RESULTS & DISCUSSION

IV. RESULTS AND DISCUSSION

Technological characteristics, such as chemical composition, physical properties, microbiological quality, optimum extraction conditions and sensory properties play an important role in processing steps and quality of tamarind and carob beverages. This chapter deals with some of these aspects, which could serve to obtain some useful data for differentiation between tamarind and carob beverages and their processing, to establish optimum conditions for extraction natural beverages.

The present investigation covers two main parts, which will be presented under the following titles:

Part I: Tamarind:

1- Physicochemical analysis of tamarind materials.
2- Microbiological quality of tamarind pulp varieties.
3- Chemical analysis of tamarind seeds.
4- Establishment of optimum extraction conditions for tamarind pulp.
5- Survey study of tamarind beverage samples collected from local markets.
6- Determination of essential mineral content of tamarind pulp varieties.
7- Nutritional evaluation of tamarind beverages.
8- Study of volatiles components of tamarind pulp.
9- The differentiation between natural and synthetic tamarind beverages.
10- Technological feasibility for producing new products from tamarind.

Part II: Carob:

1- Physicochemical analysis of carob materials.
2- Microbiological quality.
3- Chemical analysis of carob seeds.
4- Establishment of optimum extraction conditions.
5- Survey study of carob samples collected from local markets.
6- Determination of essential mineral content.
7- Nutitional evaluation of carob beverage.
8- Study of volatiles components.
9- Technological feasibility for producing new products from carob.

Part I:

4.1. Tamarind:

4.1.1. Physicochemical analysis of tamarind:

4.1.1.1. Proximate chemical composition:

Total solids content is an important factor in the production and quality of tamarind beverages, since it is well known that the higher the total solids the better will be the quality of the end product. As shown in Table (1) there was a slight difference in the total solids content between the tamarind varieties investigated. The Aswany variety had the highest total solids content (81.07%). Which agree with those reported by **Shaker (1979)** and **Zin El-Dine (1999).**

Total carbohydrates constituted the major component as it ranged between 58.73% to 63.82% on wet basis and 74.13% to 78.72% on dry weight basis. These obtained results agree with those reported by **FAO (1982)** and **Ishola *et al.* (1990)**.

The edible part (pulp) of tamarind is relatively poor in fat but not in protein content as presented in Table (1) the higher content (0.91%) was for the Indian variety. These obtained results are agree with those reported by **Alian *et al.* (1983).**

Crude protein content ranged between 3.67% to 3.89% on wet basis and 4.63% to 4.80% on dry weight basis. Aswany variety had the higher protein content (4.80%), while Indian variety showed the lower content (4.63%). These obtained results are in general agreement with those reported by **Shankaracharya (1998)** who found that the content of crude protein in tamarind pulp ranged from 2.00-8.79%. Tamarind pulp proved to contain a good appreciable quantity of ash. The

Table (1): Physicochemical properties of examined natural tamarind pulp*.

Components*	Varieties			
	Makham waan variety		Aswany Variety	
	On wet basis	On dry basis	On wet basis	On dry basis
Moisture %	20.77±0.17		18.93±0.64	
Total solids %	79.23±0.17		81.07±0.64	
Crude fat %	0.72±0.01	0.91	0.70±0.02	0.86
Crude protein %	3.67±0.12	4.63	3.89±0.19	4.80
Ash %	5.38±0.54	6.79	3.26±0.07	4.02
Total carbohydrates %**	58.73	74.13	63.82	78.72
Crude fibers%	10.74±0.16	13.56	9.43±0.27	11.63
Total sugars %	47.68±0.21	60.18	47.18±0.30	58.20
Reducing sugars %	36.33±0.17	45.85	35.46±0.20	43.74
Non reducing sugars %	11.35±0.63	14.33	11.72±0.26	14.46
Titratable acidity %	10.18±0.02		9.68±0.04	
Vitamin C (mg/100g)	5.46±0.15		4.25±0.11	
Tannins %	0.05±0.02		0.03±0.01	
pH value	2.81±0.01		2.87±0.02	
Color index	7.86±0.23		6.64±0.18	
Anthocyanin (mg/100g)	2.05±0.10		2.04±0.07	

* Mean of triplicate determinations ±SE.
** Calculated by difference.

ash content ranged between 3.26% to 5.38% on wet basis and 4.02% to 6.79% on the dry weight basis. The higher content was for Indian variety (6.79%) while the lower was for Aswany variety (4.02%). These obtained results to agree with those reported by **Afifi and Hussein (2001)** who found that the ash content of the pulp of the Egyptian tamarind pulp was 4.27%.

4.1.1.2. Crude fibers content:

The higher content of crude fibers (13.56%) was of Indian variety, which agree with those reported by **Shankarachary (1998)** who found that crude fibers content in tamarind ranged between (2.2% to 18.3%).

4.1.1.3. Total, reducing and non-reducing soluble sugars:

Soluble sugars are the most important quality parameters for the tamarind pulp used in making beverages; because of it is contribution to flavor, palatability and discoloration of tamarind beverages. Indian variety showed the highest content (60.18%) on wet basis and 47.68% on dry basis. These obtained data agree with **El-Siddig *et al.* (2006)** who mentioned that total sugars in tamarind pulp Jaehom and Piyai varieties were 47.71 and 47.19%, respectively.

4.1.1.4. Titratable acidity and pH value:

Acidity and pH value are important factors that influence the quality of tamarind pulp and its use as beverages. Traditionally, tamarind pulp is considered as a good source of tartaric acid **(Shankarachary, 1998)** Indian variety showed the highest value (10.18%) of titratable acidity.The pH values were 2.81 and 2.87 for Indian variety and Aswany variety, which agree with **Shankarachary (1998)**.

4.1.1.5. Ascorbic acid and tannins:

Tamarind pulp could be considered a good source of ascorbic acid. Table (1) showed that Indian variety had the highest content in ascorbic acid (5.46 mg/100g), and Aswany variety had a value of 4.25 mg/100g. Only 200g of tamarind pulp could satisfy or cover $1/5^{th}$ the daily requirements of adult humans from vitamin C as indicated by **WHO and FAO (2004)**. Tannins content ranged between 0.03 to 0.05%. Aswany and Indian variety had values of 0.03 and 0.05%, respectively, which disagree with **Duke (1981)** who reported a much higher value in pulp of an Indian variety about 9 mg/100 g ascorbic acid.

4.1.1.6. Color index and anthocyanin content:

The color index (O.D. at 420 nm) was 6.64 and 7.86 for Aswany and Indian varieties, respectively, while anthocyanin content was nearly the same. The highest value was present in Indian variety.

Form, the abovementioned results, it could be worthy to mention that tamarind pulps were shown to contain variable different constituents, some of which are present in considerable amounts such as carbohydrates, sugars, minerals and vitamins which may contribute to its importance for use as a refreshing nutritious drink. However, these obtained results are also in general agreement with those obtained by **Shaker (1979)**.

4.1.2. Microbiological quality of tamarind pulp:

Total bacterial count, Yeasts and molds, *Sporformer, Lactic acid, Psychrophylic, Coliform bacteria* and *Staphylococcus* counts were determined in tamarind varieties.

From data in Table (2) it could be observed that total bacterial count of tamarind, Aswany variety and Indian variety was, $1.06x10^4$ and $6.35x10^2$ c.f.u./g, while yeasts and molds count was, $6.9x10^2$ and $4.9x10^2$ c.f.u./g, respectively. The highest total microbial, Yeasts and molds counts were found in the compressed packaged Aswany variety, which agree with **Kakar and Udipi (2000).**

Lactic acid bacteria of tamarind, Aswany and Indian variety were: $2.4x10^2$ and $1.2x10^2$ c.f.u./g, besides. *Psychrophylic* counts were: $1.94x10^2$ and $1.6x10^2$ c.f.u./g, respectively, which agree with **Abo El-Azm (1999).**

On the other hand, all different varieties tested were found free from *Sporformer bacteria*, *Colifrom bacteria* and *Staphylococcus*. Therefore, it could be concluded that these aforementioned microorganisms could not grow or survive in tamarind pulp probably because of its high acidity. In addition, tamarind pulp was mostly reported to contain antibacterial substances as previously discussed by **Alian *et al.* (1983) and Pszczola (2001).**

4.1.3. Chemical analysis of tamarind seeds:

4.1.3.1. Proximate chemical composition:

Total solids, mainly carbohydrates, are the important predominant constituent in tamarind seeds. It is well known that the higher total solids in seeds, the better they could be utilized

Table (2): Microbiological quality of examined natural tamarind pulp*.

