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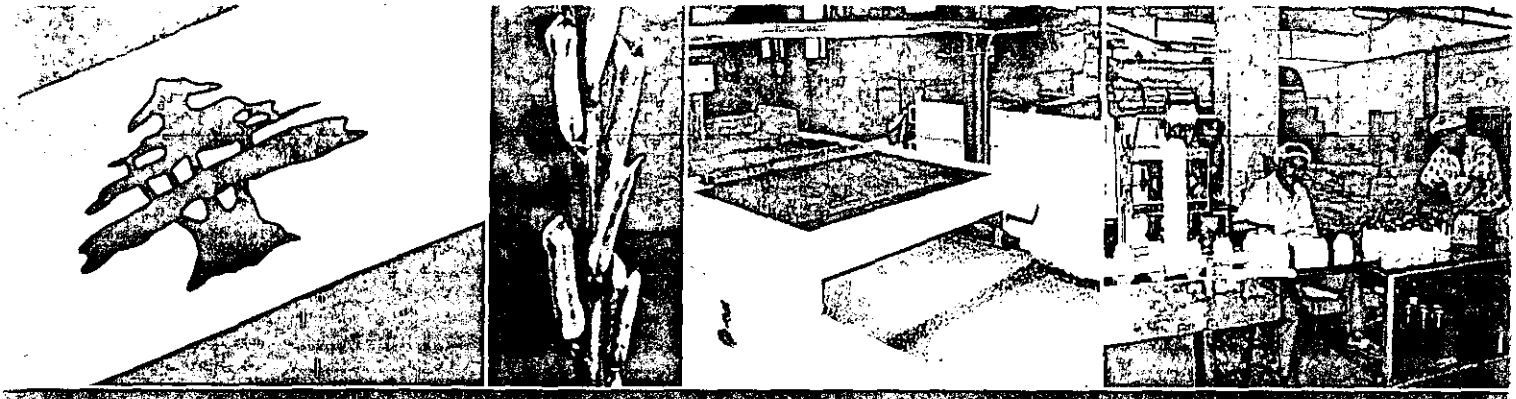

LEBANON

Tahineh and Halaweh Project Report

TO ENHANCE THE COMPETITIVENESS OF THE LEBANESE INDUSTRY AND ITS INTEGRATION IN THE GLOBAL MARKET

Emergency Assistance to Food Safety

UNIDO

UNITED NATIONS
INDUSTRIAL DEVELOPMENT
ORGANIZATION

Ministry of Industry, Lebanon

Ministry of Economy, Lebanon

Scientific Committee
of the Lebanese Food Safety Panel

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Vienna, 2004

Executive Summary

"Tahineh" and "Halaweh" are two of the most important food production sectors in Lebanon. They are consumed on a large scale locally and exported widely to other countries. However, those sectors have suffered serious export problems as they have been under detention in several countries due to biological and chemical contaminations, mainly with salmonella and aflatoxin. Moreover, there was a large debate in the country about the addition of a whitening chemical, titanium dioxide that has been added to Tahineh in order to lighten its color.

The Scientific Committee of UNIDO's Food Safety Panel (FSP) in Lebanon conducted a project to assess the Tahineh and Halaweh sectors through visiting a representative number of the factories (17 factories) producing Tahineh and Halaweh, and performing laboratory analysis for their brands. Samples were taken from all stages along the production lines of the products and were analyzed for aflatoxin level, salmonella and other microbiological contamination, and titanium dioxide level. In addition a survey was carried out in order to explore the average daily consumption of Tahineh and Halaweh and hence the amount of titanium dioxide intake through both products in Lebanon.

It was found that the raw material used for Tahineh production is sometimes contaminated with aflatoxin. Moreover, there is a hygienic problem causing microbiological contamination through the production process; five factories had salmonella in their water, end product or on the processing line. Also other bacterial infections were recorded along the production lines. Titanium dioxide levels were found to be within the limits set by the Lebanese Norms and Standards Institution.

It is recommended to follow the good manufacturing practices (GMP) and HACCP principles in order to overcome the different problems arising in the Lebanese Tahineh and Halaweh production. The Scientific Committee worked a GMP guideline for Tahineh and Halaweh factories in addition to HACCP plans for the two products.

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I. Introduction

Tahineh is a fatty food product elaborated from the milling of de-hulled, roasted seeds (*Sesamum indicum*). The product has a creamy- brownish color with nutty ground flavor. It is generally filled and packed in various sizes and shapes. Most commonly, they are filled in 450 g and/or 1 Kg plastic and/or glass jars, whereas bulk product is filled in large tins or barrels. A detailed manufacturing process of Tahineh is illustrated in the HACCP plan guidelines.

Sesame plant is an ancient oil crop supplying seeds for confectionery purposes, edible oil, paste (Tahineh), cake, flour and sometimes used as additive ingredient in various products such us thyme.

Major sesame producers in the world include India, Sudan, Mexico, China, Ethiopia and Venezuela. The sesame seed plant is an annual with a branched stem that grows to a height of about 2-4 feet. The small seeds vary in size up to 3.5 mm. The whole seeds are enhanced by lightly toasting before use.

The nature of agricultural production together with harvesting and handling of seeds as raw material allow high possibility of contamination, particularly when primitive technologies are used. Contaminants may be biological such as pathogens, chemical such as pesticide residues and/or physical such as soil. Thus, particular attention should be given to the quality of sesame seeds when used as raw material for the production of food intended for human consumption.

Lebanon, however, does not produce sesame seeds, but imports such raw materials usually from Sudan to produce Tahineh and subsequently a wide variety of other food products that contain Tahineh as an ingredient. These include Halaweh, Hommos (chickpeas + Tahineh), Baba Ghannouge (eggplant + Tahineh) and various other dishes.

The most common Tahineh based product is known as Halaweh. This is made by cooking a mixture of Tahineh (50 %) and sugar (about 50 %) and other additives such

as emulsifiers and flavorings. The end product is sweet in taste, cream in color, a solid texture and fibrous-like body.

Poor quality of raw material, poor manufacturing practices, lack of sophisticated quality control systems (GMP), lack of qualified employees are major elements that contribute to the production of inferior quality end product (Tahineh).

The greatest problem was the presence of the pathogen Salmonella in the products, which has alarmed the government, stakeholders, consumers and other concerned bodies. As a result, a comprehensive study concerning the processing conditions and safety of Tahineh production was carried out by UNIDO within the framework of the project: "To enhance the competitiveness of the Lebanese Industry and its integration in the global market. Emergency assistance to food safety". The study was carried out in collaboration with the Ministry of Economy and Trade, and the Syndicate of food industry.

II. Objectives

I. Review of raw materials , processing conditions and consumption of Tahineh and its derivatives

II. Assessment of risks associated with all production steps and operations including chemical, biological and physical hazards.

III. On-site confirmation of risk assessment by various convenient sampling techniques and analysis

IV. Elaborate suggestions and recommendations for optimum production and safety conditions based on GMP and HACCP concepts.

V. Construct a check list for the inspection of Tahineh and Halaweh production chains.

III. Products' Description

III. A. Tahineh Product:

Tahineh is a pasty, heavy sauce-like, classified as fatty food with safe moisture content. Fat content varies according to the cultivar and the manufacturing conditions. The norms of the product as stated by the Lebanese Institution for Standards and Norms (LIBNOR) are as follows:

Humidity	not more than 1%
Protein	more than 27%
Fat	more than 45%
Acidity	not more than 1.8%
Ash	not more than 3.5%

Experimental analyses of various samples taken from the retailers' shelves have shown contradictive results, particularly concerning protein contents. Experimental figures are presented in the table (1) below.

Table 1: Chemical analysis of various Lebanese Tahineh products

Brand	pH (%)	Acidity (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	A.V. (%)	P.V. mEq/Kg
A	5.76	0.036	2.06	2.80	20.2	46.83	2.80	43.95
B	5.98	0.034	1.95	2.60	19.35	48.14	3.64	49.50
C	6.35	0.038	1.94	2.60	19.35	42.92	2.52	49.95
D	5.83	0.018	2.01	2.98	23.83	45.08	0.84	5.00
E	5.97	0.014	0.96	3.00	22.98	43.76	1.12	6.50
F	5.77	0.015	1.96	2.39	23.40	41.84	0.84	5.00

- **Acidity and pH**

Tahineh, and as can be seen from the results is a very low acid food i.e. the almost neutral nature of this product is a favorable condition for pathogen growth and/or pathogen resistance to various treatment e.g. *Salmonella* survived a pH of 4.0 (HCl and Lactic acid). Most bacteria have an optimum pH near 6.8 and can grow at pH ranging from 4 to 8 (Tahineh belongs to this range, see Fig. 1). Usually, the growth rate decreases as the pH drops below the optimum value. Approaching the lower limiting pH for growth, microorganisms are first inhibited and eventually killed. Concerning pH, as a critical processing factor and as can be seen from Fig. 1, pH values of various Tahineh product does not suppress pathogens or eliminate them. Thus, other critical factors should be assessed for their efficacy in suppressing growth or resistibility of pathogens to processing conditions.

