QUALITY EVALUATION OF FRESH AND STORED POTATO CHIPS PRODUCED IN EGYPT

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ABSTRACT

This study was carried out to evaluate the quality of fresh and stored potato chips produced in Egypt during the shelf life of 6 months. Potato chips was purchased from two different companies with different flavours (Lemon'n Chili, Salt and Cheese). Storage condition used were laboratory and local market conditions. The moisture content of potato chips purchased from the first company was higher than that of the second company and higher than the recommended percentages of the **E.S.S specifications (1993)** which must not exceed 2%. The rest of the gross chemical composition was within the recommended percentages. The salt (sodium chloride) content of potato chips samples from the two companies with two flavours (Lemon'n chili and Salt) was ranged from 1.94 to 2.48%. The higher range of 2.48 exceed the recommendations that sodium chloride should not exceed 2%. The heavy metals of potato chips ranged between (20.46 to 23.76), (0.00), (4.29 to 5.61) and (7.76 to 8.42) p.p.m. for iron, copper, zinc and manganese, respectively. These values correlated with that mentioned in the literature except for copper which was absent.

The moisture content of potato chips increased during storage period, the effect of storage at local market on the moisture content was more pronounced than that at laboratory conditions. The oil content of potato chips stored at different conditions was decreased. The decreasing rate was higher in samples stored at local market conditions compared to those stored at laboratory conditions. The changes that took place in both moisture and oil content of stored potato chips, effect their crispness. The crispness of potato chips in all samples was found to decrease as the storage period increased.

Peroxide value of extracted oil increased slowly in the first stage of storage especially in oil extracted from potato chips stored at laboratory. The rate of peroxidation increased rapidly especially in oil extracted from potato chips stored at local market. The peroxide value of potato chips reached the border line of acceptability (10 ml.eq of O_2 / Kg of oil extract) after 60 days of storage at laboratory, meanwhile, it reached the same level after only 30 days during storage at local market conditions. The rate of change in peroxide value of potato chips with Lemon'n chili flavour was lower than that of potato chips with salt flavour. The rate of increase in acid

value was higher in potato chips stored at local market compared to those stored at laboratory conditions for six months.

The obtained data revealed that thiobarbituric acid value (TBA) increased gradually during storage. The rate of increase was higher in potato chips stored at local market conditions. The rate of increase in TBA was higher in potato chips with lemon'n Chili flavour compared with potato chips with salt flavour.

From the present investigation, it could observed that the unsaturated fatty acids linoleic and lenolenic decreased with increasing storage period, while oleic acid saturated fatty acids increased. The decreasing in fatty acids composition was lower in potato chips stored at laboratory conditions.

Loss of consumer acceptability which often comes from off flavours and off odour compounds as a result of rancidity was evaluated by taste panel. It could be seen that the potato chips stored in local market was not accepted by the panelists after 90 days and after 120 days at laboratory conditions. The potato chips with Lemon' n chili flavour was highly accepted by the consumers.

This research proved the need of tight control over factories to make sure that they use fresh oils with low initial peroxide number and must insure that salt content does not exceed the recommended percentage (2%). That is why close inspection should be done on marketing outlets to insure storing, display in proper conditions and expired period should be reduced to insure the quality throughout this period.

INTRODUCTION

Potato chips (crisps) are a deep fat fried snack food containing high percentage of oil and constitute one of the most popular snack products consumed in the Egyptian market and through the world.

Potato chips (crisps) should contain about 2% moisture or less and 35% edible oil. Stored chips under reasonable conditions have maximum shelf life of 12 weeks, after which moisture uptake and rancidity development become unacceptable (**Allen and Hamilton, 1983**).

The Egyptian standard specifications (**Anon, 1993**) recommended that the moisture, oil, total acidity (as oleic acid), salt, fiber, acid insoluble ash and total protein, must not exceed 2, 42, 1, 2, 2.5, 0.05 and 6% (on dry weight), respectively.

Ragab (1998) studied the gross chemical composition of potato chips brand distributed in local Egyptian market Minufiya Governorate which included the moisture, total protein, crude fat, total ash, sodium chloride,

fiber and carbohydrates contents. The values ranged between (1.56-2.74); (4.76-7.21); (40.06-47.91); (3.03-3.21); (1.41-1.72); (2.32-2.87) and (38.68-45.82) %, respectively.

Pangloli *et al.*, (2002) studied the moisture and fat content of potato chips fried in different oils. They found that the moisture content was ranged from 1.9 to 2.1 % and fat content was ranged from 38.5 to 40.0 %.

During the shelf life of the snacks, two deterioration aspects take place together, one being texture loss due to moisture pick up, the other being rancidity development (**Allen and Hamilton, 1983**).

Potato chips industry considered chips still in the acceptable range at 2% and may lose its crispness if the moisture content was higher than 2% (**Gamble *et al.*, 1987**) .

Deterioration of fatty foods by oxidation is a major concern during storage of some dehydrated or deep fried foods. Oxidative rancidity of lipids, or free radical mediated process, becomes one of the major deteriorative reactions in deep fat fried foods including potato chips (**Quast and karel, 1972**). Loss of consumer acceptability often comes from the production of off-flavour and off-odour compounds as a result of rancidity reactions. It is well known that lipid oxidation lead to changes in functional, sensory and nutritive value and even safety of rancid foods (**Alexander, 1978, Pearson *et al.*, 1983 and Frankel, 1998**).

Factors which result in high free fatty acid levels include steam stack condensate drip back, contamination by cleaning materials, contamination by metals, e.g. from pump impellers or paddle shaft wear, poor fryer cleaning techniques, excessive aeration and holding the oil in the fryer at frying temperature with no product going through (**Allen and Hamilton, 1983**).