Microorganisms	Varieties	
	Makham waan variety	Aswany variety
Total bacterial count	$6.35x10^2$	$1.06x10^4$
Sporformer bacteria	ND**	ND
Lactic acid bacteria	$1.2x10^2$	$2.4x10^2$
Psychrophylic bacteria	$1.6x10^2$	$1.94x10^2$
Coliform group	ND	ND
Staphylococcus	ND	ND
Yeasts and moulds	$4.9x10^2$	$6.9x10^2$

* Mean of duplicate determinations.
** ND: Not detected.

in different industrial uses such as seed powder mix, kernel powder and sizing materials for textiles **(Duke, 1981).** As shown in Table (3) there is a slight difference in total carbohydrates, total solids and moisture % which agree with **Marangoni *et al.* (1988)** who found that the moisture content was 9.4%, and **Anon (2006b)** who reported was 8.1%.

Crude protein, crude fat and ash percentage revealed 14.58, 15.74; 6.40, 5.90 and 2.47, 2.48 % in Indian and Aswany varieties, respectively, which agree with **Ishola *et al.* (1990)** and **Bhattacharya *et al* (1994).** However, crude fibers were 6.97% in Indian variety and 5.58% in Aswany variety.

4.1.3.2. Total, reducing and non-reducing soluble sugars:

Total soluble sugars and reducing sugars were 11.93, 13.78 and 7.26 and 8.66% in Indian variety and Aswany variety, which reveals higher content of Egyptian variety, which agree with **Ishola *et al.* (1990)** who found that total soluble and reducing sugars were11.30 and 7.43 g%, respectively, and **El-Siddig *et al.* (2006)** who reported that total sugars content ranged from 11.3-25.3% and reducing sugars 7.4%.

The obtained abovementioned results on seeds composition, strongly suggest the importance of tamarind seeds, which were shown to contain considerable amounts of carbohydrates, crude protein and crude fat as well. For example, one kilogram of tamarind seeds would contain 663.8 and 639.8 of total carbohydrates, 132.8 and 143.5 of crude proteins and 58.3, and 53.8 g/kg of crude fat, Indian and Aswany variety, respectively). Therefore, tamarind seeds could possibly be used as food and feeds. Moreover, seeds could be explored for their

Table (3): Chemical composition of examined natural tamarind seeds*.

Components*	Varieties			
	Makham waan variety		Aswany Variety	
	On wet basis	On dry basis	On wet basis	On dry basis
Moisture %	8.91±0.03		8.85±0.21	
Total solids %	91.09±0.03		91.15±0.21	
Crude fat %	5.83±0.03	6.40	5.38±0.09	5.90
Crude protein %	13.28±0.17	14.58	14.35±0.18	15.74
Ash %	2.25±0.07	2.47	2.26±0.09	2.48
Total carbohydrates %**	63.38	69.58	63.98	70.19
Crude fibers%	6.35±0.13	6.97	5.18±0.11	5.58
Total sugars %	10.87±0.15	11.93	12.56±0.20	13.78
Reducing sugars %	6.61±0.10	7.26	7.89±0.09	8.66
Non reducing sugars %	4.26±0.06	4.67	4.67±0.06	5.12

* Mean of triplicate determinations ±SE.
** Calculated by difference.

suitability to be exploited in some unconventional uses in various new industries.

4.1.4. Establishment of optimum extraction conditions of tamarind pulp:

This part of investigation employed tamarind pulp powders, obtained from Aswany variety and Indian variety. The various factors, which influence maximum extractability of tamarind pulp components into acceptable beverage, were investigated.

A cumulative extraction parameter represented the total extracted components. Parameters for measuring optimum extractability included determination of total soluble solids, pH value, and intensity of extracted color measured in optical density.

4.1.4.1. Extractability of the Indian tamarind variety:

4.1.4.1.1. Effect of flotation ratio (water: pulp) on extraction rate:

The effect of flotation ratio (water: pulp) from 2:1 to 10:1 on water extraction rate at room temperature was investigated.

Data in Table (4) illustrate that there was a general trend of gradual decrease in (T.S.S.) and (O.D.) with increase in flotation ratio from 2: 1 to 10:1. The highest values (23.83% and 4.442 nm) were attained with flotation ratio of 2:1. On the other hand, the lowest values for (6.00% and 1.226 nm, respectively) were attained at flotation ratio of 10:1. In addition, the lowest proportion of extract total soluble solids was (7.57%).

Table (4): Effect of flotation ratio at room temperature (33°C) *on extraction rate of* Indian tamarind.

Flotation ratio Water: pulp	Sequence of extraction	Determination*		
		pH	T.S.S.	O.D.
2:1	1st	2.20±0.20	23.83±0.29	4.442±0.34
	2nd	2.56±0.06	11.00±1.00	2.223±0.23
	3rd	2.80±0.08	4.50±0.50	0.893±0.10
	Cumulative		39.33	
4:1	1st	2.36±0.06	14.5±0.50	2.219±0.22
	2nd	2.71±0.07	3.50±0.50	0.779±0.09
	3rd	2.89±0.09	0.50±0.00	0.245±0.07
	Cumulative		18.50	
6:1	1st	2.49±0.05	10.17±0.29	2.169±0.26
	2nd	2.80±0.05	1.50±0.50	0.611±0.08
	3rd	3.06±0.06	0.00±0.00	0.232±0.07
	Cumulative		11.67	
8:1	1st	2.52±0.02	7.5±0.00	1.549±0.14
	2nd	2.85±0.1	0.50±0.00	0.365±0.08
	3rd	3.11±0.1	0.00±0.00	0.203±0.07
	Cumulative		8.00	
10:1	1st	2.54±0.08	6.00±1.00	1.226±0.16
	2nd	2.88±0.03	0.50±0.00	0.320±0.08
	3rd	3.33±0.08	0.00±0.00	0.190±0.05
	Cumulative		6.50	

* Mean of triplicate determinations ±SE.

All flotation ratios took the same trend was observed that the first extraction trial always exhibited the highest proportion of extracted total soluble solids and optical density (O.D.), followed by the second re-extraction, while the 3rd successive extraction showed the least values. In contrast, pH values showed a general behavior of increase with the repetition of the three successive extractions.

The maximum T.S.S. achieved after first extraction were 23.83%, which represent T.S.S. about 30.07%, while 2nd re-extraction added another 11.0%, which represent 13.88% besides 4.5 of the 3rd which achieved 5.68% of the total solids contained in pulp. After the three successive re-extraction trials, the maximum cumulative extraction reached 39.33%, which represent about 49.63% recovery of T.S.S. contained in the starting pulp powder.

The observed pH values during extraction are not surprising because tamarind is known to contain appreciable contents of organic acids as mentioned by (**Leung** and **Foster, 1993, Jayaprakasha** and **Sakariah 1998 and Zin El-Dine, 1999).** Which explain progressive increase in pH with the increase in flotation ratio more than 2:1 as the dilution with water would result in such increase.

Table (5) and Figure (1) demonstrate that gradual decrease in values for T.S.S. and O.D. with the increase in flotation ratio from 2: 1 to 10:1.

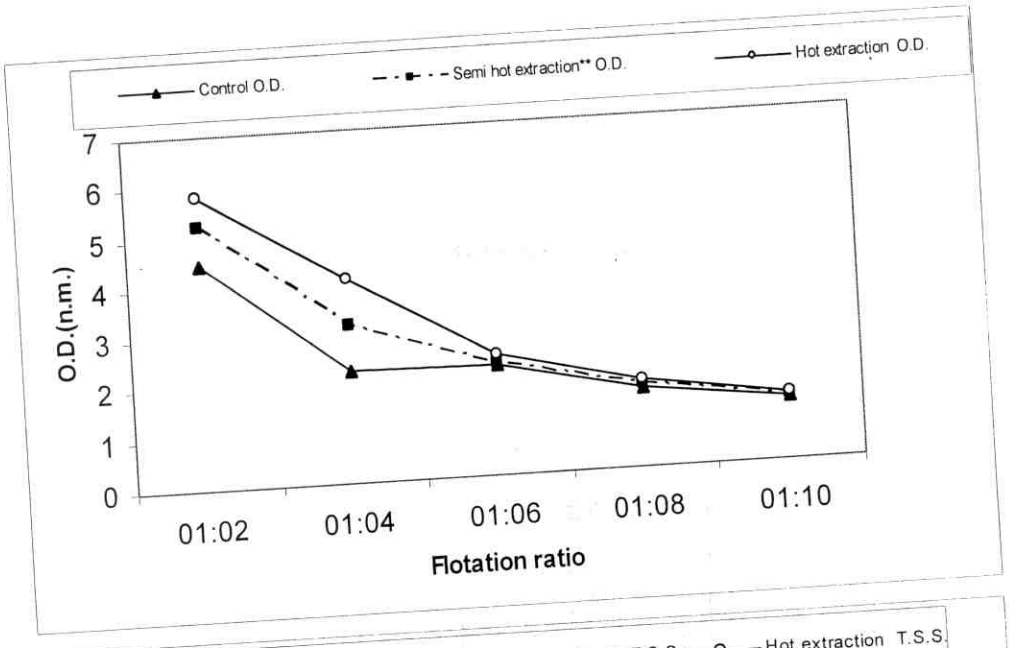
The first extraction exhibited the highest proportion of extracted T.S.S. and O.D., followed by the second re-extraction, while the 3rd successive extraction showed the least values. In

Table (5): Effect of flotation ratio at hot and semi hot conditions on extraction rate of Indian tamarind.