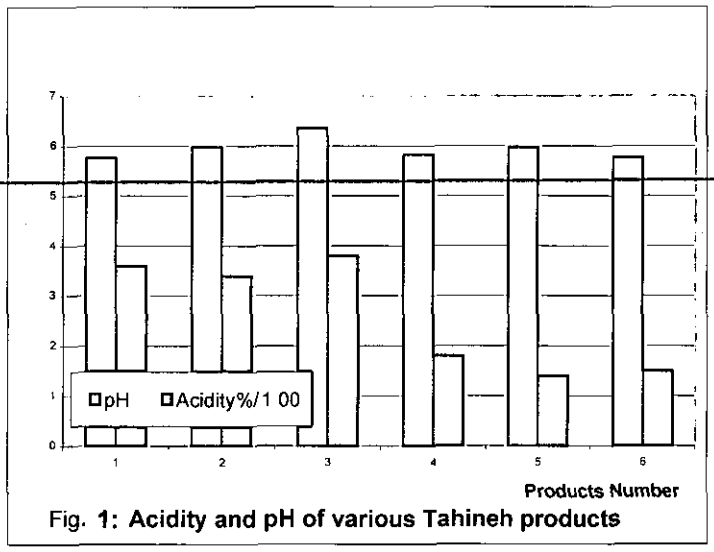


Fig. 1: Acidity and pH of various Tahineh products

- **Moisture content and water activity**

Microbial growth occurs only in the presence of water. This does not necessary need to be an obvious, visible, aqueous layer. Microorganisms may grow only in substrates having a water activity higher than 6.1. Tahineh, however, has a much lower value than 6.1. As can be seen in Fig. 2, the moisture content of various market products did not exceed 2 % in most samples i.e. water activity is less than 0.1. Thus, moisture content in Tahineh is an effective critical factor that can suppress the growth of pathogens, but does not necessarily mean their elimination. On the opposite, such conditions may increase the resistibility of organisms to vigorous processing conditions. D value can be increased i.e. heat resistant enhanced, if water activity is lowered. For example, it was reported that *Salmonella typhymurium* has survived the following heat treatment:

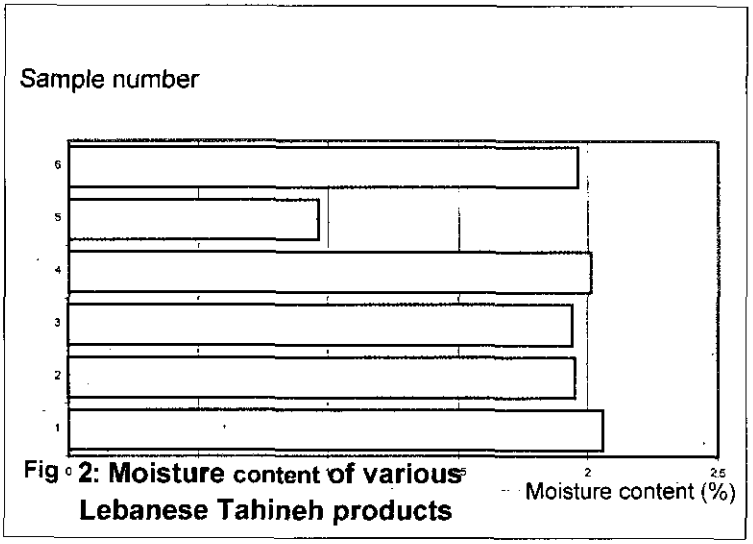


Fig. 2: Moisture content of various Lebanese Tahineh products

D_{70} ^{0}C value of 678 – 1050 minutes

D_{80} ^{0}C value of 222 minutes

D_{90} ^{0}C value of 72 – 78 minutes

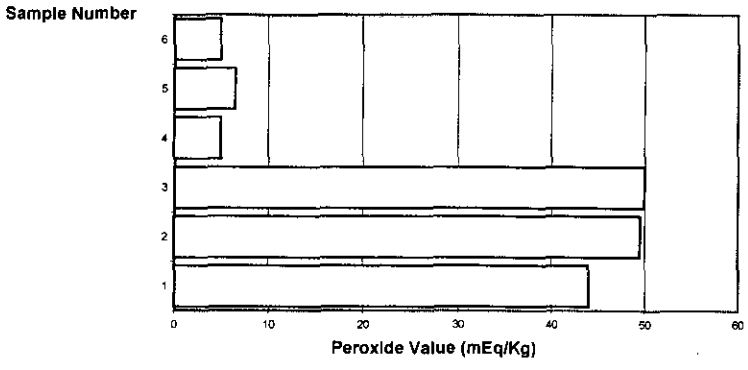
Therefore, the processing conditions of Tahineh are not considered enough to eliminate pathogenic risks, especially when strains of *Salmonella* are involved.

- **Oxidative and lipolytic rancidity**

Oxidative and lipolytic rancidity are subsequently expressed as peroxide and acid value of the fat part of Tahineh product. These values are presented in Figures 3 and 4. Acid value was accepted for all experimented samples i.e. lipolytic rancidity is

almost negligible. On the other hand, some products showed high values for peroxide value in comparison to others i.e. the process of Tahineh could enhance oxidative rancidity. This is eventually, enhanced by heat and by subjecting the product to air.

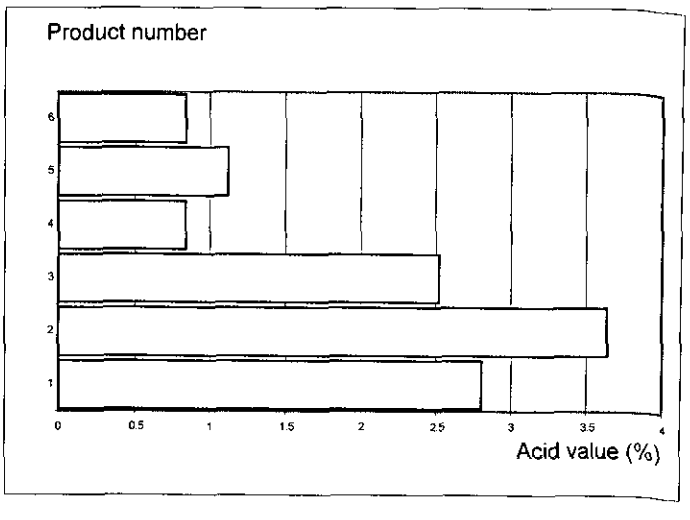
Fig . 3 : Peroxide value of various Lebanese Tahineh products



Oxidative rancidity is not really directly related to the growth of microorganisms. It presents organoleptic problems in addition to the resulting chemicals which may include chemical risks such as free radicals. Products characterized by such a nature are normally treated through the addition of anti-oxidants.

Other samples showed low values of peroxide, which imply that the processing conditions can be maintained and monitored to limit the formation of peroxide and subsequently oxidative rancidity.

Fig. 4 Acid value of Various Lebanese Tahineh Products



In addition to the formation of stable flavor compounds as a result of oxidation and subsequently deterioration of sensory characteristics of the end product, major physical deformation may occur. These include the coalescence of fat or oil and

subsequently the breakdown of emulsion. Furthermore, hardening of the non-fatty substances may take place and result in an inferior quality end product and shorter shelf – life.

To summarize, Tahineh product is not suitable for the growth of microorganisms, particularly pathogens due to its low moisture and high fat contents. Such conditions are not favorable for the microbial growth. Yet, processing steps, operations and conditions do not impose those critical factors that eliminate or destroy available pathogens, particularly *Salmonella*. Heat treatment applied during the process is not actually designed to kill such pathogens. Thus, it is vitally important, and within these conditions, to prevent microorganisms (contaminating ones) from reaching the product, especially in the actual processing areas. Such precautions are better handled by good manufacturing and hygienic practices.

III. B. Halaweh Product:

As it has been mentioned before, Halaweh processing is based on Tahineh product with the addition of about 50 % sugar. Thus, the efficacy of process critical factors (water activity, pH, Acidity, temperature) does not significantly differ than that of Tahineh.

However, the chemical composition of Halaweh is presented in the table (2) below:

Table 2: Chemical composition of various Lebanese Halaweh products

Brand	pH (%)	Acidity (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	A.V. (%)	P.V. mEq/Kg
A	5.26	0.013	2.08	1.20	11.10	24.10	0.84	7
B	5.25	0.022	2.06	1.39	10.10	21.16	0.56	3.5
C	5.66	0.022	1.86	1.40	9.10	19.28	0.56	8.5
D	5.33	0.01	1.48	1.39	12. 55	21.75	1.12	15
E	5.53	0.01	3.51	1.39	11.85	16.55	1.40	3
F	5.90	0.013	2.00	2.19	11.70	19.73	1.68	3.5

As can be seen from Table 2, both acid and peroxide values are lower than those of Tahineh. This is actually due to masking effect of the added sugar which acted as a diluting ingredient. This clearly observed from the differences between samples which resemble those of Tahineh.

On the other hand, contamination of Halaweh is caused by Tahineh and/or low level of GMP application. However, the short production chain of Halaweh makes it more possible to control operations and steps of manufacturing. Yet, similar approach to Tahineh should be adapted to assure the quality and safety of this product.

IV. On- site inspection of Tahineh and Halaweh Production

IV.A. Approach:

A list of all Tahineh and Halaweh manufacturing industries was prepared and classified according to size and capacity of production. A representative sample constituting of 17 sites was chosen for inspection. This sample includes large (production more than 5 tones per day), medium (production between 2 and 5 tones per day) and small size (production less than 2 tones per day) Tahineh and Halaweh institutions located in the various Lebanese areas (see Ref. 1).

Ref 1. Names, locations and Sizes* of visited Tahineh & Halaweh factories:

Size here means that of Tahineh and Halaweh production in the factory

Factory	Location	Size
1. El Kanater	Beirut	Large
2. Al Rabih	Northern Lebanon	Large
3. Mounir Bsat	Southern Lebanon	Large
4. El Yaman	Southern Lebanon	Large
5. Kassatly Chtaura	Bekaa Valley	Medium
6. Chahine	Northern Lebanon	Medium
7. Kamel Badawi Bsat	Southern Lebanon	Medium
8. Alameddine	Northern Lebanon	Medium
9. El Yaman	Bekaa Valley	Medium
10. A.O Ghandour	Beirut	Medium
11. Khater	Bekaa Valley	Small
12. Al Rabia El Khadra	Southern Lebanon	Small
13. Al Ghazal	Southern Lebanon	Small
14. Kalaajieh	Northern Lebanon	Small
15. Cortas	Beirut	Small
16. Cadmous	Southern Lebanon	Small
17. El Chafei	Southern Lebanon	Small

Each enterprise was inspected by a team of experts, according to a pre- planned check list. Main parts of the check list included elements and critical factors of Good manufacturing Practices (GMP), Hazard Analysis and Critical Control Point (HACCP), and management and administrative approach. In addition, the check list detailed questionnaire was also prepared to assess investment level, quality and quality assurance availability, waste disposal systems, laboratories and conformity to national and international norms and standards.