Smith *et al.*, 1985; Anon, 1993 and Benjelloun *et al.*, 1991 mentioned that the presence of minute amounts of certain metals such as copper or copper alloys or iron in the fat can hasten its break down. Metals as strong catalysts and pro-oxidations, oxidative ability varies between metals. Sodium and calcium are weak compared to copper and other transition an heavy metals (**NCPA, 2002**).

Complaints of rancid crisps of snacks which are still within their stated life are often a result of poor storage conditions of some stage in the distribution and selling chain.

Quast and Karel (1972), Katz and Labuza (1981) determined the effect of environmental factors on the oxidation of potato chips. The rate of

oxidation was lowest around 40% RH and increased considerably with increasing %RH. Furthermore the product with water activity (aw) fall in the (0.35 - 0.50) aw range found to be unacceptable because of the loss of crispness.

The diffuse of artificial room light can have a significant effect on the rate of oxygen uptake. This effect becomes more important at higher water activity.

It is noticed that in our local market, small shops and street sellers which display these products exposed to direct sunlight although most of the manufacturers print a recommendations on the crisp to store in cool dry place. Thus this investigation was undertaken to evaluate fresh and stored potato chips at these conditions at local market compared with those stored at laboratory conditions.

MATERIALS AND METHODS

MATERIALS :

The fresh samples of potato chips products (chipsy) with different flavours (lemon'n Chili, salt and cheese) were obtained from local different companies for food industries, which have a high production in Egypt. Fresh samples of potato chips were obtained from two companies No 1 in Cairo city (with lemon'n Chili) and No 2 in Tanta city (with lemon'n Chili and with salt). The expired date for these samples written on the packages was 6 months.

All samples were obtained from these companies in the same day of production, during summer season, 2004.

Potato chips processing :

The potato chips products obtained from the two companies used the same processing technique as follows :

The potatoes (Russet Burbank) 2.5-4 cm diameter were washed thoroughly, automatically peeled using stainless steel peeler. A further wash was done. The peeled potatoes were sliced to uniform thickness (0.12 inch) using an automatic electric slicer. The slices were washed two times in warm water (35°C) to remove surface starch and dried under forced air flow. The crisps were prefared immediately by dipping the slices in a thermostatic fryer tank containing palm oil at 180°C. Oil was added back to the fryer as needed to keep the level at the full mark during frying. As they emerge from the cooker, the crisps were inspected and imperfect specimens were removed. The crisps were then passed under a hopper, where

flavouring materials or salt were added as they cool. The crisps were then carried by head conveyors and channeled to the weighers of the packaging machines, where metallized polypropylene pouches filled under vaccum were used.

METHODS :

Storage conditions :

All samples (potato chips) were transferred directly fresh to the Food Tech. Dept., Fac. of Agric. Kafr El-Sheikh, Tanta Univ. for analysis. The rest were stored. Two storage experiments were undertaken the first in the laboratory at room temperature (15-30°C and 55-72% RH). The polypropylene pouches were placed on a table for six months for potato chips. The second experiment was undertaken in conditions like the local market at (12-55°C and 20-78% RH) were placed on shelfes exposed to direct sunlight and air then in the night transmitted indoor for the same period. The temperature and relative humidity (RH) were measured by hygrometer AC-751, China and the obtained data were recorded three times every day. During the storage period (6 months) the analysis was carried out every 30 days for potato chips.

Preparation of samples for analysis :

All the fresh and stored pouches were opened and the products were crushed to pass through 20 mesh sieve and kept in brown glass jars with tight plastic lids in polyethylene bags in the refrigerator at 5°C until analysed in the same day.

Chemical analysis :

Gross chemical composition :

Moisture, ether extract, crude protein (N × 5.7), crude fiber, total ash and sodium chloride contents were determined according to the methods of **AOAC (2000)**. Total carbohydrates were calculated by difference.

Heavy metals :

Four elements, namely, manganese (Mn), iron (Fe), zinc (Zn) and copper (Cu) were determined by Flame atomic absorption as described by **Peterburgski (1968)**.

Evaluation of extracted oils from potato chips :

- **Oil extraction :** The total oil was extracted from the fresh and stored samples using hexane at room temperature according the method described by **Kahlon *et al.* (1992)**. The solvent was evaporated using a

rotary film evaporator under vaccum at 30°C. The samples was completed to a known volume of hexane, flushed by nitrogen and kept in brown glass bottles at 5°C until analysis.

- **Peroxide value (PV) :** Peroxide value of the extracted oil was determined according to the method described by Pearson (1976). The results were always described as m.eq O_2Kg^{-1} of oil extract.
- **Free fatty acids (FFA) :** Free fatty acids of the extracted oil were determined by titration methods of **AOAC (2000)**. The free fatty acids was calculated as percent oleic acid.
- **Thiobarbituric acid number (TBA) :** Thiobarbituric acid number of the extracted oil was carried out according to the method described by **Ottolenghi (1959)**. TBA value was calculated as milligrams of malondialdehyde / kg oil extract = D × 7.8.
- **Fatty acids composition:** Determination of fatty acids composition of the extracted oil was carried out at the Central Laboratory, Faculty of Agriculture, Alexandria University, Egypt. According to **Radwan (1978) and Vogel (1975)**. The fatty acid methyl esters were analyzed by gas liquid chromatography apparatus (GC model Schimadzu-4cm (PFE) equipped with PID detector and glass column 2.5 m × 3 mn i.d. The standard fatty acids methyl esters were injected in the apparatus under the same conditions. the weight percentage of each fatty acid was calculated as percentage of the total fatty acids.
- **Sensory evaluation :** Colour, odour, taste texture and overall acceptability of potato chips was evaluated subjectively using ten students and staff members of Food Technology Dep., Fac. of Agric., Kafr El-Sheikh, Tanta Univ. Nine point headonic scale was used as described by **El-Sheikh (1999)**.