Flotation ratio Water: pulp	Sequence of extraction	Methods of Extraction*								
		Hot extraction (100 °C)			Semi hot extraction**			Control at room temperature		
		pH	T.S.S.	O.D.	pH	T.S.S	O.D.	pH	T.S.S.	O.D.
2:1	1st	2.50 ±0.05	26.50 ±0.5	5.786 ±0.36	2.35 ±0.01	24.50 ±0.50	5.216 ±0.35	2.20 ±0.2	23.83 ±0.29	4.442 ±0.34
	2nd	2.93 ±0.03	12.50 ±0.5	3.161 ±0.31	2.72 ±0.09	11.50 ±0.50	2.824 ±0.21	2.56 ±0.06	11.00 ±1.00	2.223 ±0.23
	3rd	3.14 ±0.01	4.5 ±0.5	0.905 ±0.12	3.01 ±0.01	4.50 ±0.00	0.896 ±0.11	2.80 ±0.08	4.50 ±0.50	0.893 ±0.10
	Cumulative		43.50			40.50			39.33	
4:1	1st	2.67 ±0.07	15.67 ±0.29	4.036 ±0.12	2.45 ±0.11	15.17 ±029	3.132 ±0.29	2.36 ±0.06	14.50 ±0.50	2.219 ±0.22
	2nd	3.02 ±±0.08	3.50 ±0.00	0.908 ±0.69	2.90 ±0.10	3.50 ±0.00	0.865 ±0.10	2.71 ±0.07	3.50 ±0.50	0.779 ±0.09
	3rd	3.30 ±0.09	1.17 ±0.29	0.274 ±0.11	3.04 ±0.09	1.00 ±0.00	0.261 ±0.08	2.89 ±0.09	0.50 ±0.00	0.245 ±0.07
	Cumulative		20.34			19.67			18.50	
6:1	1st	2.77 ±0.07	10.33 ±0.29	2.380 ±0.24	2.60 ±0.05	10.33 ±0.29	2.231 ±0.39	2.49 ±0.05	10.17 ±0.29	2.169 ±0.26
	2nd	3.15 ±0.01	2.00 ±0.00	0.640 ±0.08	3.02 ±0.1	1.50 ±0.5	0.622 ±0.08	2.80 ±0.05	1.50 ±0.50	0.611 ±0.08
	3rd	3.56 ±0.05	0.00 ±0.00	0.273 ±0.06	3.21 ±0.1	0.00 ±0.00	0.247 ±0.08	3.06 ±0.06	0.00 ±0.00	0.232 ±0.07
	Cumulative		12.33			11.83			11.67	
8:1	1st	2.84 ±0.04	8.17 ±0.29	1.749 ±0.14	2.71 ±0.06	7.67 ±0.5	1.627 ±0.17	2.52 ±0.02	7.50 ±0.00	1.549 ±0.14
	2nd	3.26 ±0.04	1.00 ±0.00	0.581 ±0.09	3.06 ±0.06	0.67 ±0.29	0.455 ±0.09	2.85 ±0.1	0.50 ±0.00	0.365 ±0.08
	3rd	3.71 ±0.06	0.00 ±0.00	0.213 ±0.06	3.33 ±0.03	0.00 ±0.00	0.210 ±0.06	3.11 ±0.1	0.00 ±0.00	0.203 ±0.07
	Cumulative		9.17			8.34			8.00	
10:1	1st	2.99 ±0.05	6.5 ±0.5	1.335 ±0.20	2.90 ±0.15	6.50 ±0.50	1.284 ±0.12	2.54 ±0.08	6.00 ±1.00	1.226 ±0.16
	2nd	3.36 ±0.1	0.67 ±0.29	0.336 ±0.08	3.15 ±0.21	0.50 ±0.00	0.329 ±0.08	2.88 ±0.03	0.50 ±0.00	0.320 ±0.08
	3rd	3.90 ±0.08	0.00 ±0.00	0.192 ±0.06	3.49 ±0.05	0.00 ±0.00	0.190 ±0.08	3.33 ±0.08	0.00 ±0.00	0.190 ±0.05
	Cumulative		7.17			7.00			6.50	

* Mean of triplicate determinations ±SE.

** Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



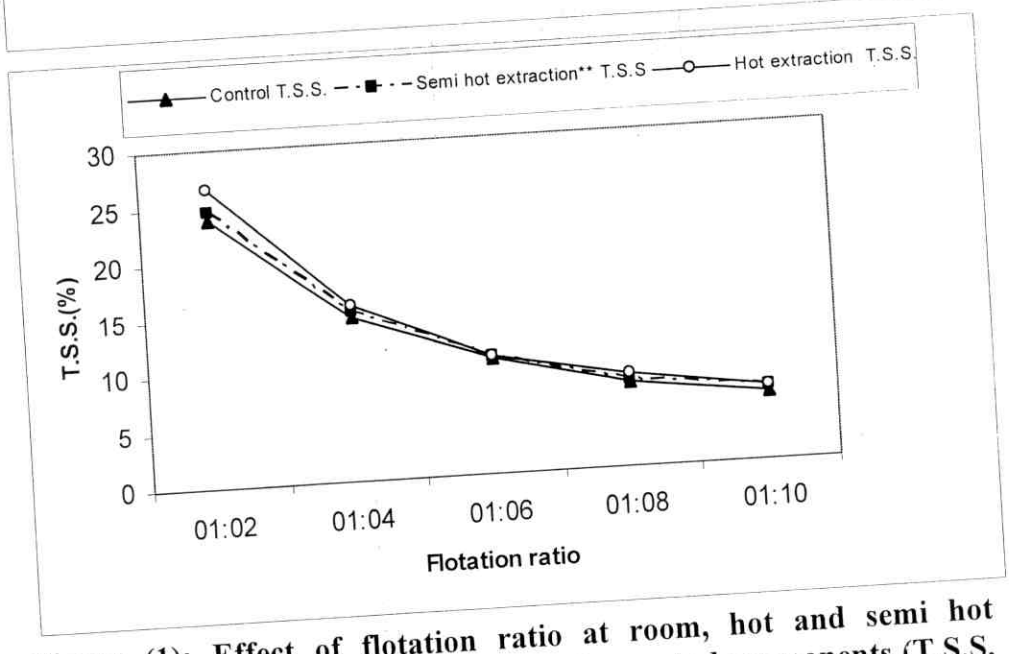


Figure (1): Effect of flotation ratio at room, hot and semi hot temperature (33°C) of extraction rate of tamarind components (T.S.S. and O.D.) from the Indian variety.

contrast, pH values showed increase with three successive extractions.

The maximum T.S.S. in hot extraction achieved one (2: 1) was 26.5%, which represent about 33.45%, while 2nd re-extraction added another 12.5%, which represent 15.78% of the total solids contained in pulp. After the three successive re-extraction trials, the maximum cumulative extraction reached 43.50%, which represent about 54.91% T.S.S. contained in the starting pulp powder.

With Semi-hot extraction, the maximum, T.S.S. achieved after one first extraction 24.5% which represent about 30.92%, while 2nd re-extraction added another 11.5%, which represent 14.51% of the total solids contained in pulp. After the three successive re-extraction trials, the maximum cumulative extraction reached 40.50%, which represent about 51.11% of T.S.S.

With all the temperature conditions, increasing the flotation ratio more than 2:1 did not improve the extractability of tamarind pulp components. Similarly, increasing re-extraction more than double did not improve the extractability of tamarind pulp components where the maximum T.S.S. of 3rd extraction were only 4.5%. Which represent about 5.68% recovery of T.S.S.

