	0.00	45	90	120
External defect (%)								
Greening	0.00 [a]*	0.00 [a]	0.00 [a]	0.00 [a]	[a] 0.00	[a] 0.00	[a] 0.00	[a] 0.00
Secondary growth & Mis shaped	0.10 [a]	0.10 [a]	0.10 [a]	0.10 [a]	[a] 0.20	[a] 0.20	[a] 0.20	[a] 0.20
Bruising	0.10 [c]	0.10 [c]	2.30 [b]	2.50 [a]	[c] 0.10	[b] 0.30	[a] 1.16	[a] 1.23
Any damage (e.g. mechanical, shatter cracking)	0.20 [c]	0.20 [a]	2.00 [b]	2.50 [a]	[b] 0.30	[b] 0.30	[a] 3.03	[a] 3.30
Rot	0.00 [c]	0.20 [b]	0.20 [b]	0.25 [a]	[b] 0.10	[b] 0.15	[b] 0.15	[a] 0.35
Other disease	0.30 [a]	0.30 [a]	0.30 [a]	0.30 [a]	[a] 0.30	[a] 0.30	[a] 0.30	[a] 0.30
Sun burnt	0.01 [a]	0.01 [a]	0.01 [a]	0.01 [a]	[a] 0.02	[a] 0.02	[a] 0.02	[a] 0.02
Sprout	0.00 [d]	1.50 [c]	1.80 [b]	2.30 [a]	[c] 0.00	[b] 2.00	[a] 2.30	[a] 2.40
Skin spot	0.30 [b]	0.50 [a]	0.50 [a]	0.50 [a]	[b] 0.40	[b] 0.40	[b] 0.40	[a] 0.60
Scab	0.30 [a]	0.30 [a]	0.30 [a]	0.30 [a]	[a] 0.20	[a] 0.20	[a] 0.20	[a] 0.20
Growth cracks, Growth cracks containing soil	0.04 [a]	0.04 [a]	0.04 [a]	0.04 [a]	[a] 0.04	[a] 0.04	[a] 0.04	[a] 0.04
% Total	1.35	3.25	7.55	8.80	1.76	4.01	7.90	5.56

[*]**Means in a raw not sharing the same superscript are significantly different at P< 0.05 (right letter are within Herms while the left letters are for Lady Rosetta).**

B) Internal defects: Results in Table (3) showed that among the internal defects the level of development of black heart, other discoloration, and rot were gradually increased in potato tubers with extending of storage period. The rate of the development of such defects was more pronounced after 90 days of storage. Nearly no changes in other internal defects were observed

during storage. Generally, the total internal defects in the end of storage period were less than 5%. It was higher in tubers of Lady Rosetta cultivar than Herms one. Generally the changes in most of the studied chemicals measures were noticeable at the first 45 days of storage due to the high temperature of store. High temperature accelerates biological changes while low temperature can worsen bruising damage and causes internal discoloration. The aforementioned results showed that the conditions used to store potato tubers in this study keep the quality of tubers near the fresh one. The development of an external and/or internal defects was less than the allowable limits. Also, it causes slight changes in chemical properties of the tubers (see Table 1).

Table: (3): Internal defects in potato tubers during storage [*].

Storage period / days	Herms				Lady Rosetta			
Potato cultivar								
Internal defect (%)	0.00	45	90	120	0.00	45	90	120
Hallow heart	0.01 b*	0.02 a	0.02 a	0.02 a	a 0.04	a 0.04	a 0.04	a 0.04
Black heart	0.04 c	0.07 c	0.23 b	0.33 a	d 0.02	c 0.12	b 0.25	a 0.57
Pest / insect damage	0.50 b	0.60 a	0.60 a	0.60 a	a 0.60	a 0.60	a 0.60	a 0.60
Compression bruising /blue spot	0.40 a	0.40 a	0.40 a	0.40 a	a 0.50	a 0.50	a 0.50	a 0.50
Other discoloration	0.20 b	0.20 b	0.20 b	0.24 a	b0.30	b 0.30	a 0.50	a 0.50
Purple pigmentation	0.00 a	0.00 a	0.00 a	0.00 a	a 0.20	a 0.20	a 0.20	a 0.20
Internal sprouting	0.00 a	0.00 a	0.00 a	0.00 a	a 0.00	a 0.00	a 0.00	a 0.04
Rot	0.20 b	0.20 b	0.20 b	1.20 a	c 0.60	c 0.60	b0.82	a 1.20
Rust spots	0.20 a	0.20 a	0.20 a	0.20 a	a 0.40	a 0.40	a 0.40	a 0.40
% Total	1.55	1.69	1.85	2.99	2.66	2.76	3.31	4.05

[*] **As in Table 2**

2- Chips of stored potatoes: Samples of potato tubers were withdrawn at zero time and after 45, 90, and 120 days of storage under the conditions described previously. The withdrawn samples were subjected for preparing slicing and frying and the following parameters were determined:

A- Chip defects: As shown in Table (4) the inspection of the chips of stored potatoes showed only undesirable color, in addition to external and internal defects. Generally the sum of the observed external and internal defects were relatively higher in chips made from stored potato tubers than unstored ones. Also, these defects were observed clearly in long stored potato tubers than short storage ones. On the other hand, the undesirable color level was more pronounced in chips of both unstored and 120 days stored potato than tubers which stored for 45 and 90 days. This is an indication that extending of storage period of potato tubers at low temperatures to 120 days associated with the formation of this defect in chips made from such tubers. Conditioning of potato tubers for a short period may lead to suppress the undesirable color formation.