RESULTS AND DISCUSSIONS

Chemical composition of some potato chips products :

The gross chemical composition of different samples of potato chips purchased from two different companies are shown in Table (1). According to Egyptian Standard Specification (**Anon, 1993**). The best potato chips should have high content of total solids i.e. low moisture content (not more than 2%), high protein content (not less than 6%), low oil content (not higher than 42%) and low crude fiber content (not more than 2.5%).

The obtained data shows that moisture content in the potato chips products from the two companies ranged between 2.00%: 2.54%. It is also

noticed that the moisture content of potato chips purchased from the first company was higher than that of the second company. The obtained values are agreed with those obtained by **Matz, (1993), Rageh, (1998) and Pangloli *et al.* (2002).**

Fat content in potato chips samples ranged between 31.89-33.50 which is lower than that reported by **Bakr and El-Adawy (1998), Rageh (1998) and Pangloli *et al.* (2002).** The reported values for fat content were 38.20, 40.06-47.91 and 38.50-40.00%, respectively. The differences in fat content of potato chips between these studies were probably due to the differences in the specific gravity of raw potatoes, type of potatoes, thickness of potato slices, type of oil used and the frying temperature **(Gamble *et al.* 1987; Selman and Hopkin, 1989 and Pangloli *et al.*, 2002).** These values are in agreement with those reported by **Matz (1993) and Nagi (1994),** who reported that the lipid content values were 32.00-35.00 and 34.60%, respectively. As shown in Table 1, the ash content of potato chips ranged from 3.55 to 3.73% which are higher than those mentioned by **Nagi (1994).**

Table (1): Gross chemical composition of some potato chips products on **dry weight basis.**

Constituents (%)	Products		
	Company 1	Company 2	
	Lemon'n chili	Lemon'n chili	Salt
Moisture	2.54	2.00	2.01
Ether extract	33.50	31.89	33.09
Ash	3.73	3.55	3.70
Protein	10.26	10.71	10.28
Crude fiber	2.66	2.35	2.47
Carbohydrates	49.85	51.50	50.46

The obtained values are generally in agreement with those obtained by **Matz (1993) and Rageh (1998).** Unfortunately there is no limit for the allowed content of total ash in potato chips recommended by **Anon (1993).**

The protein content of potato chips samples ranged between 10.26 and 10.71% which is clearly higher than those obtained by **Matz (1993), Nagi (1994) and Rageh (1998).** The protein differences of potato chips between these studies were probably due to the differences in cultivars for potato chips, manufacturing conditions and fertilization treatments **(Klein *et al*, 1980 and Sharfuddin and Voican, 1984).**

It could be noticed from presented data in Table (1), that crude fiber content of the studied potato chips samples ranged from 2.35 to 2.66%.

These results agreed with the recommended values of those reported by **Anon, 1993** and the results of **Ragch (1998).**

The results of total carbohydrates of potato chips ranged from 49.85 to 51.50%. These results are in agreement with those reported by **Ragch (1998)** but lower than those of **Haytawitz and Mathews (1984) and Matz (1993).**

Salt (sodium chloride) and heavy metals contents of some potato chips products :

It could be noticed from presented data in Table (2), that the salt (sodium chloride) content of potato chips ranged from 1.94% in samples obtained from first company to 2.11-2.48% in those from second company. **Nagi (1994)** reported that sodium chloride content of potato chips ranged from 1.88 to 2.35% for samples obtained from different markets of Minofiya Governorate. The **E.S.S. (Anon, 1993)** recommended that sodium chloride should be not more than 2%. The Dietary guide lines for healthy food choices by **USDA (1993)** suggested moderate salt for consumption. Heavy metals, namely Fe, Cu, Zn and Mn, studied in potato chips were determined and the results are presented in Table (2).

Table (2): Salt (sodium chloride) and heavy metals content of some potato chips products.

Constituents	Products		
	Company 1	Company 2	
	Lemon'n chili	Lemon'n chili	Salt
Sodium chloride %	1.94	2.11	2.48
Heavy metals (p.p.m) :			
Fe	23.76	22.28	20.46
Cu	0.00	0.00	0.00
Zn	5.61	4.62	4.29
Mn	8.42	7.76	7.92

From data in Table (2), potato chips purchased from the first company had the highest Fe, Zn, Mn levels. Iron (Fe) content of potato chips purchased from two companies ranged from 20.46 to 23.76 p.p.m. which was higher than that obtained by **Haytawitz and Mathews (1984)** and **Matz (1993)** who found that the Iron content of potato chips was 1.19 mg/100 gm and 1.63 p.p.m., respectively.

Data in Table 2 showed that all samples were free of Cu. These results were disagreed with those obtained by **Matz (1993), Nagi (1994) and Ragch (1998),** who found that the Cu content was 0.31, (7.25-9.25) and (4.19-5.11) p.p.m., respectively. Zn content of potato chips purchased from two companies ranged between (4.29-5.61) p.p.m. These results are in

accordance with those stated by **Ragab (1998),** who found that the Zn content of potato chips purchased from different markets of Minofiya Governorate was ranged between 5.02-7.31 p.p.m. The **E.S.S. (Anon, 1993)** stated that provisional tolerable daily intake for human was 0.3-1.0% mg/kg body weight. Excessive intake of Zn can cause anemia, weight loss, elevated white blood cell count and renal failure (**Whitney *et al.*, 1990**).

Manganase content of potato chips purchased from the two companies ranged from 7.76 to 8.42 p.p.m., which are relatively higher than that estimated by **Haytawitz and Mathews (1984) and Matz (1993)**. They found that the Mn content was 0.44 mg/100 gm and 0.44 p.p.m., respectively.

Effect of storage conditions on chemical composition of some potato chips products :

Moisture and oil are the two major critical variables affecting potato chips quality and acceptability (**Mohamed, Sabria 1997**).