In parallel, samples of raw materials, on- line swabbing, and end- products were taken for chemical analysis (composition, titanium dioxide and aflatoxin) and microbiological analysis, particularly *Salmonella*. Analyses were carried out at the laboratories of the Saint Joseph University (USJ), American University of Beirut (AUB) and the Lebanese University (LU).

IV.B. Lebanese Tahineh and Halaweh sector:

IV.B.1. Number of enterprises, size of production and investment

According to the Lebanese industrial Index and the Lebanese Syndicate of Food Industry, there are 58 enterprises producing Tahineh and Halaweh in Lebanon. Among them, only 4 are considered as large-sized producers, eleven are medium-sized, whereas the remaining are small- sized institutions.

The majority of these enterprises produce Tahineh and Halaweh as the main product, whereas most significant ones are multi-products producers. Among large-sized producers, there is only one factory that produces Tahineh and its derivatives as main products. Production capacity ranges from 1 tone of sesame seeds/ day up to 15 tones/ day.

IV.B.2. Good Manufacturing Practices (GMP)

a. Personnel hygiene

- Medical examination is not implemented in the visited factories.
- In most of the factories food handlers do not wear suitable protective clothing.
- There was no evidence that the personnel wash their hands when personal cleanness could affect the safety of the food, for example after using the toilet or after handling any contaminated material.
- There is no eating/ drinking area. People eat or drink in the production area where they can for a small period of time.
- In some cases, we can notice indications to avoid smoking in the production area.
- The washing facilities are rare, at the most 2 for the whole production plant. In addition, these facilities are not kept clean.
- In most cases toilets and changing rooms open directly into the production plant. Furthermore, where changing rooms don't exist, the employees' clothes are left in the production area.
- Absence of signs reminding about hygiene principles and about the recommended hand washing method.

b. Design of establishment

b.1. The location of some of the equipment inside the factory and their installation does not facilitate maintenance and cleaning.

b.2. Environmental conditions

- The establishment is located near commercial buildings (fuel station, main road, other factories such as cosmetic and paper factories) which is considered as a polluted environment and is posing serious threat of contamination due to their industrial and commercial activities.
- Reception areas of raw material are not separated from other areas of processing.
- The flow of the personnel is not well organized or controlled.

b.3. Ventilation

- No mechanical ventilation system exists, ensuring and controlling that air does not flow from area to another.
- In the production area, an elevated ambient temperature is recorded due to the roasting process; no control is taking place.

b.4. Lighting

- Artificial and natural lighting system is provided. Nonetheless, it is fairly adequate to enable safe and hygienic processing.
- Lighting fixtures are not protected.

b.5. Drainage

- Drainage channels in the production area are absent. Cleaning water is drained to some holes in the floor that are covered with plastic covers.
- Facilities for sewage disposal are not available in most of the visited sites.
- Drainage system is not equipped with no return flow valves.

b.6. Walls

- The surfaces of walls in the processing areas are not made of convenient materials.
- They are not cleaned according to regulations and need maintenance.

b.7. Doors

- Doors are not easily cleanable and do not have any automatic closing device nor vision panels. In some places doors are made from iron and we can see the corrosion on it.
- External open doors are not kept closed.
- Entrances to the production area have more than 1 cm of opening between the doors and the floor.

b.8. Windows

- Windows in the production and storage area are not fitted with insect-proof screens to prevent the entrance of birds and insects.

b.9. Floors

- Cracks and open joints in the floors are found in most of the sites which makes cleaning and drainage less effective.

IV.B.3. Quality and quality assurance systems

Determinant factors of Tahineh quality from the producer points of view are mostly organoleptic. Particular attention is normally given to viscosity, uniformity of homogenousity and color. Safety of Tahineh was never considered as significant issue due to the false common impression that the product is fatty and has a very low moisture content and subsequently low water activity. Such an impression resulted in ignoring major safety issues such as microbial contamination and oxidation which is still not addressed. Thus, quality assurance systems were not given enough attention in this sector of food production. Generally speaking, most of Tahineh production factories are operating with no respect to Good Manufacturing or Hygienic Practices or to Hazard Analysis and Critical Control Point (HACCP), or any other quality assurance system.

Besides, internal inspection is not carried out in a strategic manner, hence leading to incompliance with related norms and standards. Furthermore, external inspection procedures lack the systematic, organized and strategic approach.

The problem of Tahineh and Halaweh safety was not raised until recently when *Salmonella spp.* was detected in several Tahineh and Halaweh exported products. As a result, those products were placed under detention lists in several countries.

V. Aflatoxin and Microbiological tests:

V.A. Introduction:

The chemical (A) and microbiological (B) tests covered a sample of 17 Lebanese factories producing Halaweh and Tahineh. These factories are distributed in different regions on Lebanese territory. This sample was chosen to be representative of the Tahineh and Halaweh production in Lebanon.

During each visit samples were collected through the lines of production in order to determine the hazards related to every step. Samples were taken from:

- Raw material (sesame seeds)
- Sesame after washing
- Sesame after roasting

- Tahineh swab from the stone mill
- Tahineh before filling
- Packaging material
- Water
- Finished products (Tahineh and Halaweh)

Tests were conducted to search for Aflatoxin, B_1 and B_2, in the raw material and the finished products, using the E.L.I.S.A.[1] technique according to the FDA[2] protocols by which 25grs of the sample are tested and the accepted level is < 20.0 ppb. The results are displayed in Table 3.

Through the microbiological tests, the search was mainly for *Salmonella* spp. According to the FDA protocol 25grs of the sample are treated in XLD[3] and HOEKTOEN selective media, after which the identification procedure is performed with the API 20E test.

The results of microbiological tests are shown in Table 7 where only the counts of *Salmonella* are specified. However, the other present bacteria are pointed out. The table also shows the stage in which the contamination was detected i.e. (water, stone, final product, etc...).

All equipment used for the purpose of the samples analyses are calibrated according to recognized certifications.

V.B. Results:

1. Aflatoxin:

All the results show that the raw material at the receiving stage contains aflatoxin in sesame seeds at different concentration levels. This means that specifications for sesame seeds should be agreed upon with the suppliers and tests must be performed at an earlier stage, upon seeds receiving. In some products like Halaweh, pistachios were added to the finished products; in this case, the level of Aflatoxin was higher.

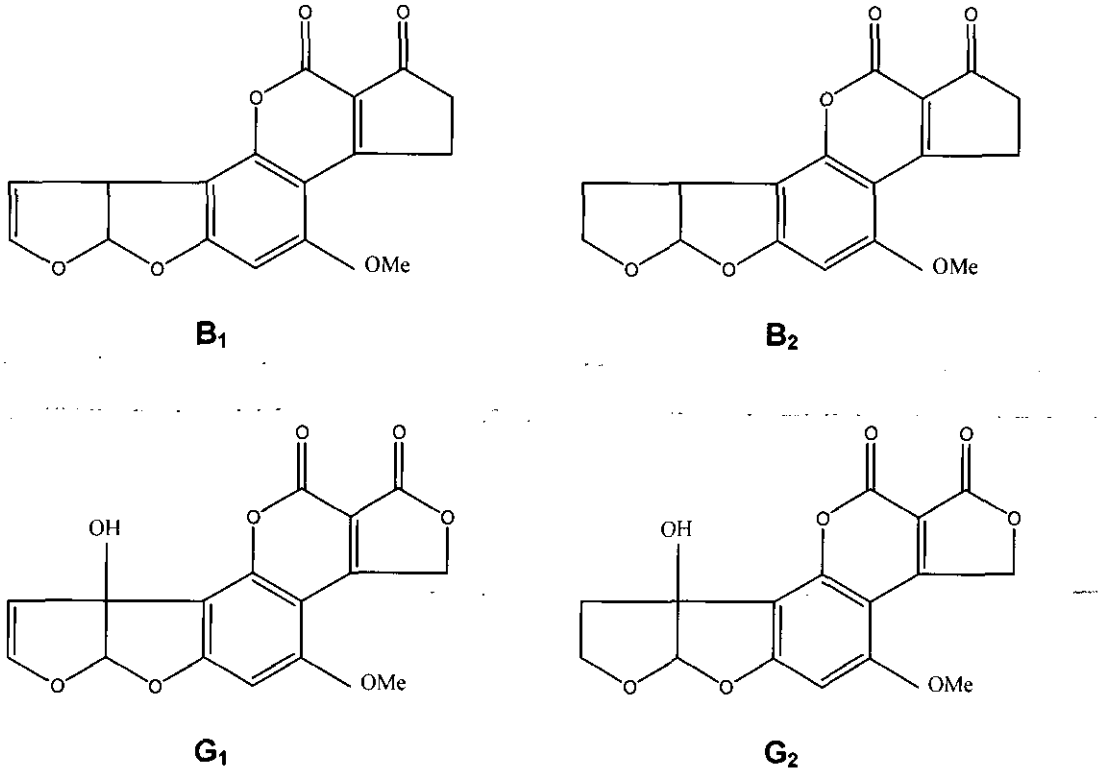
[1] E.L.I.S.A: Enzyme Linked Immuno-Sorbent Assay
[2] FDA: Food and Drug Administration
[3] XLD: Xylose Lysine Decarboxylase

Here again, specifications for pistachios should be agreed upon with the supplier and tested before use.