Table (4): Defects in chips prepared from stored potatoes

Storage period / days	Herms				Lady Rosetta			
Potato cultivar / Defects (%)	0.00	45	90	120	0.00	45	90	120
- Total external and internal	1.82	2.05	4.52	5.44	3.22	3.42	3.70	4.02
- Undesirable color	1.37	0.97	0.80	1.20	1.06	0.91	0.64	1.40

B- Yield and some chemicals constituents of chips: As seen in Table (5), the yield of chips made from stored potato tubers ranged from 36.98-38.70%. Slight differences were observed for both cultivars and during storage period of potato tubers on the yield of the produced chips. During frying, moisture is removed and oil is absorbed by potato slices. Therefore, the moisture content and oil values of the processed chips were ranged from 1.75–1.95% and 35.96 – 41.67%, respectively. This means that there is a reverse relationship (r=-0.705 **) between moisture and oil content of chips .The unstored potato slices absorbed relatively more oil during frying than stored ones. Meanwhile tubers of both cultivars and storage period showed marked changes in oil and moisture contents of the resulted potato chips. Also, data in Table (5) revealed that reducing sugars and non protein nitrogen varied from 0.56 – 0.72 % and 0.16 –0.20 %, in potato chips, respectively. Both components were found in higher values in chips made from unstored potato tubers than stored ones. Moreover, chips of long stored potatoes contained less reducing sugars and non protein nitrogen than short stored ones. This means that there is a parallel relationship (r=0.951**) between the two components during storage and frying process. The reaction between two components was responsible for undesirable color formation in tubers and their processed chips (*Alberto et al. 1999*)

Table (5): Yield and some compositional parameters of chips from stored potato tubers under controlled conditions*.

Component %	Potato cultivar	Storage period /Day			
		0.00	45	90	120
Yield	Herms	^{*a} 38.70	^{ab} 38.20	^{a} 37.80	^{c} 37.06
Moisture		^{a} 1.75	^{b} 1.80	^{b} 1.81	^{b} 1.82
Fat content		^{a} 40.87	^{b} 39.66	^{c} 38.19	^{d} 37.19
Reducing Sugars		^{a} 0.72	^{b} 0.65	^{c} 0.59	^{c} 0.56
Non protein nitrogen		^{a} 0.19	^{ab} 0.18	^{bc} 0.17	^{c} 0.16
Yield	Lady Rosetta	38.60 ^{a*}	38.40 ^{a}	37.70 ^{b}	36.98 ^{c}
Moisture		1.80 ^{b}	1.81 ^{b}	1.93 ^{a}	1.95 ^{a}
Fat content		41.67 ^{a}	36.12 ^{b}	36.40 ^{b}	35.96 ^{c}
Reducing Sugars		0.70 ^{a}	0.66 ^{ab}	0.61 ^{bc}	0.57 ^{c}
Non protein nitrogen		0.20 ^{a}	0.18 ^{b}	0.17 ^{bc}	0.16 ^{c}

*** As in Table 1**

3- Organoleptic properties of chips: Table (6) and Fig.(1) summarized the organoleptic properties of chips made from unstored and stored potato tubers . The data in this respect revealed that except color of unstored and

120 days stored chips, the sensory properties of the chips products were described by panelists as good for color (yellow), an excellent for texture (crispy), good for odour (normal odour) and an excellent for taste (slightly oil). On the other hand, color of both unstored and 120 days stored potato chips from the tubers of the two used cultivars was described by panelists as poor (yellow red) and fair (dark yellow), respectively. These may be due to the high level of reducing sugars and non protein nitrogen in both harvested unstored and long stored at low temperature potato tubers before frying. During frying non enzymatic browning reaction between reducing sugars and non protein nitrogen occurred (Eijck, and Haverkort, 2002). This led to darkening of the pale yellow color of chips. Generally, these results agree with those stated in Table (4) for the development of undesirable color in chips made from unstored and stored potato tubers. Karuna *et al.,* (1994) stated that potato chips should be fried until 2% moisture content. They should exhibit light yellow color, pleasing and desirable flavor and odor as well as crispy texture. Moreover, chips may contain < 15% of blister and <10% minor defects as well as 32-40% fat content. According to these specifications, storage of potato under the conditions used in this study for 120days gave chips with an excellent quality except color. Also, no influence was noticed for cultivar on sensory properties of fried chips from stored potato tubers. Such results confirm the needs of removing or reducing the factors responsible of darkening chip color of the 120 days or late stored tubers. Therefore both short conditioning periods at room temperature and/or using some technological treatments should be tried to overcome such problem (Melton *et al*. 1993 and Cees *et al*. 2002 a,b).