The moisture content :

Moisture content of potato chips is an important factor that greatly affects their quality. If the moisture content of potato chips was more than 3.5%, it become unpalatable and lost crispness (**Kubiak *et al.*, 1982**). The moisture content of packaged potato chips depends on the water vapour permeability (WVP) of the used packaging materials. The increasing of moisture in potato chips considered a big problem in potato chips industry even more than the oxidative rancidity (**Stanley and Rager, 1970**). The changes occurred in the moisture content of potato chips with different flavours purchased from the two companies are followed up during the storage period of 180 days at laboratory and local market conditions. The moisture content of potato chips tended to increase gradually during storage at both conditions (Table 3). These results have the same trend as reported by **Nagi (1994) and Mohamed, Sabria (1997)**.

The highest level of the moisture content was found in the potato chips stored at local market conditions compared to those stored at laboratory conditions. The observed increase in the moisture content of potato chips stored at local market conditions could be mainly due to the higher temperature and relative humidity, which raised the water vapour permeability through the polymer and hence raised the moisture contents of packaged foods especially those with a very low moisture content which become more hygroscopic. The moisture content of potato chips reached the critical moisture content (3.5%) (**Mohamed, Sabria 1997**) after 60 and 90 days of storage at local market and laboratory conditions, respectively.

Table (3): Effect of different storage conditions on moisture content (%) of some potato chips products.

Storage period (days)	Storage conditions					
	Laboratory			Local market		
	Company 1	Company 2		Company 1	Company 2	
	Lemon'n chili	Lemon'n chili	Salt	Lemon'n chili	Lemon'n chili	Salt
0	2.54	2.00	2.01	2.54	2.00	2.01
30	3.06	2.50	2.34	3.16	2.81	2.77
60	0.38	2.91	2.63	3.65	2.23	3.05
90	3.85	3.36	2.98	3.79	3.59	3.14
120	3.93	3.62	3.04	3.96	3.73	3.34
150	4.02	3.87	3.10	3.99	3.82	3.42
180	4.27	3.71	3.17	4.29	3.98	3.64

It is also clear that the increasing rate of moisture content in potato chips with salt was less than that of potato chips with Lemon'n Chili flavour, this may be due to correlation the moisture with the salt.

Ether extract :

From the obtained results (Table 4) it was clear that the ether extract tended to decrease during storage of potato chips after 180 days. The results are in agreement with those obtained by **Mohamed, Sabria (1997)**. The observed decrease in the oil content of potato chips during storage could be mainly due to the adsorption of some absorbed oil which accumulated at the inner surface of the packaging film. This adsorption of ether extract was affected by the storage conditions especially temperature and storage time (**Kozempel *et al.*, 1991**).

Table (4): Effect of different storage conditions on ether extract of some potato chips products (as % on dry weight basis).

Storage period (days)	Storage conditions					
	Laboratory			Local market		
	Company 1	Company 2		Company 1	Company 2	
	Lemon'n chili	Lemon'n chili	Salt	Lemon'n chili	Lemon'n chili	Salt
0	33.50	31.89	33.09	33.50	31.89	33.09
30	32.84	31.23	32.85	32.45	30.69	32.80
60	32.44	30.69	32.57	32.37	30.50	32.00
90	31.45	30.33	32.46	31.64	30.13	31.97
120	31.52	29.98	32.43	31.49	29.80	31.76
150	31.32	29.73	32.50	31.37	29.59	31.63
180	31.27	29.80	31.99	31.14	29.64	31.58

The decreasing rate of ether extract was higher in the samples stored at local market conditions compared to those stored at laboratory conditions. This may be due to higher temperature and relative humidity, rancidity of fats (**Hafiz *et al.*, 1990**).

Effect of different storage conditions on the quality extracted oil from some potato chips products :

The practical aspects of detecting and monitoring rancidity development in unsaturated fats and oils has been carried out through the measurement of peroxide value, which is considered as main indicator of autooxidation (**Mohamed, Sabria 1997**).

Peroxide value :

The peroxide value expressed in milliequivalent of absorbed oxygen and reflects the degree of oxidation of oil. The changes in peroxide value of potato chips purchased from the two companies with different flavours (Lemon'n chili and Salt) and stored under different conditions (at laboratory and local market) are shown in Fig. (1). From these results, it could be noticed that the peroxide value of the oil extracted from potato chips under investigation was ranged between (4.01 and 5.40 ml.eq. O_2 kg^{-1} oil extract) at the beginning of the storage period. These high value may be due to frying conditions (e.g. excessive aeration and holding the oil in the fryer at frying temperature with no product going through), multiple frying and contamination by metals (Fe, Zn, Mn, ...), e.g. from pumps or paddle shaft wear (**Schultz *et al.*, 1962 and Allen and Hamilton 1983**). The results are in agreement with those reported by **Ara *et al.* (1978), El-Sharkawy (1979) and Abd El-Satter (2000)**. As shown in Fig. (1) the peroxide value increased by different rates in all studied samples due to storage conditions. These results are in harmony with those obtained by **Lee *et al.* (1985), Park *et al.* (1996), Mohamed, Sabria (1997) and Pangloli *et al.* (2002)**.

The highest increase in the peroxide value was obtained in potato chips stored in local market conditions compared to those stored at laboratory conditions. This could be attributed to the direct sunlight and hence the Ultraviolet rays, whereas sunlight accelerate the lipid autooxidation.

The results also revealed that the peroxide value of potato chips reached the border line of acceptability (10 ml.eq of oxygen/kg of extracted oil) after the first 30 days of storage at local market conditions. On the other hand, the same border line was reached after 60 days of storage in laboratory conditions.

The results given in Fig. (1) show that the peroxide value increased then decreased with increasing storage period, this may be explained by the conversion of peroxides to other oxidative products as aldehydes of low molecular weight.