Progressive increase in pH with the increase in flotation ratio more than 2:1 could be attributed to dilution of media with water.

In general, the flotation ratio of 2: 1 (water: pulp) could be regarded the best or optimum ratio which gave maximum extractability. Furthermore, extraction under hot condition

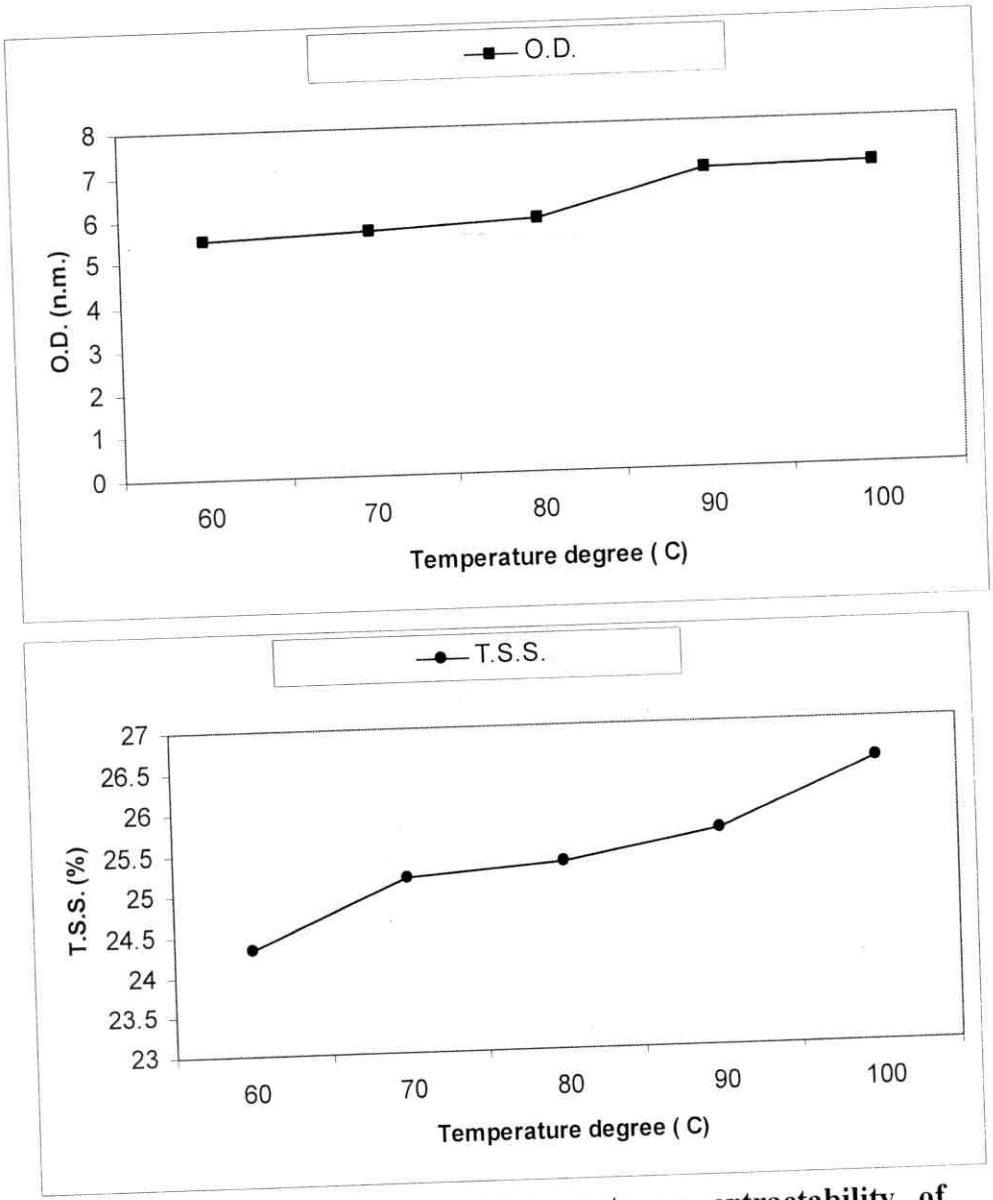


Figure (2): Effect of temperature rate on extractability of tamarind components (T.S.S. and O.D.) from Indian variety

These obtained results were parallel with those obtained by **Sharf (2003).**

4.1.4.1.3. Effect of extraction periods on extraction rate of Indian tamarind pulp at hot temperature:

The effect of duration extraction of tamarind components of pulp was investigated and results are presented in Table (7) and Fig. (3).

In a general rule, as the duration of extraction increased the total soluble solids content and optical density increased. However, such increase was not pronounced with increasing period of extraction longer than 30 min. In contrast, pH value decreased.

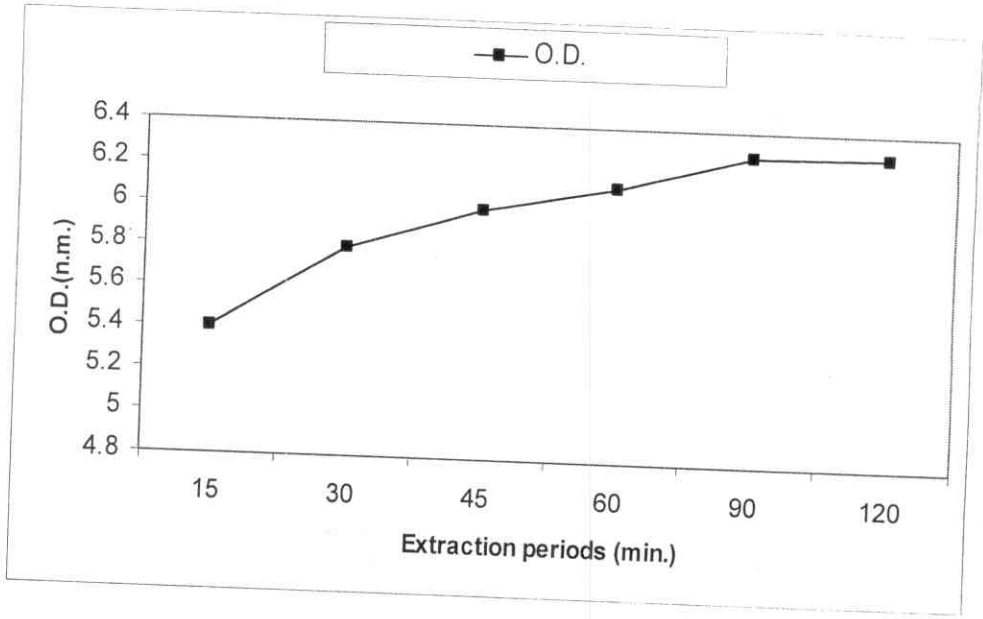
After the first extraction, T.S.S. reached 27.50%, which represent about 34.71%, while 2nd re-extraction added another 14.67%, which represent 18.52% and after the three successive re-extraction, the maximum cumulative extraction reached 46.67%, which represent 58.91% of the total solids contained in tamarind pulp. The minimum T.S.S. value was achieved after 15 min of extraction; where the first extraction attained only 25.5% which represent about 32.18%, while 2nd re-extraction added another 11.17%, which represent 14.10% and after the three successive re-extraction trials, the maximum cumulative extraction reached 41.17%, which represent 51.96% of the total solids contained in tamarind pulp. These obtained results are close with those obtained by **Zin El-Dine (1999)** who found that extraction at boiling point for 90 minutes gave higher solids content than extraction obtained by 60 minutes.

From the presented data, it could be concluded that optimum extraction period revealed 30 min at hot temperature

Table (7): Effect of extraction periods at hot temperature (100 °C) on extractability of Indian tamarind.