Table 3: Aflatoxin levels in the tested products

	SESAME SEEDS	TAHINEH	HALAWEH WITHOUT PISTACHIOS	HALAWEH WITH PISTACHIOS	PISTACHIOS
AL KANATER	7,0	7,0	12,0	-	-
CORTAS	6,8	5,0	11,0	-	-
CHAHINE	6,6	6,0	16,0	-	-
BSAT MOUNIR	4,6 (±0,2)	2 (±0,08)	8 (±0,3)	-	-
GHAZAL	8,8 (±0,3)	5,8 (±0,2)	14,5 (±0,6)	-	-
YAMAN	5,7 (±0,2)	5,6 (±0,2)	11,3 (±0,4)	10,4 (±0,4)	-
KHATER	14,4 (±0,6)	10 (±0,4)	-	-	-
GHANDOUR	15,3 (±1,3)	12 (±1)	13,1 (±1,2)	17,3 (±1,5)	-
EL-RABIH	19 (±1,7)	18,2 (±1,6)	15,3 (±1,4)	18,4 (±1,6)	-
EL-CHAFEI	15,9 (±1,2)	8 (±0,6)	15,3 (±1,2)	-	61,3 (±4,9)
BSAT KAMEL	17,7 (±1,4)	7,2 (±0,5)	10,1 (±0,8)	-	4,9 (±0,4)
YAMAN SAÏDA	6 (±0,5)	3 (±0,2)	-	-	-
CADMOUS	5 (±0,25)	5 (±0,25)	-	-	5 (±0,25)
GREEN HILL	5 (±0,25)	5 (±0,25)	7,7 (±0,4)	5 (±0,25)	5 (±0,25)
KASSATLY CHTAURA	3,8 (±0,3)	5,5 (±0,4)	9 (±0,7)	15 (±1,2)	-
KALAJEYEE	11,0 (±0,4)	8,2 (±0,4)	8,5 (±0,6)	-	-
ALAM El-Deen	7,2 (±0,25)	6,5 (±0,3)	7,5 (±0,5)	-	-

Aflatoxins are produced by *Aspergillus* species mainly *A. Flavus*, *A. Parasiticus*, and *A. Nomius*. Chemical structures of Aflatoxins B_1, B_2, G_1, G_2, and M_1, M_2 are given in fig. 5 and specifications are given in table 4. Among Aflatoxin four main species B_1 is the most predominant and the most toxic one. Aflatoxin B_2 and G_2 were identified as the di-hydroxy derivatives of B_1 and G_1 respectively. Aflatoxin M_1 is 4-hydroxy-Aflatoxin B_1 and Aflatoxin M_2 is 4-hydroxy-Aflatoxin B_2. Both M-Afltoxins are found in dairy products.



B_1 **B_2**

G_1 **G_2**

Fig. 5: Chemical structures of Aflatoxins B_1, B_2, G_1, G_2

Table 4: Specifications of Aflatoxins

SPECIES	FORMULA	CAS NUMBER	MW [g/mol]
B_1	$C_{17}H_{12}O_6$	1162-65-8	312,3
B_2	$C_{17}H_{14}O_6$	7220-81-7	314,3
G_1	$C_{17}H_{12}O_7$	1165-39-5	328,3
G_2	$C_{17}H_{14}O_7$	7241-98-7	330,3
M_1	$C_{17}H_{12}O_7$	6795-23-9	328,3
M_2	$C_{17}H_{14}O_7$	6885-57-0	330,3

The detection of Aflatoxin in Sesame Seeds must be controlled at earlier stages at the borders, according to existing specifications. On the other hand, in case of the presence of Aflatoxin due to low level of GMP, or deficiencies in sanitation procedures, corrective actions must be taken:

Several strategies are available for decontamination of food products containing mycotoxins. Many studies have indicated the possibility of using chemicals for the detoxification of contaminated raw material by destroying the mycotoxins and reducing their toxic effect. These chemicals are acids/bases (e.g. ammonia, sodium hydroxide), oxidizing reagents (e.g. hydrogen peroxide, ozone), reducing agents (e.g. bisulfate, sugars), chlorinating agents (e.g. chlorine), salts and miscellaneous reagents such as formaldehyde.

Most of these chemicals are potentially unsafe to use due to the formation of toxic residues, or the adverse effect on nutrient content, flavor, odor, color, texture or other properties of the product.

2- Microbiological tests:

The common causes of food-borne outbreaks include:

- Contamination of the primary food raw materials or cross- contamination from a contaminated source.
- Production processes that include no process which reduces or destroys the contaminating organisms.
- Cross Contamination due to low level of personal or equipment hygiene.

The results of the microbiological testing show clearly that the water is one of the most important factors regarding the safety of Tahineh when used during the washing steps. Contaminated Tahineh which in turn is used for Halaweh processing contaminates this latter product.

- Salmonella:

Salmonella spp. is facultative anaerobic, Gram negative, straight, small (0.5-0.7 x 1-3 µm), usually motile with flagella.

Salmonella of which there are over 2000 varieties is associated with:

- Domestic and wild animals
- Poultry and non domestic birds
- Insects
- Human beings

It is usually found in the following types of food:

- poultry
- pork sausages
- raw milk
- raw meat and eggs
- fruit and vegetables
- other raw materials

The infective dose of *Salmonella* has, been considered to be in excess of 100,000 cells but a number of outbreaks have been recorded particularly in products containing high fat levels in which the infective dose was found to be very low (<100 cells).

Salmonella is readily destroyed by heat, in foods with a high water activity, e.g. >=0.98 but in food materials with a low water activity, e.g. high fat content (Tahineh and Halaweh), much higher temperatures are needed to kill the organism.

The optimal conditions for the growth of *Salmonella* are shown in table 5.

Table 5: Optimal conditions for the growth of *Salmonella*

Parameter (other condition being optimal)	Minimum	Maximum
Temperature (°C)	5.2	46.2
pH	3.8	9.5
Water activity	0.94	>0.99

Table 6: *D*- value for *Salmonella* in some food substrate

Food substrate/ conditions	Temperature (°C)	*D*- value
Milk(sterile, homogenized)	68.3	0.28-10 s depending on serotype
Ground beef	63	0.36 min
Milk chocolate	71	4.5- 6.6 h depending on serotype
Liquid whole egg	60	0.55- 9.5 min depending on serotype

If *Salmonella* is found to be present in 25 g of any product groups described in table 6, then the advice given is to consider the food "unacceptable" and potentially hazardous. Moreover, if the food is of vulnerable groups, this should lead to complete removal of products from retail and be subject to recall.

Salmonella spp. causes illness by means of infection. It multiplies in the small intestine, colonizing and subsequently invading the intestinal tissues, producing an enterotoxin and causing diarrhea. The organism can get into the blood stream and/ or the lymphatic system and cause more severe illnesses.

Whatever the *Salmonella* serotype is, effective controls for eliminating the hazard of *Salmonella* from foods are the same and involve control of the following:

- Raw material
- Personnel, equipment and environmental hygiene
- Manufacturing process conditions

The application of high temperatures in cooking or pasteurizing of foods is one of the best means to destroy *Salmonella*. The organisms are readily destroyed by moist heat end temperatures deigned to destroy pathogenic *E. coli* will equally destroy *Salmonella*. These heat processes generally confer a significant margin of safety in relation to most serotypes of *Salmonella*. Application of heat to destroy organisms in low moisture environments, i.e. Tahineh, where water activity is very low requires much longer times or higher temperatures.

- Post- process contamination
- Retail and catering practices
- Consumer handling

Table 7 below shows the microbiological tests results for the 17 visited factories for Salmonella and other bacteria that showed to be present in the samples taken from the different production stages (starting raw material to end products); the results indicate a serious problem in the sanitation and hygienic level of the factories. Consequently, serious work should be done on the GMP and GHP levels with large focusing on personal hygiene.

	Enterobacter cloacae	*Enterobacter alvei*	*Citrobacter freundii*	*E. coli*	*Enterobacter sakazaki*	*Aeruginosa hydrophila*	*Crysomonas*	*Klebsiella ozanae*	*Klebsiella oklitica*	*Morganella morganii*	*Salmonella*
Al Kanater	-	-	-	-	-	Tahineh	-	-	-	-	-
Cortas	-	-	-	-	-	-	-	Tahineh	Tahineh	-	-
Chahine	Tahineh* Halaweh**	-	-	-	-	-	Tahineh Halaweh	-	-	-	-
Bsat Mounir	-	-	-	-	Tahineh	-	-	-	-	-	-
Ghazal	-	Tahineh Water	Tahineh Water	Tahineh Water	-	-	-	-	-	-	-
Yaman	-	-	-	-	-	-	-	Tahineh Halaweh	-	-	-
Khater	-	-	-	-	Tahineh Water	-	-	-	-	-	**Water:** 40cfu/5 l
Ghandour	-	-	-	-	-	-	-	-	-	-	**On-line product:** 24cfu/25grs **Halaweh:** 4cfu/25grs **Water:** 65cfu/5 l
El- Rabih	Stone	-	-	-	-	-	-	-	-	-	-
El- Chafee	-	-	Tahineh	-	-	-	-	-	-	Tahineh	-
Bsat Kamel	-	-	-	-	Halaweh	-	-	-	-	-	-
Al Yaman (Saida)	Tahineh Water	-	-	-	-	-	-	Tahineh Water	-	-	**Tahineh:** 13cfu/25grs **Water:** 42 cfu/5 l
Kadmous	Tahineh Water	-	-	-	-	-	-	-	-	-	**Tahineh:** 13cfu/25grs **Water:** 56cfu/5 l
Green Hill Rabia	-	-	-	-	-	-	-	Tahineh Halaweh Water	-	-	**Water:** 33 cfu/5 l
Kassatly Chtoura	-	Tahineh Halaweh	Tahineh Halaweh	-	-	-	-	-	-	-	-
Kalajeyee	-	-	-	Water Tahineh Halaweh	-	-	-	-	-	-	-
Alam El-Deen	-	-	-	Water	-	-	-	-	-	-	-

* Tahineh stands for the final product of Tahineh filled and packed

** Halaweh stands for the final product of Halaweh filled and packed

Table 7. Microbiological tests results

VI. Titanium Dioxide Survey:

VI. A. Introduction:

Lebanese Tahineh manufacturing industries were found to be adding Titanium Dioxide ($TiTO_2$) to their end products in order to whiten the traditional light beige color of Tahineh. The reason behind this is that white color is more attractive to consumers, thus making the addition of $TiTO_2$ a marketing tool to increase sales. $TiTO_2$, more commonly known as E171, is a white pigment mainly extracted from ilmenite (iron titanate), which is an iron-black, metallic oxide mineral, composed of iron and titanium oxide. It is used in cosmetics and in pharmaceutical and food products. For instance, it is found in tablets and capsules, sun blocks, some cheeses and in sweets where its role is to provide a barrier between different colors. It is also found in cream and sauces to increase their opacity in addition to its main purpose.