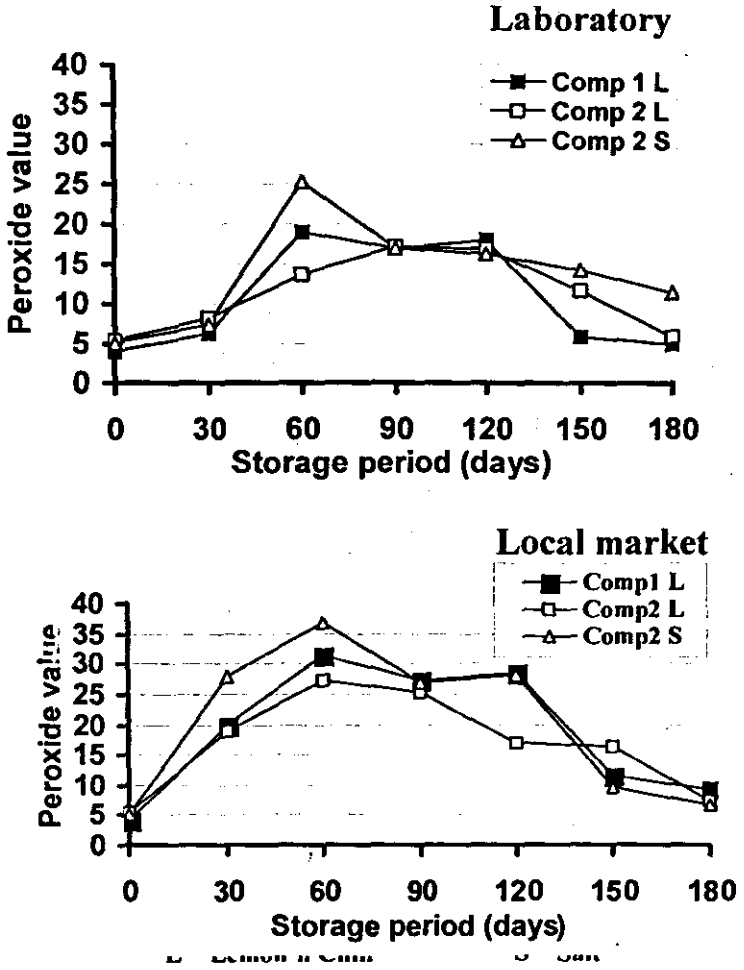

Fig. (1): Effect of different storage conditions on peroxide value (ml.eq.O_2 kg^{-1} oil extract) of some potato chips products.

Free fatty acids (FFA) :

Acid value is a good parameter that could be used to follow up the oil deterioration during handling and storage and is good indicator for hydrolytic rancidity, in which the oil triglycerides are decomposed to

glycerol and free fatty acids. Furthermore, the acid value is often used as a general indication of the edibility of oils (**Pearson, 1976**).

The free fatty acids and acid value of potato chips purchased from the two companies with different flavours (Lemon'n chili and Salt) and stored either at laboratory or at local market conditions for 180 days was evaluated and the obtained results are hereafter shown in Fig. (2).

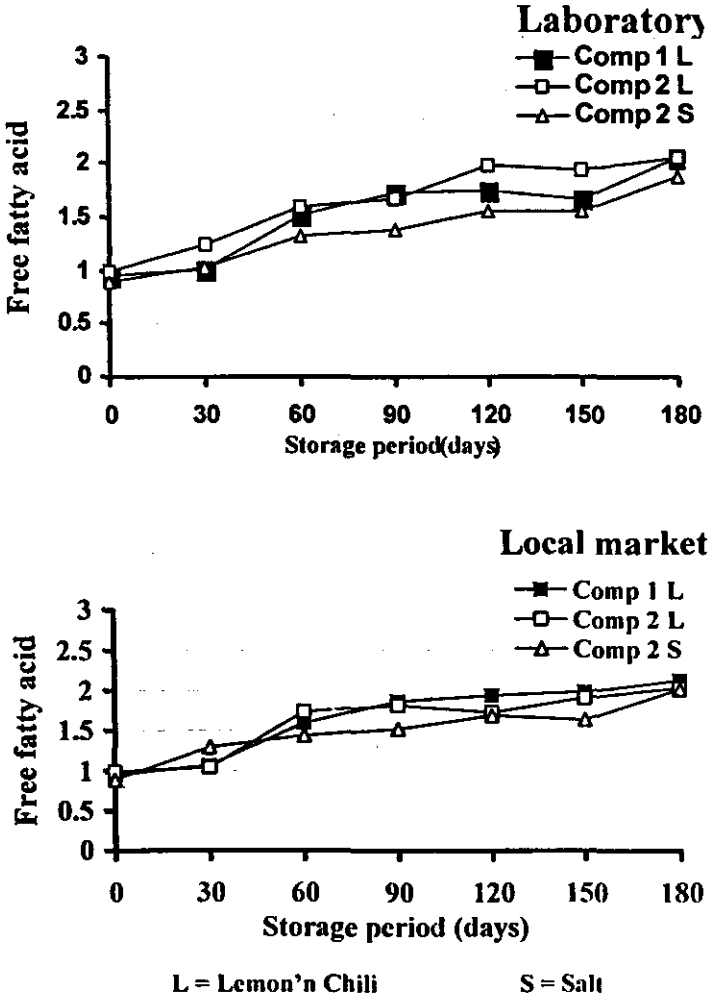

Fig. (2): Effect of different storage conditions on FFA (% as oleic acid) of some potato chips products.

Free fatty acids (as oleic acid) were ranged between 0.89 and 0.99% in fresh samples, these high values may be due to frying conditions, then increased in all samples as the storage period increased. These results are in the line of those reported by **Mohamed, Sabria (1997) and Rageh (1998)**. The increasing of free fatty acids during the storage period may be due to increasing moisture content during the storage, which caused the hydrolytic rancidity and presence of heavy metals (**Allen and Hamilton 1983 and Benjelloun *et al.*, 1991**).