Extraction periods	Sequence of extraction	Determination*		
		pH	T.S.S.	O.D.
15 min.	1st	2.81±0.1	25.50±0.5	5.397±0.41
	2nd	2.91±0.04	11.17±0.29	3.091±0.38
	3rd	3.22±0.06	4.50±0.5	1.002±0.13
	Cumulative		41.17	
30 min.	1st	2.77±0.07	26.50±0.5	5.786±0.44
	2nd	2.87±0.07	12.50±1.00	3.161±0.31
	3rd	3.14±0.1	4.50±0.00	0.905±0.10
	Cumulative		43.50	
45 min.	1st	2.72±0.05	26.67±0.29	5.987±0.46
	2nd	2.85±0.1	12.50±0.5	3.203±0.35
	3rd	3.12±0.11	4.50±0.5	0.889±0.11
	Cumulative		43.67	
60 min.	1st	2.71±0.06	26.67±0.29	6.113±0.41
	2nd	2.82±0.02	12.50±0.5	3.206±0.33
	3rd	3.11±0.11	4.50±0.00	0.889±0.10
	Cumulative		43.67	
90 min.	1st	2.70±0.10	27.50±0.5	6.285±0.41
	2nd	2.80±0.05	12.83±0.29	3.545±0.32
	3rd	3.09±0.09	4.50±0.5	0.766±0.08
	Cumulative		44.83	
120 min.	1st	2.69±0.09	27.50±0.5	6.288±0.42
	2nd	2.76±0.06	14.67±0.29	3.747±0.27
	3rd	3.06±0.06	4.50±0.00	0.672±0.08
	Cumulative		46.67	

* Mean of triplicate determinations ±SE.



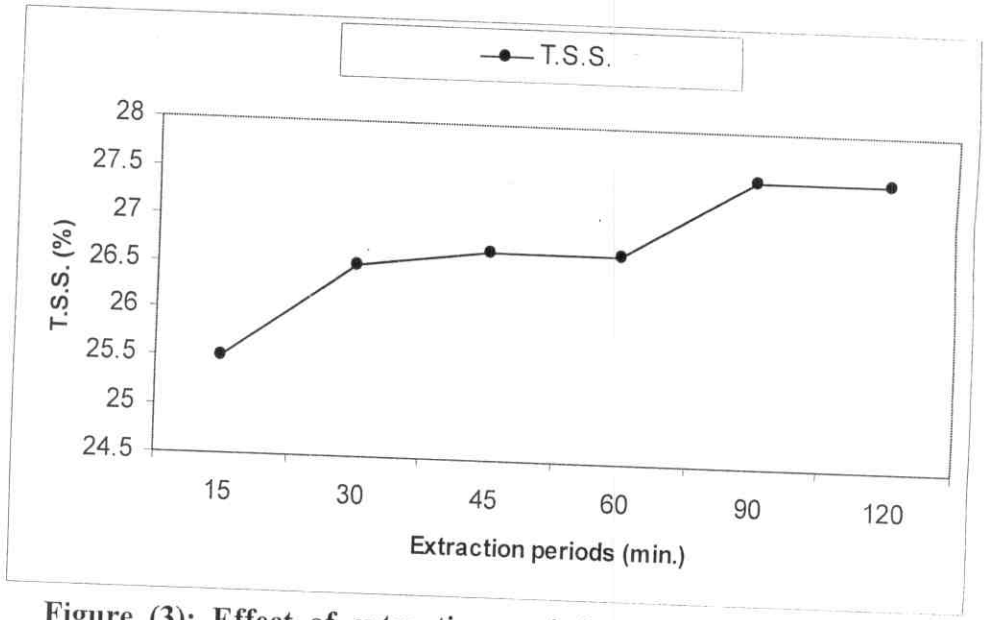


Figure (3): Effect of extraction periods at hot condition on extractability of tamarind components (T.S.S. and O.D.) from the Indian variety

selected as a compromise between speed of extraction and maximum extractability of components of Indian tamarind.

In order to study the possibility of replacing the extraction, which was maximized after about 30 min., longer periods of extraction under room or semi-hot condition were investigated.

Table (8) and Fig. (4). Illustrate the effect of applying longer duration of extraction extractability rate or successive extraction of components.

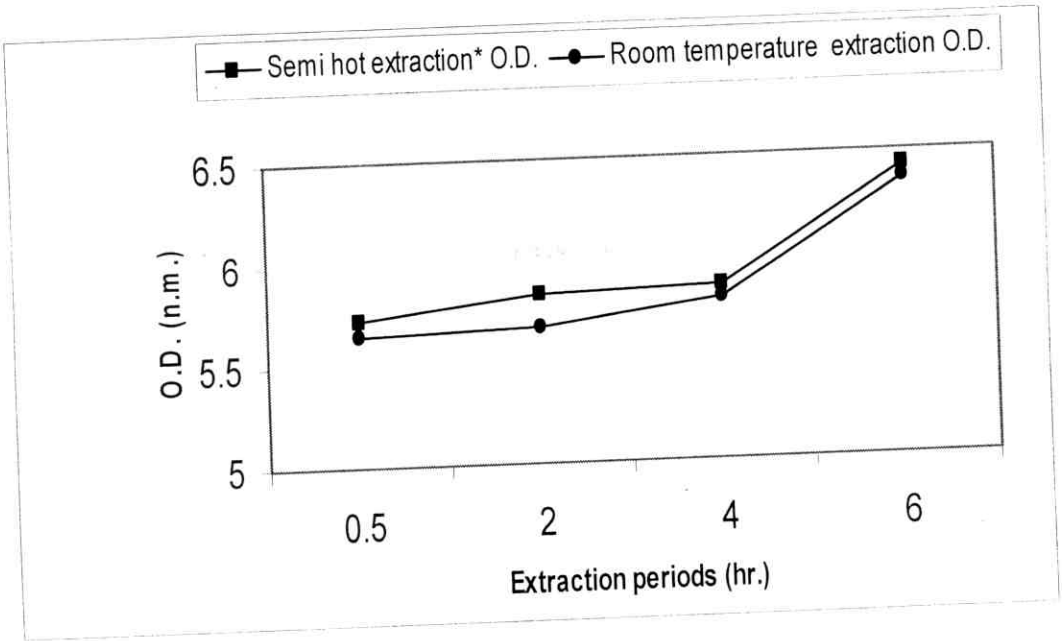
There was a gradual increase in values for T.S.S. and O.D. with increase in duration to 6 hrs. However, such increase was not pronounced than two hrs. In contrast, the pH of extraction medium decreased gradually with increase in duration of extraction.

With semi-hot temperature, the maximum T.S.S. were achieved after 6 hrs of extraction. 1st extraction reached 26.00% which represent about 32.82%, while 2nd re-extraction added another 13.00%, which represent 16.41% of the total solids contained in pulp. After the three successive re-extraction trials, maximum cumulative extraction reached 44.50%, which represent about 56.16% recovery of T.S.S. contained in pulp powder. At room temperature, the maximum T.S.S. was achieved after 6 hrs where 1st extraction attained 24.17% which represent about 30.51%, while The 2nd re-extraction added another 11.33%, which represent 14.30% and after the three successive re-extraction, the maximum cumulative extraction reached 40.00%, which represent about 50.48% recovery of T.S.S. contained in pulp powder. These obtained results agree with those obtained by **Zin El-Dine (1999)** who illustrated that

Table (8): Effect of extraction periods at room temperature (33°C) and semi hot conditions* on extractability of Indian tamarind.

Extraction periods	Sequence of extraction	Methods of extraction					
		Room temperature extraction			Semi hot extraction*		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
0.5 hr.	1st	2.38 ±0.08	22.67 ±0.29	5.640 ±0.38	2.66 ±0.1	25.00 ±0.10	5.724 ±0.36
	2nd	2.56 ±0.1	11.00 ±0.5	2.997 ±0.38	2.72 ±0.1	12.00 ±0.50	3.014 ±0.02
	3rd	2.80 ±0.03	4.17 ±0.29	0.881 ±0.09	2.94 ±0.04	4.50 ±0.50	0.990 ±0.11
	Cumulative		37.84			41.50	
2 hrs.	1st	2.33 ±0.1	23.17 ±0.29	5.671 ±0.41	2.60 ±0.1	25.17 ±0.29	5.838 ±0.35
	2nd	2.54 ±0.04	11.17 ±0.29	3.284 ±0.25	2.68 ±0.08	12.50 ±0.50	3.326 ±0.28
	3rd	2.62 ±0.02	4.33 ±0.29	1.161 ±0.16	2.89 ±0.05	4.50 ±0.00	1.276 ±0.11
	Cumulative		38.67			42.17	
4 hrs.	1st	2.23 ±0.03	24.17 ±0.29	5.788 ±0.39	2.58 ±0.1	25.5 ±0.50	5.853 ±0.42
	2nd	2.45 ±0.05	11.33 ±0.28	3.425 ±0.33	2.62 ±0.02	13.00 ±0.50	3.514 ±0.31
	3rd	2.57 ±0.07	4.50 ±0.00	1.269 ±0.12	2.76 ±0.06	5.00 ±0.29	1.321 ±0.12
	Cumulative		40.00			43.50	
6 hrs.	1st	2.08 ±0.08	24.17 ±0.29	6.365 ±0.42	2.44 ±0.04	26.00 ±0.50	6.426 ±0.44
	2nd	2.40 ±0.04	11.33 ±0.25	3.870 ±0.34	2.49 ±0.27	13.00 ±0.50	3.894 ±0.33
	3rd	2.53 ±0.03	4.50 ±0.00	1.288 ±0.11	2.65 ±0.05	5.50 ±0.25	1.432 ±0.14
	Cumulative		40.00			44.50	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