This additive has been a controversial issue for many years. Many researches studied its toxic and carcinogenic effects. Although it is known to be excreted from the body in the urine, and although it has not been found to be easily absorbed, detectable amounts can be found in the blood, brain and glands with the highest concentrations being in the lymph nodes and lungs. Even though metal oxides' toxicity is well known, many studies conducted on rats and mice showed that orally ingested $TiTO_2$ is not carcinogenic. This suggests that, so far, this issue has not been set yet.

In the Code of Federal Regulations, Title 21, Volume 1, the Food and Drug Administration (FDA) restricted the quantity of $TiTO_2$ not to exceed 1 percent by weight of the food as compared to 0.2 percent (2 g per Kg), which is the maximum level set by the Lebanese Institute for Standards and Specifications (LIBNOR).

To our knowledge, Tahineh is very widely consumed in Lebanon as part of many dishes such as chickpea salad dip, Tahineh sauce, locally known as Taratour, eggplant dip...or as a main ingredient such as in Halaweh, a Mediterranean sweet. It is suspected that Tahineh is consumed in Lebanon in much larger quantities than in other countries where the above standards have been set. Therefore, the purpose of this survey is to quantitavely find out the amount of

Tahineh consumed by the Lebanese population to assess the level of $TiTO_2$ that is ingested, which may present a health hazard.

VI. B. Materials and Methods:

The targeted sample constituted of 500 Lebanese participants aged between 10 and 69 years old. This age range was chosen because it was thought to include all the categories, which are able to answer this questionnaire[1]. Documents concerning the age and sex distribution of the total population as well as the geographic distribution of the population in all the Lebanese Mohafaza[2] were brought from the Ministry of Social Matters. According to this information, the sample size was distributed by Mohafaza as shown in table 8:

Table 8. Table of participants' distribution by Mohafaza

Mohafaza	Number of Participants
Beirut	66
Mount Lebanon	184
Bekaa	63
North	108
South	46
Nabatieh	33

And by gender as follows in table 9:

Table 9. Frequency Distribution of 500 participants by gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	237	47.4	47.4	47.4
Female	263	52.6	52.6	100.0
Total	500	100.0	100.0	

[1] A copy of the original questionnaire is attached to the end of the report.

[2] Mohafaza is defined as the most important regions that divide Lebanon. They are constituted of Beirut, Mount Lebanon, Bekaa, North, South and Nabatieh.

- The sample was also distributed by age as in figure 6.

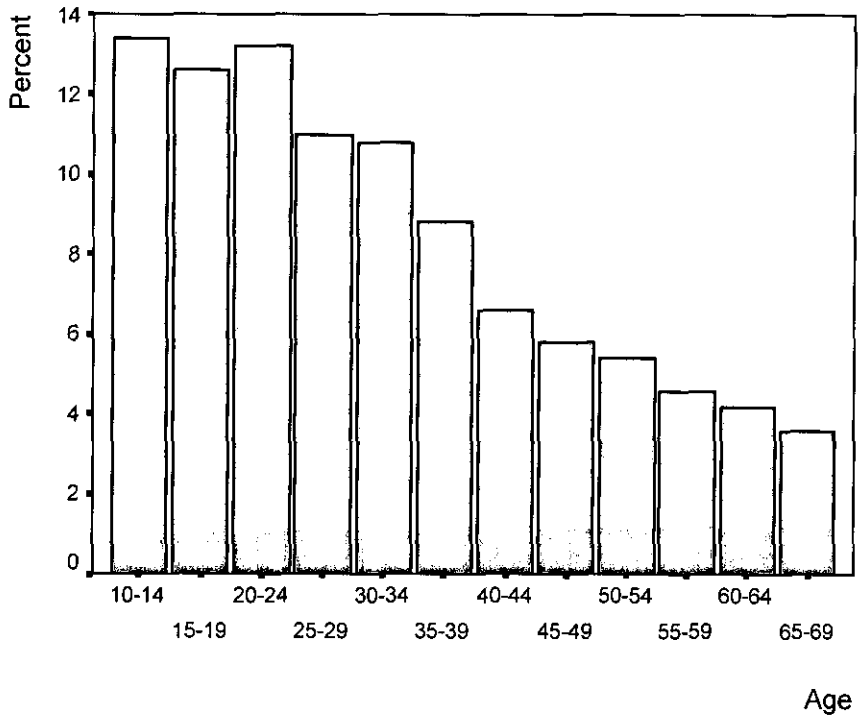


Fig. 6. Bar Chart of 500 Participants by Age

The questionnaire mainly focused on the frequency of Tahineh containing foods consumption. It was also concerned with the tendency of participants to abide by, decrease or increase the normal quantities of Tahineh upon cooking. This questionnaire also included a Food Frequency Questionnaire to evaluate the exact amount of Tahineh consumed in grams per day. Recipes of Tahineh containing dishes were taken from five references of Lebanese cook books and were used to get the percent Tahineh in the dishes mentioned in the Food Frequency Questionnaire. The quantitative assessment of Tahineh in grams per day was done in the following manner:

Quantity of Tahineh (g) = Frequency / day * weight of the food item (g) * % Tahineh.

The weight of the food item was done in the following manner. Each food item from the food frequency questionnaire was cooked according to the five reference cooking books. We used a tablespoon, a ladle and a plate to measure the quantity of each food item consumed. We filled the above utensils with the

specific food item and weighed its quantity. The weighing was done three times and the average weight of a tablespoon, ladle and plate of each food item was used in our calculations.

As for the % Tahineh, it was calculated from the recipes of the Tahineh containing food items found in the five reference books.

Data was collected and analyzed using the SPSS 10.1 program.

VI. C. Results and Discussion:

The education level of the participants mainly ranged between illiteracy and university education (Table 10).

Table10. Frequency Distribution of 500 participants by Education Level

Education level	Frequency	Percent	Valid Percent	Cumulative Percent
Illiterate	30	6.0	6.0	6.0
Elementary	60	12.0	12.0	18.0
Intermediate	119	23.8	23.8	41.8
Secondary	92	18.4	18.4	60.2
University	172	34.4	34.4	94.6
Technical school	27	5.4	5.4	100.0
Total	500	100.0	100.0	

According to the survey, 88.6 % of the participants consume Tahineh. Mount Lebanon witnessed the highest percentage of consumption while South Lebanon the lowest. Table 11 shows the difference in Tahineh consumption among regions. The difference in the percentage of Tahineh consumed is probably due to the diversity in the meals containing Tahineh among the regions. In other words, 93.5 % of the Tahineh consumers who live in Mount Lebanon know and cook more Tahineh containing dishes.

Table 11. Frequency Distribution of region of 500 Participants by Tahineh Consumption

			Tahineh consumption		Total
			Yes	No	
Region	Beirut	Count	61	5	66
		% Within mouhafaza	92.4%	7.6%	100.0%
	Mount Lebanon	Count	172	12	184
		% Within mouhafaza	93.5%	6.5%	100.0%
	Bekaa	Count	52	11	63
		% Within mouhafaza	82.5%	17.5%	100.0%
	South Lebanon	Count	36	10	46
		% Within mouhafaza	78.3%	21.7%	100.0%
	Nabatiyeh	Count	28	5	33
		% Within mouhafaza	84.8%	15.2%	100.0%
	North Lebanon	Count	94	14	108
		% Within mouhafaza	87.0%	13.0%	100.0%
Total		Count	443	57	500
		% Within mouhafaza	88.6%	11.4%	100.0%

Moreover, the frequency of Tahineh consumption was investigated and the results, displayed in Table 12 came as follows: 4 % eat Tahineh everyday, 41.8 % consume it one to two times a week, 42.8 % two to four times a week and 11.4 % do not at all.

Table 12. Distribution of 500 participants by frequency of Tahineh Consumption

	Frequency	Percent	Valid Percent	Cumulative Percent
Everyday	20	4.0	4.0	4.0
1-2 times a week	209	41.8	41.8	45.8
2-4 times a month	214	42.8	42.8	88.6
Never	57	11.4	11.4	100.0
Total	500	100.0	100.0	

In addition to this, 30.8 % of the participants cook meals containing Tahineh. Among those participants, and with reference to the five cooking books, it was found that only 14.9 % cook according to normal standards as compared to 39 % who put Tahineh less than the normal level and to 46 % who add Tahineh in excess. The highest percentage reflects the tendency of the Lebanese to exceed the amount of Tahineh upon cooking, which in return reflects higher risks of becoming subject to $TiTO_2$ intake.

Moreover, the Food Frequency Questionnaire revealed that on average, the Lebanese consumer eats 17 g of Tahineh per day (Table 13).