The same results in Fig. (2) indicated that the increasing rate of FFA was higher in the potato chips stored at local market than that of stored at laboratory conditions. These results may be attributed to high temperature and relative humidity.

Thiobarbituric acid number (TBA) :

TBA value (as expressed by mg of malondialdehyde/kg oil extract) of potato chips purchased form the two companies with two different flavours and stored either at laboratory and at local market conditions are presented in Fig. (3). It is evident from these results that TBA values are positively related to storage period and storage conditions. TBA value increased in all samples as the storage period increased. Similar results were obtained by **Mohamed, Sabria (1997)**. Storage at relatively higher temperature and relative humidity in local market conditions raised sharply TBA values of all stored samples compared to those of stored samples for the same period at laboratory conditions. The major effect of the local market storage on the TBA value of stored potato chips could be attributed to the direct sunlight and hence the ultraviolet rays, whereas sunlight accelerate the lipid autooxidation.

The results given in Fig. (3) show that the lower increasing rate in the TBA value was recorded for these samples with Lemon'n chili flavour, this may be due to the presence antioxidant materials such as ascorbic acid in the flavour agents.

From the above results (Pv, FFA and TBA values) it could be concluded that the storage at laboratory conditions (at low temperature and relative humidity) considered the best conditions that can be used with potato chips, it can retard both oxidative and hydrolytic rancidity. Lemon'n chili flavour delayed the rancidity and hence may prolong the shelf life of potato chips stored at laboratory and local market conditions.

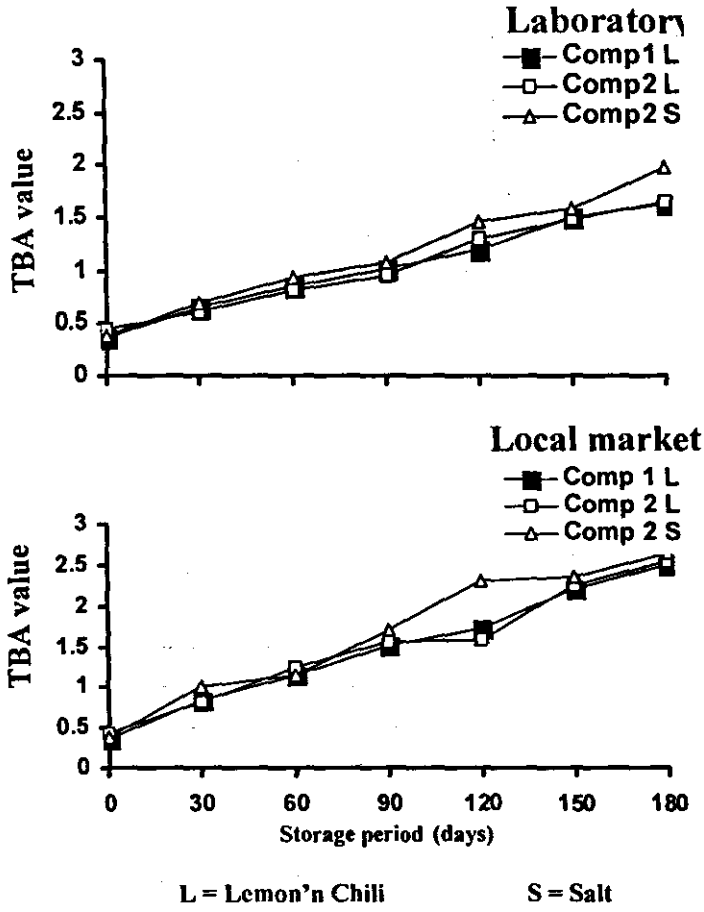

Fig. (3). Effect of different storage conditions on TBA value of some potato chips.

Fatty acids composition :

Fatty acids composition of the oil extracted from potato chips purchased from the two different companies with different flavours (Lemon'n chili and Salt) were identified before and during storage at laboratory and local market conditions. The obtained results are shown in Table (5).

It is evident from the results that the fatty acids of palm oil (frying oil) extracted from fresh potato chips contained saturated and unsaturated fatty acids. The saturated fatty acids were lauric acid ($C_{12:0}$) 0.44-0.81; myristic acid ($C_{14:0}$) 1.35-1.73; palmitic ($C_{16:0}$) 34.45-35.12; margaric ($C_{17:0}$) 0.19-0.39 and stearic ($C_{18:0}$) 3.24-4.85. Meanwhile the unsaturated fatty acids

were palmitoleic ($C_{16:1}$) 1.01-2.12; oleic ($C_{18:1}$) 41.01-42.68; linoleic acid ($C_{18:2}$) 12.06-14.47 and linolenic acid ($C_{18:3}$) 1.65-1.93. Similar results were reported in the literature (**Smith *et al.*, 1985 and Barrera-Arellano and Esteves, 1992**). The changes that took place in fatty acids pattern during storage either at laboratory or at local market conditions revealed that the unsaturated fatty acids linolenic and linoleic had decreased during the storage with an increase in oleic acids and other fatty acids. The results are in line stated by **Robertson and Morrison (1978), Mohamed, Sabria (1997) and Che-Man and Tan (1999).**

Table (5): Effect of different storage conditions on fatty acids composition of oil extracted from some potato chips products. (% of total fatty acids)