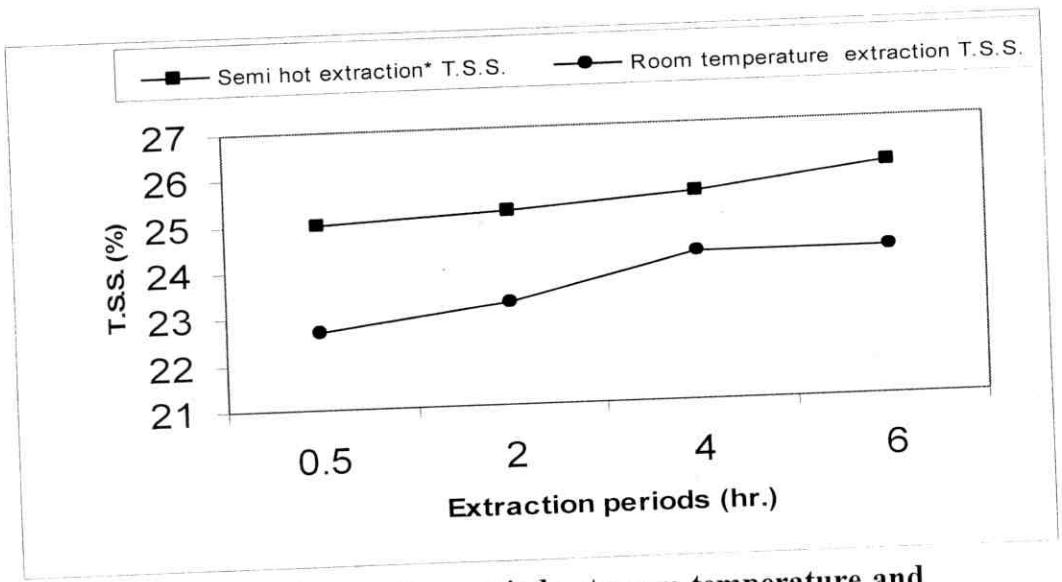


Figure (4): Effect of extraction periods at room temperature and semi hot conditions on extraction rate of tamarind components (T.S.S. and O.D.) from the Indian variety.

soaking tamarind at room temperature for 4 hours gave higher solids content than extraction obtained by 30 minutes.

Although the period of extraction of 6 hrs was found the best for maximum extractability at both room and semi-hot temperature.

Extraction period of only two hrs was selected as a compromise between speed, economy of extraction and maximum extractability of tamarind components in pulp of Indian tamarind variety.

4.1.4.1.4. Effect of pH medium on extraction rate of tamarind pulp of Indian variety:

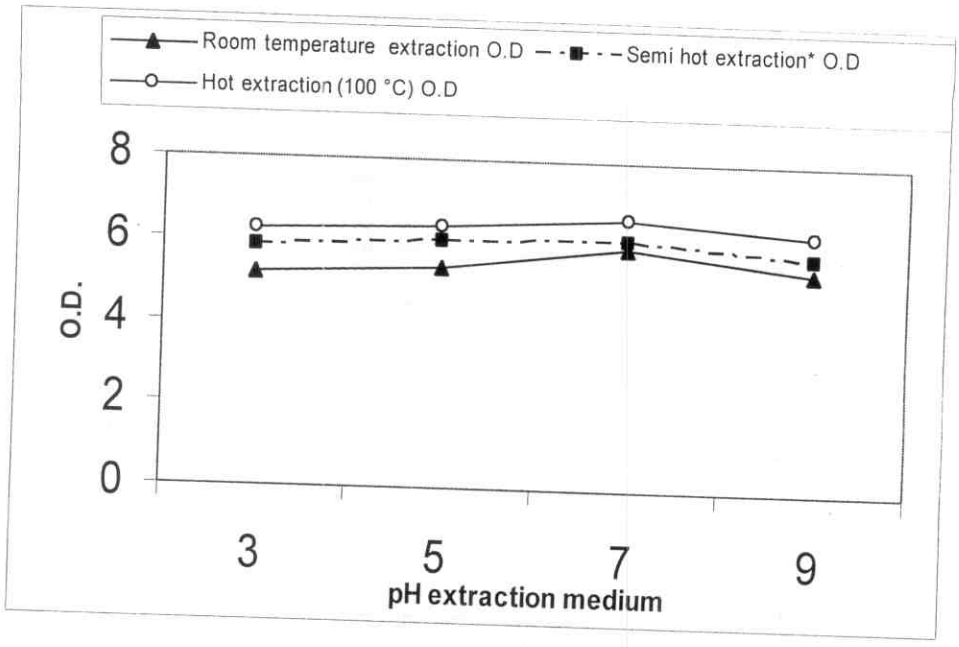
The effect of in pH on successive extraction of components of tamarind pulp of variety was investigated and results are tabulated in Table (9) and Fig. (5).

With hot temperature, the maximum T.S.S. were achieved when pH value of extraction medium was pH = 7, where the 1st extraction trial reached 25.50% which represented about 32.18%. The 2nd re-extraction added another 12.83%, which represent 16.19% pulp. After the three successive re-extraction, the maximum cumulative extraction reached 43.50%, which represent about 54.90% of T.S.S. contained in pulp powder. With semi-hot temperature, maximum T.S.S. were achieved when pH value of extraction medium was (pH = 7), where the 1st extraction reached 24.17% which represent about 30.51%. The 2nd re-extraction added another 12.17%, which represent 15.36%. After the three successive re-extraction, maximum cumulative extraction reached 40.84%, which represent about 51.54% of T.S.S. contained in pulp powder.

Table (9): Effect of pH on extractability of tamarind components of Indian variety.

pH of extraction	Sequence of extraction	Methods of extraction								
		Hot extraction (100 °C)			Semi hot extraction*			Room temperature extraction		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
pH 3	1st	2.30 ±0.1	24.67 ±0.29	6.213 ±0.41	2.36 ±0.06	23.67 ±0.25	5.782 ±0.36	2.40 ±0.02	22.33 ±0.29	5.185 ±0.35
	2nd	2.43 ±0.01	12.17 ±0.22	2.865 ±0.24	2.45 ±0.11	11.5 ±0.50	2.583 ±0.32	2.45 ±0.05	9.17 ±0.29	2.387 ±0.20
	3rd	2.48 ±0.08	5.17 ±0.23	1.295 ±0.17	2.54 ±0.03	5.00 ±0.00	1.104 ±0.12	2.62 ±0.02	5.00 ±0.50	0.977 ±0.10
	Cumulative		42.01			40.17			36.50	
pH 5	1st	2.31 ±0.021	25.00 ±1.00	6.345 ±0.44	2.39 ±0.11	24.00 ±0.50	5.976 ±0.38	2.45 ±0.05	22.33 ±0.29	5.334 ±0.44
	2nd	2.45 ±0.05	12.17 ±0.29	2.873 ±0.20	2.46 ±0.05	12.00 ±0.60	2.728 ±0.20	2.47 ±0.06	9.67 ±0.29	2.693 ±0.37
	3rd	2.50 ±0.11	5.17 ±0.29	1.331 ±0.1	2.58 ±0.04	4.50 ±0.50	1.214 ±0.14	2.76 ±0.08	4.00 ±0.00	1.133 ±0.21
	Cumulative		42.34			40.50			36.00	
pH 7	1st	2.33 ±0.03	25.50 1.00	6.563 ±0.38	2.42 ±0.11	24.17 ±0.29	6.021 ±0.41	2.49 ±0.03	22.50 ±0.50	5.85 ±0.32
	2nd	2.46 ±0.05	12.83 ±0.29	2.977 ±0.22	2.48 ±0.10	12.17 ±0.29	2.813 ±0.21	2.51 ±0.10	9.67 ±0.29	2.617 ±0.22
	3rd	2.54 ±0.04	5.17 ±0.25	1.368 ±0.11	2.60 ±0.10	4.50 ±0.00	1.325 ±0.12	2.76 ±0.10	4.17 ±0.29	1.309 ±0.11
	Cumulative		43.50			40.84			36.34	
pH 9	1st	2.43 ±0.04	25.33 ±0.29	6.243 ±0.45	2.45 ±0.05	24.00 ±0.50	5.662 ±0.37	2.52 ±0.04	22.17 ±0.29	5.336 ±0.35
	2nd	2.50 ±0.04	12.83 ±0.21	3.176 ±0.32	2.52 ±0.04	12.00 ±1.00	2.786 ±0.21	2.56 ±0.05	10.00 ±1.00	2.635 ±0.24
	3rd	2.56 ±0.10	4.50 ±0.17	1.272 ±0.11	2.74 ±0.02	4.00 ±0.00	1.222 ±0.11	2.85 ±0.07	3.67 ±0.29	1.213 ±0.11
	Cumulative		42.66			40.00			35.84	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