Table 13. Descriptive Statistics of the quantity of Tahineh consumed

	N	Minimum	Maximum	Mean	Std. Deviation
Quantity of Tahineh in g/day	500	.00	259.96	17.0058	24.7329

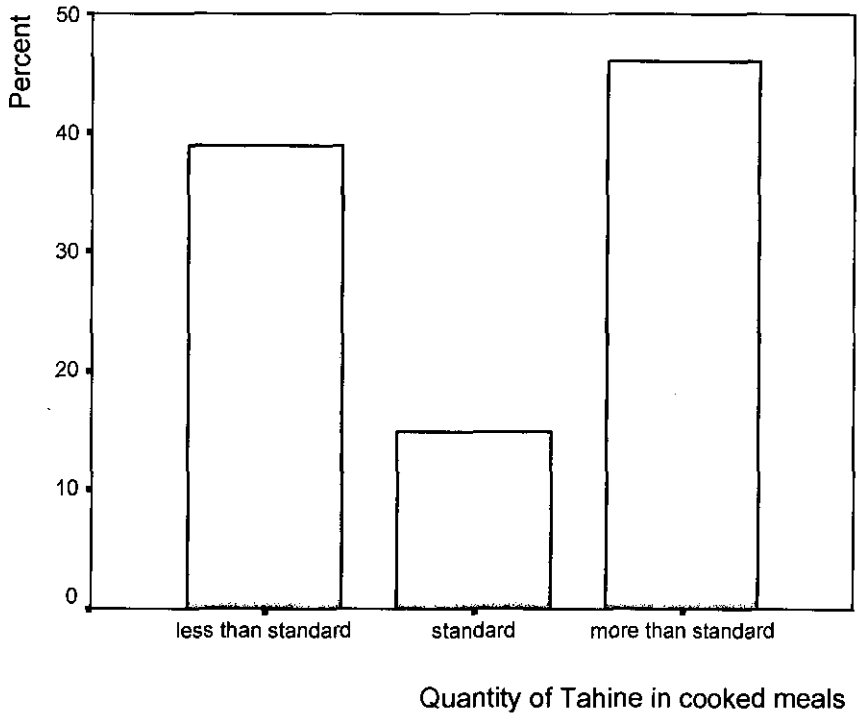


Fig. 7. Bar Chart of 154 participants by amount of Tahineh added in cooking

The standard deviation in Table 13 shows that there is no uniformity in the Tahineh intake. Some do not eat at all while others can reach a maximum of 259.96 g of Tahineh per day. This is illustrated in Figure 8. Moreover, if only the 442 Tahineh consumers were considered, the average consumption would reach 19.24 g of Tahineh per day with an approximate standard deviation of 25.48 (Table 14 and Fig.9).

Table 14. Descriptive Statistics of the quantity of Tahineh consumed by 442 participants

	N	Minimum	Maximum	Mean	Std. Deviation
Quantity of Tahineh in g/day	442	.04	259.96	19.2374	25.4782

Both Figures 8 and 9 show that most of the population fit the normal distribution curve.

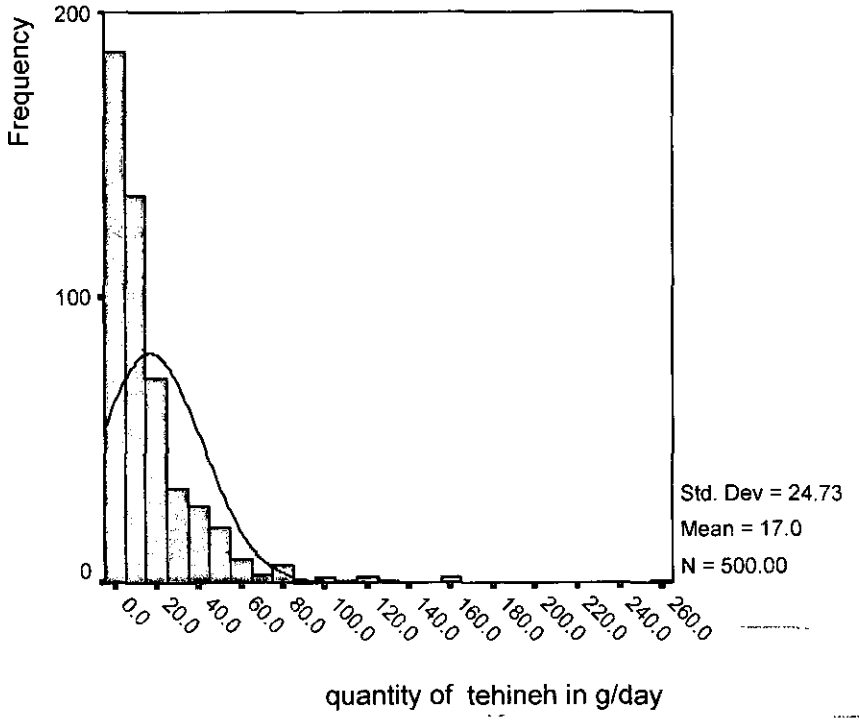


Fig. 8. Chart of 500 participants by the quantity of Tahineh consumed in g/day

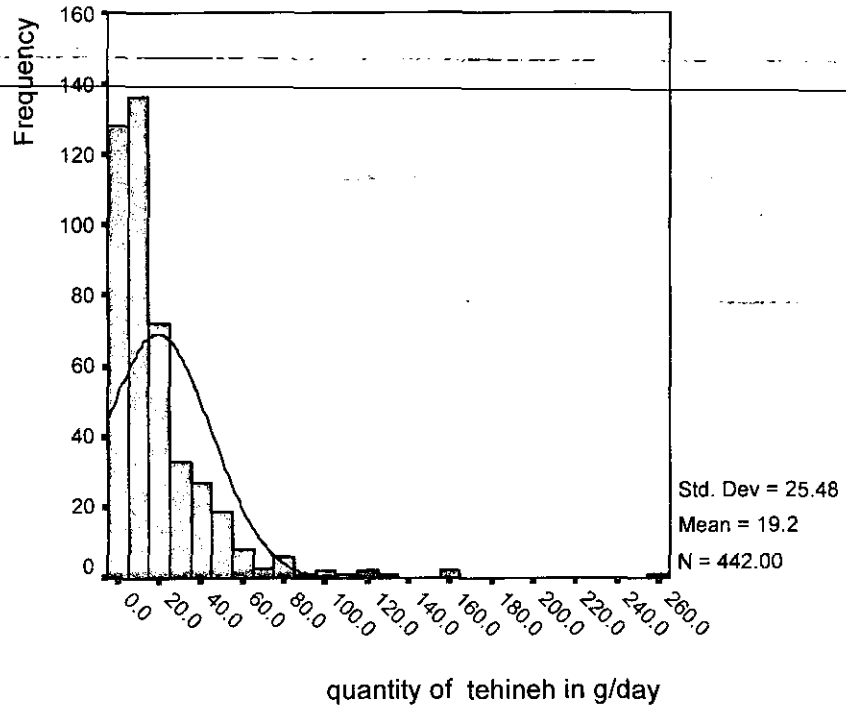


Fig. 9. Chart of 442 participants by the quantity of Tahineh consumed in g/day

However, if only the Tahineh consumers were considered, Table 15 displayed the values of both the skewness and the kurtosis to be 3.800 ± 0.116 and 23.457 ± 0.232 respectively, showing that the skewness is not significant and emphasizing the fact that the population fits the normal curve, i.e. most of the population consume the average quantity of Tahineh per day.

Table 15. Descriptive Statistics of the quantity of Tahineh consumed in g/day

			Statistic	Std. Error
Quantity of Tahineh in g/day	**Mean**		19.2374	1.2119
	95% Confidence Interval for Mean	**Lower Bound**	16.8556	
		Upper Bound	21.6191	
	5% Trimmed Mean		15.6839	
	Median		10.2300	
	Variance		649.140	
	Std. Deviation		25.4782	
	Minimum		.04	
	Maximum		259.96	
	Range		259.92	
	Interquartile Range		20.6000	
	Skewness		3.800	.116
	Kurtosis		23.457	.232

Based on Table 16, extreme values were removed and the results were illustrated in Fig. 10. The mean of the quantity of Tahineh consumed in g/day is 17.7 ± 19.43.

Table 16. Table of the Extreme Values of the quantity of Tahineh consumed in g/day

			Case Number	Value
Quantity of Tahineh in g/day	Highest	1	442	259.96
		2	441	160.18
		3	440	157.42
		4	439	134.44
		5	438	122.08
	Lowest	1	1	.04
		2	2	.18
		3	3	.19
		4	4	.23
		5	5	.31

And when asked about the brand name of the Tahineh and Halaweh they consume, 81.9 % of the participants answered as compared to 18.1 % of the participants who did not know the brand name. This is illustrated in Fig. 11.

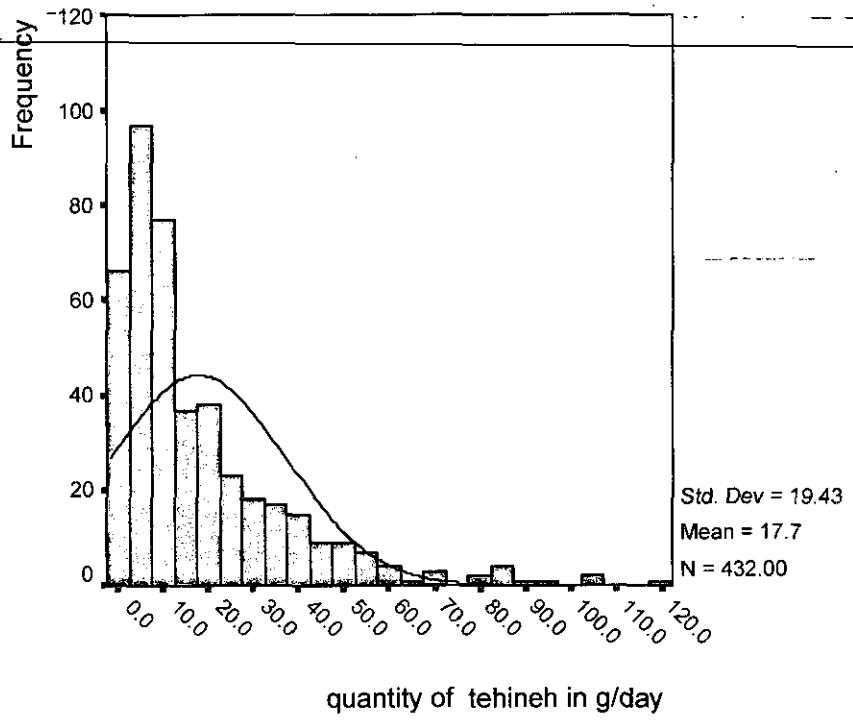


Fig. 10. Chart of 432 participants by the quantity of Tahineh consumed in g/day

The percentage of the participants who ignore the brand name was thought to be related to the education level. However, further research showed that this hypothesis is not valid, for as compared to each other, 81 % of the illiterate and 82.6 % of the university graduates know the brand name. Table 17 and Fig.12 show that at all education levels, the percentages of those who know the brand names are close to each other, which underlines the idea that awareness is the same regardless of the education level.