Fatty acids	Products														
	Company 1					Company 2									
	Lemon'n chili					Lemon'n chili					Salt				
	0	90 days		180 days		0	90 days		180 days		0	90 days		180 days	
		Lab.	Mar.	Lab.	Mar.		Lab.	Mar.	Lab.	Mar.		Lab.	Mar.	Lab.	Mar.
Saturated :															
Lauric ($C_{12:0}$)	0.61	0.61	0.49	0.50	0.48	0.81	0.53	0.52	0.53	0.55	0.44	0.43	0.49	0.53	0.46
Myristic ($C_{14:0}$)	1.45	1.41	1.32	1.43	1.38	1.73	1.47	1.32	1.50	1.52	1.35	1.32	1.41	1.34	1.31
Palmitic ($C_{16:0}$)	34.45	36.42	36.30	36.55	36.20	35.12	35.46	35.60	35.72	35.82	34.85	35.65	35.78	37.00	37.31
Margaric($C_{17:0}$)	0.19	0.18	0.20	0.29	0.34	0.39	0.41	0.40	0.43	0.42	0.38	0.30	0.37	0.50	0.22
Stearic ($C_{18:0}$)	4.85	4.22	4.59	4.61	4.95	3.24	3.72	4.08	4.00	4.22	4.07	4.13	4.23	4.70	4.25
Total SFA	41.75	42.84	42.90	43.38	43.35	41.29	41.55	41.92	42.18	42.52	41.09	41.83	42.28	44.07	43.55
Unsaturated :															
Palmioleic($C_{16:1}$)	1.12	1.08	1.04	1.13	1.11	2.12	2.02	1.92	2.12	2.58	1.01	1.17	1.11	1.20	1.14
Oleic ($C_{18:1}$)	41.01	41.63	42.01	42.67	42.54	42.63	43.09	43.53	43.29	43.89	42.68	42.85	43.24	42.48	43.55
Linoleic ($C_{18:2}$)	14.47	13.17	12.96	12.67	12.00	12.06	11.73	11.34	11.30	10.99	13.54	12.62	11.91	11.21	10.78
Linolenic($C_{18:3}$)	1.65	1.27	1.08	1.14	0.99	1.93	1.60	1.28	1.10	1.00	1.68	1.52	1.44	1.03	0.98
Total USFA	58.25	57.15	57.09	56.61	56.64	58.71	58.44	58.07	57.81	57.46	58.91	38.16	57.70	55.92	56.45

Storage conditions : Laboratory (Lab.) : 15-30°C and 55-72% RH.
Local market (Mar.) : 12-55°C and 20-78% RH.

The changes that took place in fatty acids is elated to storage conditions especially temperature and oxygen. These two factors accelerate the oxidation of unsaturated fatty acid and decomposition of saturated ones.

It is known that exposure to day light or artificial light causes a marked acceleration in deterioration of unsaturated oils. Meanwhile, the saturated fatty acids are relatively inert to the action of oxidizing agents, except in the presence of catalyst or at elevated temperature.

Effect of different storage conditions on organoleptic properties of some potato chips products :

Colour, odour, taste and texture of different samples of potato chips under investigation was evaluated by ten panelists. The obtained results (mean scores) are given in Table (6).

Table (6): Organoleptic properties of some potato chips products stored under different conditions.

Storage period (days)	Products	Storage conditions					
		Laboratory			Local market		
		Company 1	Company 2		Company 1	Company 2	
		Lemon'n chili	Lemon'n chili	Salt	Lemon'n chili	Lemon'n chili	Salt
0	Colour	9.0	9.0	9.0	9.0	9.0	9.0
	Odour	9.0	9.0	9.0	9.0	9.0	9.0
	Taste	9.0	9.0	9.0	9.0	9.0	9.0
	Texture	9.0	9.0	9.0	9.0	9.0	9.0
	Over all Acceptability	9.0	9.0	9.0	9.0	9.0	9.0
30	Colour	9.0	9.0	9.0	8.0	9.0	8.0
	Odour	9.0	9.0	9.0	8.0	8.0	7.0
	Taste	9.0	9.0	8.0	8.0	8.0	7.0
	Texture	8.0	9.0	9.0	8.0	8.0	7.0
	Over all Acceptability	8.0	9.0	8.8	8.0	8.3	7.3
60	Colour	8.0	9.0	8.0	8.0	9.0	7.0
	Odour	8.0	9.0	8.0	7.0	7.0	6.0
	Taste	8.0	8.0	8.0	7.0	4.0	6.0
	Texture	8.0	8.0	8.0	6.0	6.0	7.0
	Over all Acceptability	8.0	8.5	8.0	7.0	7.3	6.5
90	Colour	7.0	7.0	6.0	6.0	6.0	5.0
	Odour	7.0	7.0	6.0	4.0	4.0	3.0
	Taste	7.0	7.0	6.0	4.0	4.0	3.0
	Texture	7.0	7.0	6.0	4.0	4.0	4.0
	Over all Acceptability	7.0	7.0	6.0	4.5	4.5	3.8
120	Colour	6.0	5.0	5.0	5.0	5.0	4.0
	Odour	1.0	5.0	3.0	2.0	3.0	2.0
	Taste	4.0	4.0	4.0	3.0	3.0	2.0
	Texture	5.0	5.0	4.0	3.0	2.0	2.0
	Over all Acceptability	4.8	4.8	4.0	3.3	3.3	2.3

Score sheet: Liked extremely 9 — Liked very much 8 — Liked moderately 7
Liked slightly 6 — Neither liked nor disliked 5 — Disliked slightly 4
Disliked moderately 3 — Disliked very 2 — Disliked extremely 1

It is clear from the date that storage temperature and time had negative effects on sensory qualities of potato chips. The sensory quality dropped as storage temperature and time increased. These results are in agreement with those obtained by **Park *et al.* (1996), Mohamed, Sabria (1997), Regeh (1998) and Pangloli *et al.* (2002)**. The results also revealed that potato chips with Lemon'n chili flavour was more acceptable for consumers. This may be due to the Lemon'n chili flavour effect which disappear the off-flavour arise in stored potato chips. In the same Table, it could be seen that the panelists gave the lowest score for potato chips stored for 90 days in

local market and for 120 days at laboratory conditions, after the a foiementioned periods of storage off-flavour appeared and the potato chips lost its crispness, although these samples were not expired.