Table (6): Organoleptic properties of chips from stored potato tubers under controlled conditions:

Storage period (day)	Potato cultivar	Organoleptic characteristic			
		Color	Texture	Odor	Taste
0.0	Herms	Poor	Excellent	Good	Excellent
45		Good	Excellent	Good	Excellent
90		Good	Excellent	Good	Excellent
120		Fair	Excellent	Good	Excellent
0.00	Lady Rosetta	Poor	Excellent	Good	Excellent
45		Good	Excellent	Good	Excellent
90		Good	Excellent	Good	Excellent
120		Fair	Excellent	Good	Excellent

Herms Cultivar	Lady Rosetta Cultivar
	
A- At 0.0 storage period	
	
B- After 45 days of storage period	
	
C- After 90 days of storage period	
	
D- After 120 days of storage period	

Fig.: 1. Appearance of fried chips prepared from stored potatoes.

CONCLUSION:

Selection the suitable potato varieties, such varieties should be resistance to disease , with regular shape, white flesh or pulp, high in dry matter and starch content, with less shallow eyes, easily conditioned and less susceptible to sugar accumulation during storage for example Herms and Lady Rosetta cultivars. Minimizing bruising, skinning, and damage during harvesting, handling, transporting and pre storage. Curing or wound healing of harvested potato before storage at 13-15°C and 95% relative humidity over period of 10-21 days.The following are the best storage conditions to keep potato very closed to fresh one, 9.5°C, 95% relative humidity, < 2500 ppm carbon dioxide, 10-20 cubic feet per minute (cfm) of air per ton, off light and in bulk for 120 days.

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تأثير التخزين تحت ظروف محكمة على المعايير الكيماوية والفسيولوجية لدرنات البطاطس و جودة الشيبس المصنع منها .

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الملخص العربي

تم دراسة تأثير تخزين درنات البطاطس تحت ظروف محكمة من درجة الحرارة و الرطوبة النسبية و غاز ثاني أكسيد الكربون وذلك على الخصائص الكيماوية و الفسيولوجية و كذا جودة الشيبس الناتج . هذا وقد اشتملت الخصائص الكيماوية على: الرطوبة – المادة الجافة– السكاكر المختزلة– النشا– المكونات النيتروجينة بينما اشتملت الخصائص الفسيولوجية على : أ– العيوب الخارجية وهي : الاخضرار – لفحة الشمس– النموات الثانوية و العيوب الشكلية – جروح (أكبر من ١ سم^{٢} و عمق ٥ مم) – بقع قشرية (أكبر من ١ سم^{٢} و عمق ٥ مم) – الجرب (أكثر من ٢٥% من مساحة سطح الدرنة)– الكسور والتشققات (أكبر من طول ٣ سم) و تشققات أثناء النمو و الأمراض الأخرى. ب : العيوب الداخلية وهي: القلب الأجوف – القلب الأسود– الإصابات الحشرية –الكدمات الناتجة عن الضغط– و البقع الزرقاء– الصبغات القرمزية – التبرعم الداخلي – العفن – الأصداء – عيوب لونية مختلفة و تشمل اللون القرمزي و أية تغيرات أخرى في اللون . و قد أظهرت النتائج وجود علاقة عكسية ($r=-0.849^{**}$) فيما بين النشا (الذي أنخفض) و السكاكر المختزلة (التى زادت) في درنات البطاطس أثناء التخزين، بينما كانت هناك انخفاضات معنوية في كل من النيتروجين غير البروتينيى و محتوى الدهن . و بوجه عام فان مجموع العيوب الخارجية و العيوب الداخلية كانت أقل من ١٠% ، ٥% على التوالي وذلك بعد تخزين درنات البطاطس لمدة ١٢٠ يوم ولكلا الصنفين و التى لا زالت في الحدود المقبولة . و بالرغم من تزايد العيوب الداخلية و الخارجية للشيبس تدريجياً بطول فترة التخزين إلا أن مستوى اللون غير المرغوب كان اكثر وضوحاً في الشيبس المعد من بطاطس طازجة و تلك المخزنة لمدة ١٢٠ يوم بدرجة تفوق نظيرتها المخزنة لمدة ٤٥ يوم و ٩٠ يوم وقد

وجدت علاقة عكسية ($r= 0.705^{**}$) فيما بين محتوى الشيبس من الرطوبة و الدهن بينما كانت العلاقة طردية ($r=-0.951^{**}$) فيما بين السكاكر المختزلة و النيتروجين غير البروتيني للشيبس خلال تخزين درنات البطاطس . وقد أوضحت النتائج أن أفضل ظروف متحكم فيها لتخزين البطاطس والحصول على درنات مشابهة بدرجة كبيرة للدرنات الطازجة هي : درجة حرارة ٩.٥° م ورطوبة نسبية ٩٥% و تركيز ثاني أكسيد الكربون لا يزيد عن ٢٥٠٠ جزء في المليون – وسرعة هواء قدرها ١٠-٢٠ قدم^{3} / ق / طن والإظلام وذلك لمدة ١٢٠ يوم حيث أدت إلى إنتاج شيبس ذو مواصفات جودة مقبولة .

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