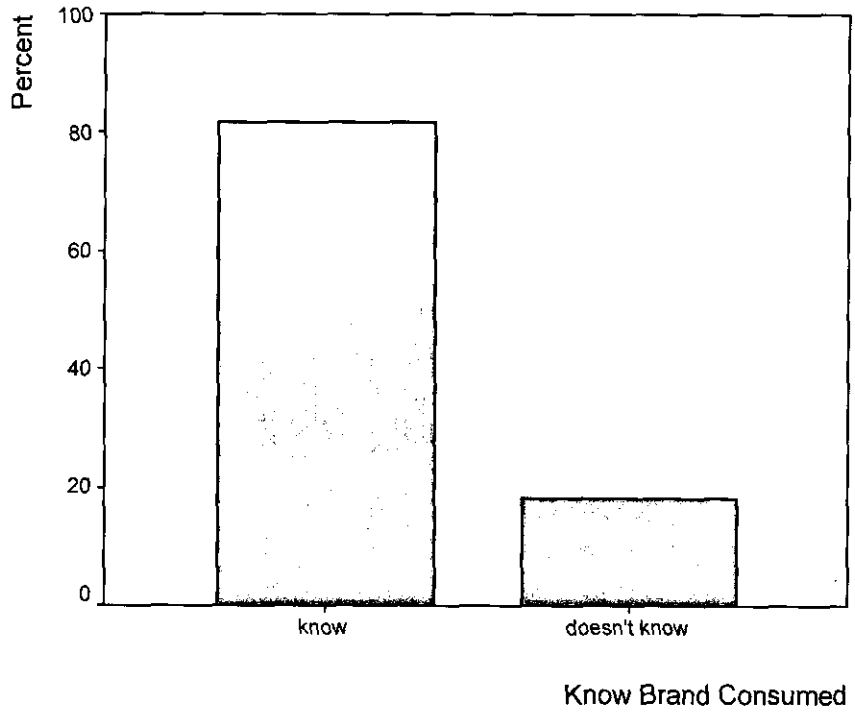


Fig. 11. Bar Chart of 422 Tahineh consumers by knowledge of brand consumed

The brands of Tahineh and Halaweh mentioned by the participants are illustrated in Fig. 13 and 14 respectively.

Fig.13 shows that 13.56 % of the participants do not know the Tahineh brand. Moreover, 13.33 % consume Wadi Al Akhdar brand, 12.64 % consume Al Rabih and 12.41 % consume Samih El Yaman brand.

As for the Halaweh, 16.06 % do not know the brand. 13.57 % of the participants consume Samih El Yaman brand, 9.50 % consume Al Rabih and both Wadi Al Akhdar and Mounir Bsat scored 7.69 % of the participants' consumption.

To emphasize the consumers' lack of awareness, it was noticed that 5.75 % and 0.45 % of the participants said that they consumed Hassan El Yaman Tahineh and Halaweh brands respectively. However, in the market, Samih El Yaman and

Hassan El Yaman are both found under the same name, meaning that they both make one manufacturer.

By this, Samih and Hassan El Yaman brand would respectively score 18.16 % and 14.02 % of the participants' Tahineh and Halaweh consumption. These percentages make this brand the most consumed in Lebanon.

Table 17. Distribution of 442 Tahineh consumers by Brand Knowledge and Education Level

			Know	Doesn't know	Total
Education Level	Illiterate	Count	17	4	21
		% Within Education Level	81.0%	19.0%	100.0%
	Elementary	Count	42	8	50
		% Within Education Level	84.0%	16.0%	100.0%
	Intermediate	Count	83	19	102
		% Within Education Level	81.4%	18.6%	100.0%
	Secondary	Count	73	15	88
		% Within Education Level	83.0%	17.0%	100.0%
	University	Count	128	27	155
		% Within Education Level	82.6%	17.4%	100.0%
	Technical school	Count	19	7	26
		% Within Education Level	73.1%	26.9%	100.0%
Total		Count	362	80	442
		% Within Education Level	81.9%	18.1%	100.0%

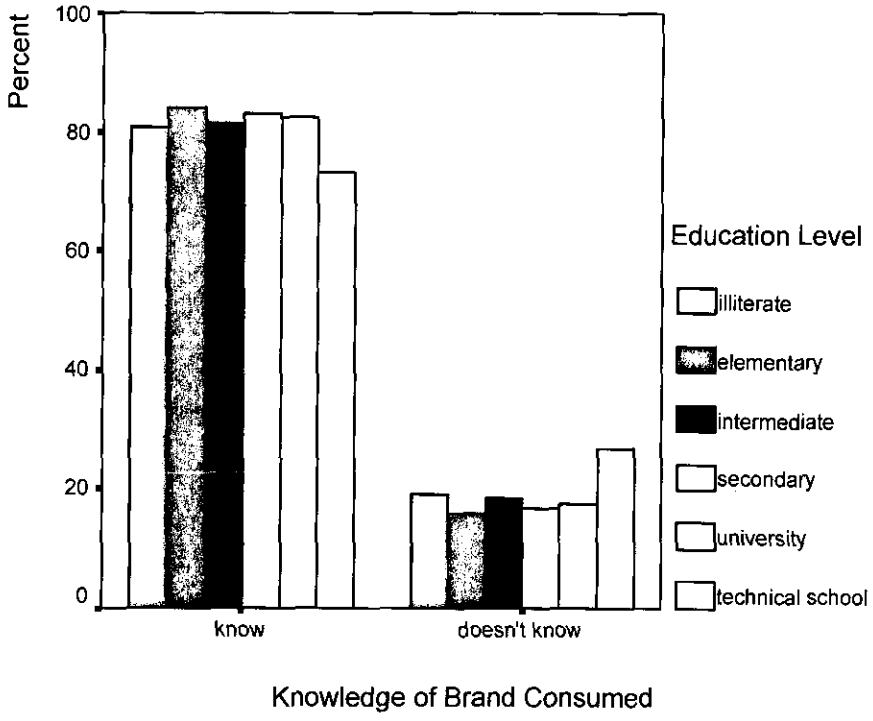


Fig. 12. Bar Chart of 442 Tahineh Consumers by Knowledge of Tahineh Brand and Education Level

Finally, 16 Tahineh samples were analyzed for the presence of TiTO2, and the results showed that the visited industries do not exceed the level set by LIBNOR (2g/Kg) (Table 18).

Table 18. Results of the analyzed 16 Tahineh samples

Factory	TiTO2 level
El Kanater	8.14 mg/kg
Al Rabih	6.41 mg/kg
Kassatly Chtaura	6.01 mg/Kg
Chahine	9.48 mg/Kg
Mounir Bsat	3.63 mg/Kg
Kamel Badawi Bsat	3.36 mg/Kg
El Yaman	3.40 mg/Kg
Khater	16.66 mg/kg
Al Rabia El Khadra'	10.03 mg/Kg
Al Ghazal	2.21 mg/kg
Alameddine	1.86 mg/Kg
Kalaajieh	3.09 mg/kg
A.O Ghandour	16.53 mg/kg
Cortas	2.16 mg/kg
Cadmous	2.31 mg/kg
El Chafei	2.49 mg/kg