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الملخص العربى

تقييم جودة شرائح البطاطس المقلية (الشيبسى) المنتجة فى مصر

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يهـدف هذا البحث الي دراسة تقييم جودة بعض الأغذية الخفيفة الأكثر تداولا وقبولا لدى جمـيع فئات المستهلكين (أطفال – بالغين) مثل شرائح البطاطس المقلية (الشيبسى) المنتجة حديثاً من بعض شركات الصناعات الغذائية الأكثر إنتاجا وتوزيعا داخل جمهورية مصر العربية.

حـيث تم دراسة تاثير كل من ظروف التخزين المختلفة (المعمل – السوق المحلى بمدينة كفرالشيخ) والطعوم المضافة (الشطة والليمون – الملح) علي الخواص الحسية و الكيميائية لهذه الأغذية خلال فترة الصلاحية لشرائح البطاطس (٦ شهور).

و قد اوضحت النتائج مايلى :ـ

- أوضح التركـيب الكيماوى لشرائح البطاطس المقلية أن قيم الرطوبة، المستخلص الأثيرى، الرماد، البروتين، الألياف الخام والكربوهيـدرات كانت تتـراوح بين (٢,٠– ٢,٥٤) ، (٣١,٨٩ – ٣٣,٥٠) ، (٣,٥٥ – ٣,٧٣) ، (١٠,٢٦ – ١٠,٧١) ، (٢,٣٥ – ٢,٦٦) و(٤٩,٨٥ – ٥١,٥٠) ٪ علـى التـرتيب ، حـيث كان محتوى الرطوبة لشرائح البطاطس المـشتراة من الشركة رقم ١ أعلى من الشركة رقم ٢، ومن المواصفات القياسية المصرية التي تنص علي أن نسبة الرطوبة و الملح لا تزيد عن ٢%.

- محتوى العينات من الملح (كلوريد الصوديوم) تراوح ما بين ١,٩٤ إلى ٢,٤٨ ٪ . ومن المعادن الثقيلة المقدرة (كجزء فى المليون) كالحديد (٢٠,٤٦ – ٢٣,٧٦) ، الزنك (٤,٢٩ – ٥,٦١) والمنجنيز (٧,٧٦ –٨,٤٢) والنحاس صفر.
- أدى تخزين هذه العينات الى زيادة محتواها من الرطوبة حيث وصل الى الحد الحرج (٣,٥%) بعد ٦٠ يوم من التخزين فى ظروف السوق المحلى و بعد ٩٠ يوم من التخزين فى ظروف المعمل. كما أدى التخزين الى خفض المحتوى الدهنى فى العينات المخزنة فى السوق المحلى وفى المعمل وهذه التغيرات فى المحتوى الرطوبى والدهنى للعينات كان له تأثير على هشاشيتها حيث لوحظ إنخفاض هذه الهشاشية فى كل من العينات مع زيادة مدة التخزين.
- وجد أن رقم البيروكسيد للزيت المستخلص من شرائح البطاطس المخزنة فى ظروف المعمل زاد ببطء فى بداية التخزين ثم ازداد معدل الأكسدة بسرعة خاصة فى الزيت المستخلص من شرائح البطاطس المخزنة فى ظروف السوق المحلى، كما وصل هذا الرقم إلى الحد الذى ترفض عنده العينات (١٠ ملليمكافئات أكسجين / كيلو جرام من الزيت المستخلص) بعد ٦٠يوماً من التخزين فى ظروف المعمل فى حين وصل إلى نفس الحد بعد ٣٠ يوماً فقط من التخزين فى ظروف السوق المحلى وكان معدل التغير فى رقم البيروكسيد فى زيت شرائح البطاطس بطعم الشطة والليمون أقل من الشرائح التى بطعم الملح.
- لوحظ أيضا أن معدل الزيادة فى الأحماض الدهنية الحرة كان أعلى فى زيت الشرائح المخزنة فى ظروف السوق المحلى عن الشرائح المخزنة فى ظروف المعمل.
- رقم الـ T.B.A ازداد تدريجياً أثناء التخزين ومعدل الزيادة كان أعلى فى حالة شرائح البطاطس المخزنة فى ظروف السوق المحلى عن المخزنة فى المعمل ، وكذلك معدل الزيادة كان أقل فى شرائح البطاطس بطعم الشطة والليمون مقارنة بشرائح البطاطس بطعم الملح .
- نسبة الأحماض الدهنية للزيت المستخلص من شرائح البطاطس تغيرت بتغير ظروف التخزين ، حيث حدث نقص فى نسبة الأحماض الدهنية الغير مشبعة بالتخزين بدرجة أعلى فى العينات المخزنة فى ظروف السوق المحلى عن المخزنة في ظروف المعمل.
- أوضحت اختبارات التذوق الحسي أن المحكمين لم يتقبلوا العينات المخزنة فى ظروف السوق المحلى بعد ٩٠ يوما وبعد ١٢٠ يوماً من التخزين فى المعمل على الرغم من عدم انتهاء فترة الصلاحية. وكانت العينات بطعم الشطة والليمون أكثر قبولا لدى المحكمين حيث ادي التخزين في ظروف السوق المحلي الي حدوث تزنخ بعد ٩٠ يوما وظهور روائح و طعوم غير مرغوبة.
- وفى النهاية يجب تشديد الرقابة على هذه الشركات بواسطة هيئة سلامة وجودة الأغذية من حيث أستخدام زيوت طازجة منخفضة فى رقم البيروكسيد المبدئي وعدم زيادة نسبة الملح عن النسب المسموح بها (٢%) وخفض فترة الصلاحية وتشديد الرقابة على منافذ البيع والباعة الجائلين وظروف البيئة المحيطة بعرض هذه المنتجات وذلك لضمان الحصول على منتجات ذات جودة أفضل للمحافظة على صحة المستهلكين من الأطفال والبالغين.