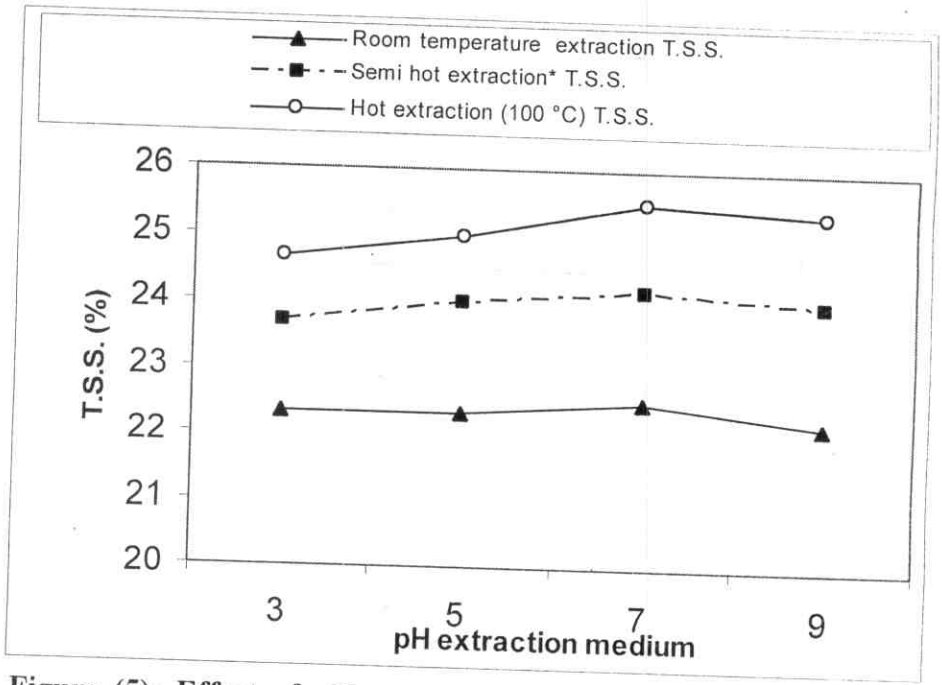


Figure (5): Effect of pH on tamarind components (T.S.S. and O.D.) from the Indian variety.

Similarly, at room temperature, the maximum T.S.S. were attained using pH value of extraction medium of (pH =7), where the 1st extraction reached 22.50% which represented about 28.40%. The 2nd re-extraction added another 9.67%, which represented 12.20%. After three successive re-extraction, the maximum cumulative extraction reached 36.34%, which represent about 45.86% of T.S.S. contained pulp powder.

From the presented data, it could be concluded that optimum pH medium of extraction of pH=7 at different temperatures was selected as a compromise between speed of extraction and maximum extractability of components of the Indian tamarind variety.

4.1.4.2. Extractability of Egyptian tamarind Aswany variety:

4.1.4.2.1. Effect of flotation ratio (water: pulp) on extraction rate of tamarind pulp Aswany variety:

The effect of flotation ratio (water: pulp) from 2:1 to 10:1 on water extraction rate at room temperature and the re-extraction successive extraction of components of tamarind pulp of Egyptian Aswany variety was investigated and results are recorded in Table (10).

Data in Table (10) illustrate that there was a general trend of gradual decrease for total soluble solids (T.S.S.) and optical density (O.D.) with the increase in flotation ratio from 1: 2 to 10:1. In contrast, the pH of extraction medium, which was strongly acidic, increased gradually. The highest values for total soluble solids and optical density (23.00% and 3.682) were attained with flotation ratio of 2:1. On the other hand, the lowest

Table (10): Effect of flotation ratio on extraction rate at room temperature of tamarind components (Aswany variety).

Flotation ratio Water: pulp	Sequence of extraction	Determination*		
		pH	T.S.S.	O.D.
2:1	1st	2.51±0.01	23.00±0.29	3.682±0.32
	2nd	2.70±0.05	10.50±0.29	2.175±0.25
	3rd	3.01±0.05	4.00±0.29	0.502±0.09
	Cumulative		37.50	
4:1	1st	2.62±0.02	13.17±0.17	2.011±0.24
	2nd	2.84±0.04	3.50±0.29	0.793±0.09
	3rd	3.09±0.06	0.50±0.00	0.281±0.07
	Cumulative		17.17	
6:1	1st	2.76±0.06	9.50±0.29	1.962±0.21
	2nd	2.94±0.04	1.50±0.29	0.619±0.08
	3rd	3.13±0.04	0.00±0.00	0.247±0.01
	Cumulative		11.00	
8:1	1st	2.80±0.11	7.00±0.29	1.245±0.13
	2nd	3.04±0.05	0.50±0.00	0.470±0.07
	3rd	3.18±0.09	0.00±0.00	0.238±0.07
	Cumulative		7.50	
10:1	1st	2.84±0.08	5.00±0.29	1.123±0.14
	2nd	3.05±0.12	0.50±0.00	0.330±0.06
	3rd	3.36±0.10	0.00±0.00	0.177±0.06
	Cumulative		5.50	

* Mean of triplicate determinations ±SE.

values for T.S.S and O.D. (5.00% and 1.123) were attained at flotation ratio of 10:1.

First extraction always exhibited the highest proportion of T.S.S. and (O.D.), followed by the second re-extraction, while the 3rd successive extraction showed the least values. In contrast, pH values showed a general behavior of increase with repetition of three successive extractions.

The maximum T.S.S. achieved after first extraction with all the flotation ratios were 23.00%, which represent about 28.37%. The 2nd re-extraction added another 10.50%, which represent 12.95%. After the three successive re-extraction trials, the maximum cumulative extraction reached 37.5%, which represent about 46.25% of T.S.S. contained in pulp powder.

Increasing the flotation ratio more than 2:1 did not improve the extractability of tamarind pulp components. Similarly, increasing re-extraction more than double did not improve the extractability of tamarind pulp components where the maximum T.S.S. of 3rd extraction achieved was only 4.00%, which represent about 4.93% of T.S.S. contained in the pulp powder.

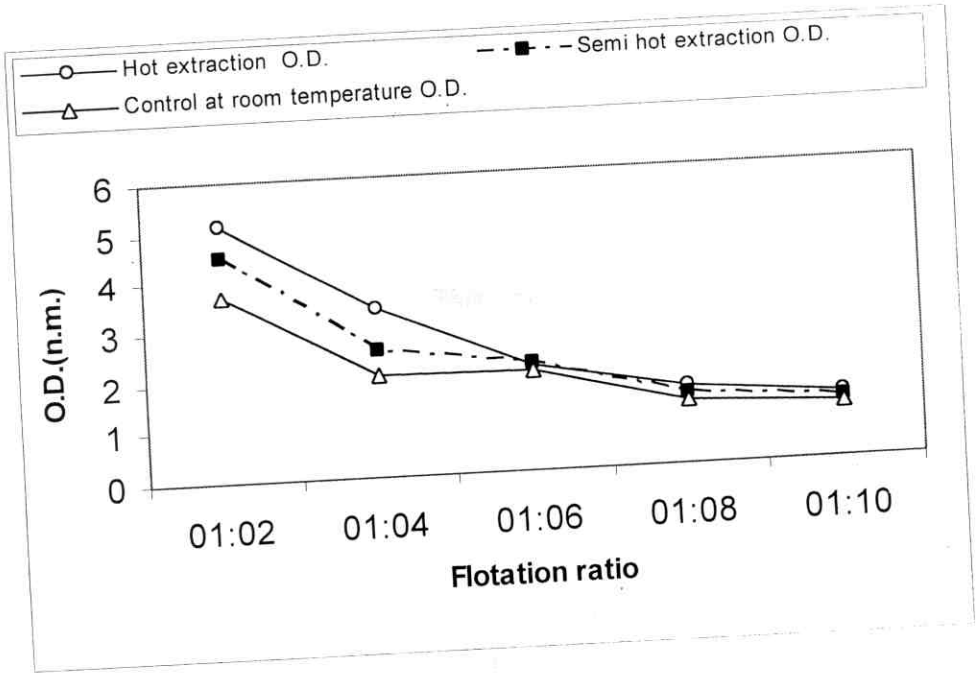
The observed pH values during extraction is not surprising because tamarind is known to contain appreciable contents of organic acids (**Shankarachary 1998, Jayaprakasha and Sakariah 1998).** These literature reports would explain the observed trend of progressive increase in pH with the re-extraction trials and with the increase in flotation ratio more than 2:1, as the dilution of media with water would result in such increase.