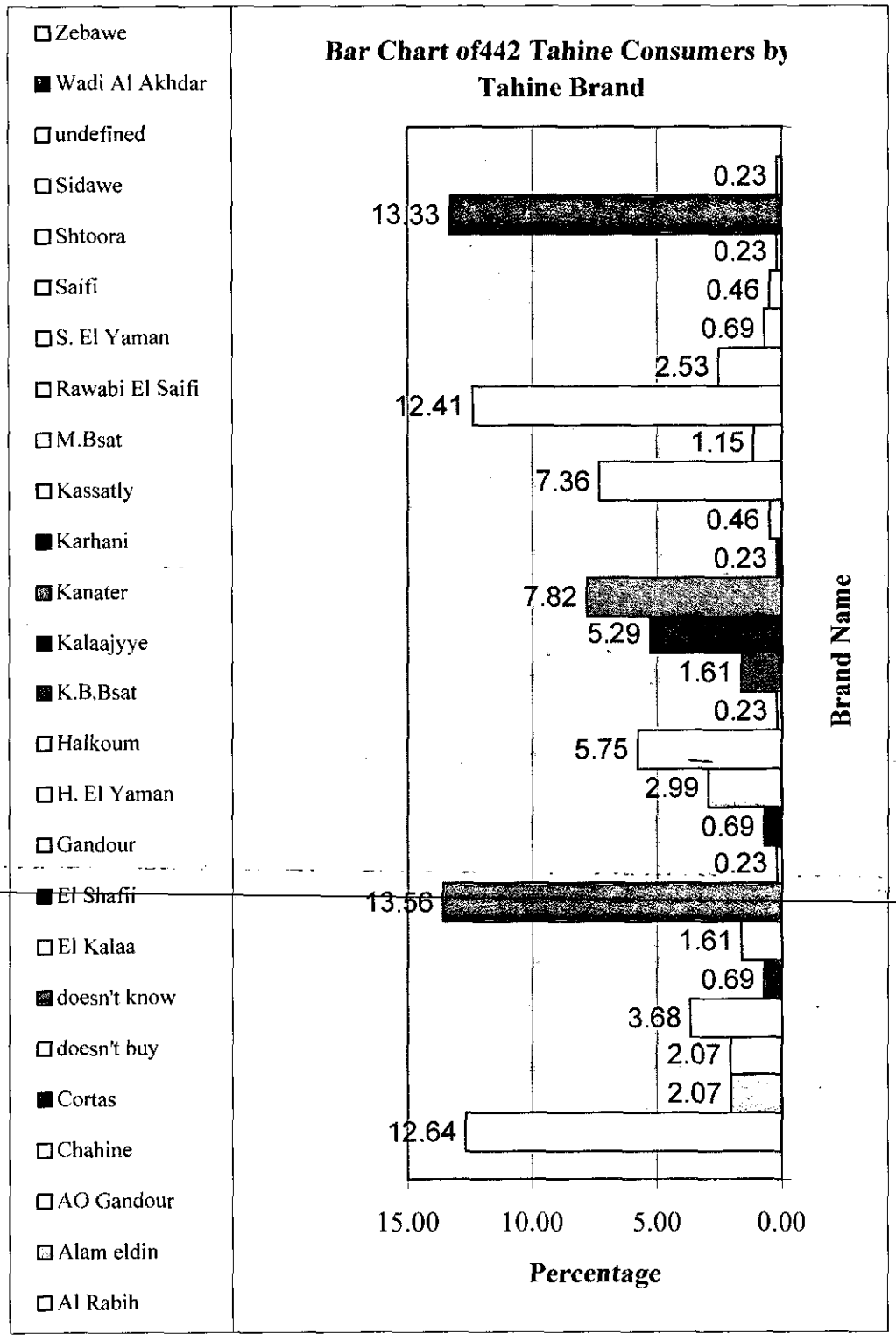


Fig. 13. Bar Chart of 442 participants by Tahineh brand

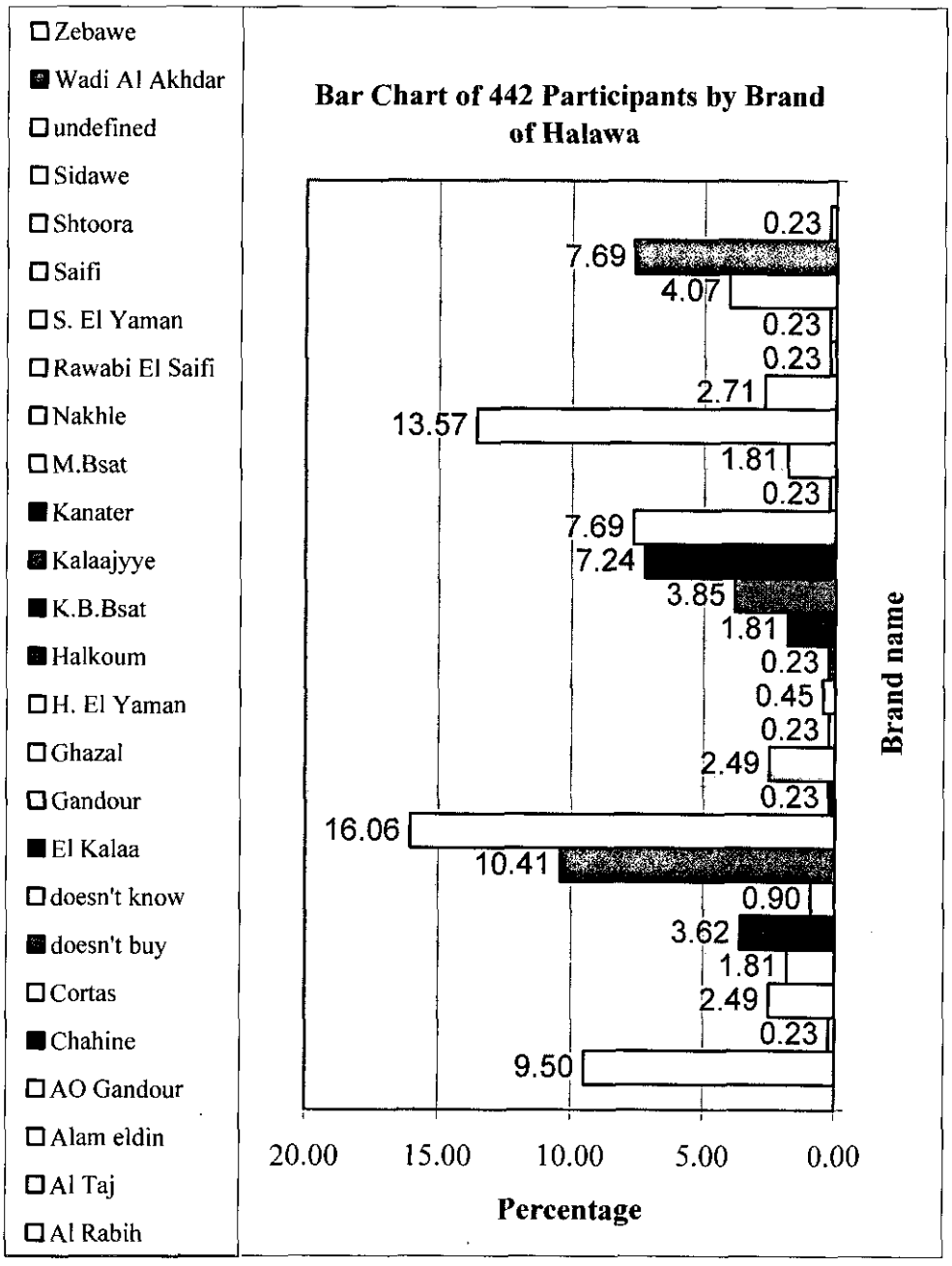


Fig. 14. Bar Chart of 442 participants by Halaweh brand

VI. D. Conclusion and Recommendations:

This survey shows that Tahineh is a very popular food product in Lebanon. When consumed, it occupies an important place in the Lebanese diet by being consumed at least once a week. People consume it much of the time at home, but this does not imply that it is not consumed at restaurants too. Some Tahineh industries underline the fact that restaurants require the Tahineh to be very light in color, which means that it will contain high amounts of TiTO2, in order to be

more attractive to the consumers. According to this survey, it was found that of all the participants who consume Tahineh, there are some who eat much more than the average. This category of people represents 29.4 % and reflects that a significant number of Lebanese people may potentially be at high risk of being harmed by the presence of TiTO2 in Tahineh.

Due to the extensive use of Tahineh and Halaweh products (around 30% of the Lebanese people are consuming more than the average of 20 g/day) some consumers may be at risk of being harmed by the amount of TiTO2 used in Tahineh; hence, it is recommended that the amount of TiTO2 added to Tahineh continue to be compatible to the standard set by LIBNOR as for Tahineh produced for local consumption, and compatible to the standards of the importing country in case of products exportation.

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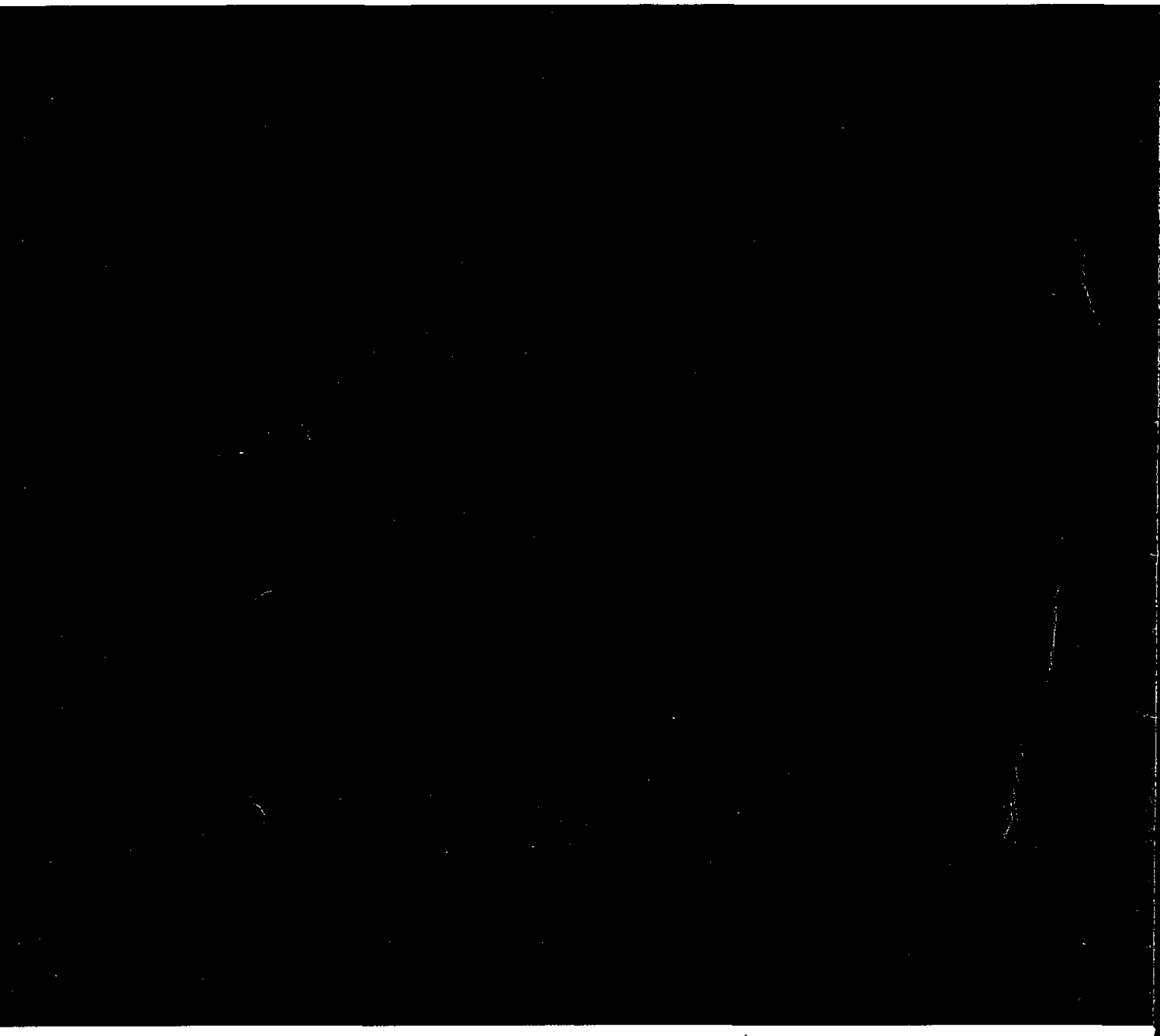

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