With all extraction temperature, Table (11) and Fig. (6) Illustrates that there was gradual decrease in values for T.S.S.

Table (11): Effect of flotation ratio at hot and semi hot conditions on extraction rate of tamarind components (Aswany variety).

Flotation ratio (Water: pulp)	Sequence of extraction	Methods of extraction								
		Hot extraction (100 °C)			Semi hot extraction*			Control at room temperature		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
2:1	1st	2.74 ±0.11	26.00 ±0.58	5.136 ±0.43	2.65 ±0.06	24.00 ±0.29	4.492 ±0.32	2.51 ±0.01	23.00 ±0.29	3.682 ±0.32
	2nd	2.98 ±0.10	13.00 ±0.29	2.832 ±0.25	2.83 ±0.09	12.00 ±0.25	2.374 ±0.31	2.70 ±0.05	10.50 ±0.29	2.175 ±0.25
	3rd	3.19 ±0.09	5.00 ±0.29	0.870 ±0.09	3.10 ±0.05	4.50 ±0.04	0.526 ±0.10	3.01 ±0.05	4.00 ±0.29	0.502 ±0.09
	Cumulative		44.00			40.50			37.50	
4:1	1st	2.86 ±0.07	14.50 ±0.58	3.340 ±0.32	2.71 ±0.05	14.00 ±0.58	2.531 ±0.19	2.62 ±0.02	13.17 ±0.17	2.011 ±0.24
	2nd	3.05 ±0.05	3.50 ±0.00	0.874 ±0.09	2.96 ±0.06	3.50 ±0.29	0.876 ±0.11	2.84 ±0.04	3.50 ±0.29	0.793 ±0.09
	3rd	3.22 ±0.10	1.50 ±0.29	0.286 ±0.08	3.15 ±0.06	1.00 ±0.00	0.242 ±0.08	3.09 ±0.06	0.50 ±0.00	0.281 ±0.07
	Cumulative		19.50			18.50			17.17	
6:1	1st	2.92 ±0.04	10.17 ±0.17	2.094 ±0.20	2.84 ±0.04	10.00 ±0.29	2.114 ±0.25	2.76 ±0.06	9.50 ±0.29	1.962 ±0.21
	2nd	3.10 ±0.10	2.00 ±0.00	0.657 ±0.08	3.06 ±0.07	1.50 ±0.00	0.632 ±0.11	2.94 ±0.04	1.50 ±0.29	0.619 ±0.08
	3rd	3.30 ±0.10	0.00 ±0.00	0.279 ±0.07	3.22 ±0.08	0.00 ±0.00	0.260 ±0.07	3.13 ±0.04	0.00 ±0.00	0.247 ±0.01
	Cumulative		12.17			11.50			11.00	
8:1	1st	2.98 ±0.09	9.33 ±0.17	1.568 ±0.13	2.89 ±0.09	7.50 ±0.29	1.384 ±0.17	2.80 ±0.11	7.00 ±0.29	1.245 ±0.13
	2nd	3.21 ±0.11	1.50 ±0.29	0.561 ±0.08	3.13 ±0.10	1.00 ±0.00	0.462 ±0.09	3.04 ±0.05	0.50 ±0.00	0.470 ±0.07
	3rd	3.45 ±0.05	0.00 ±0.00	0.235 ±0.07	3.29 ±0.06	0.00 ±0.00	0.226 ±0.06	3.18 ±0.09	0.00 ±0.00	0.238 ±0.07
	Cumulative		10.83			8.50			7.50	
10:1	1st	3.10 ±0.11	6.00 ±0.29	1.320 ±0.13	2.98 ±0.08	5.50 ±0.29	1.220 ±0.13	2.84 ±0.08	5.00 ±0.29	1.123 ±0.14
	2nd	3.41 ±0.12	0.50 ±0.00	0.362 ±0.07	3.27 ±0.07	0.50 ±0.00	0.381 ±0.07	3.05 ±0.12	0.50 ±0.00	0.330 ±0.06
	3rd	3.94 ±0.05	0.00 ±0.00	0.201 ±0.07	3.48 ±0.12	0.00 ±0.00	0.185 ±0.05	3.36 ±0.10	0.00 ±0.00	0.177 ±0.06
	Cumulative		6.50			6.00			5.50	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



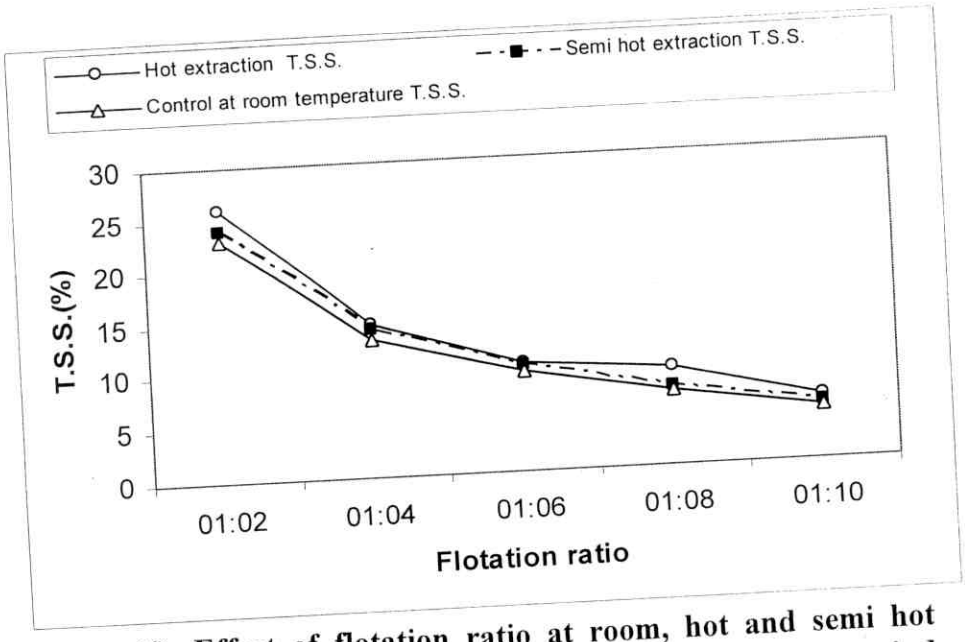


Figure (6): Effect of flotation ratio at room, hot and semi hot temperature (33°C) rate of Egyptian tamarind components (T.S.S. and O.D.) of Aswany variety.

and O.D. with increase in flotation ratio from 2:1 to 10:1. In contrast, the pH of extraction medium increased gradually. First extraction always exhibited the highest proportion of extracted T.S.S. and O.D., followed by the second re-extraction, while the 3rd successive extraction showed the least values, while pH values increased.

Using hot temperature, the maximum T.S.S. achieved after first extraction with (2:1) were 26.00%, which represent about 32.07%. The 2nd re-extraction added another 13.00%, which represent 16.03%. After three successive re-extraction, the maximum cumulative extraction reached 44.00%, which represent about 55.54% of T.S.S. contained in pulp powder.

With Semi-hot temperature, the maximum, T.S.S. achieved 24.00% after first extraction with the optimum flotation ratios (2:1) was which represent about 29.60%. The 2nd re-extraction added another 12.00%, which represent 12.80%. After the three successive re-extraction, the maximum cumulative extraction reached 40.50%, which represent about 49.95% of T.S.S. contained in pulp powder.

With all temperature conditions, increasing the flotation ratio more than 2:1 did not improve the extractability of tamarind pulp components. Similarly, increasing re-extraction more than double did not improve the extractability of tamarind pulp components where the maximum T.S.S. of 3rd extraction achieved were only 6.00 and 5.50%, which represent about 7.40% and 6.78% at hot and semi hot temperature condition recovery of T.S.S. contained in pulp powder.

Progressive increase in pH with the increase in flotation ratio more than 2:1 could be attributed dilution of media with water.

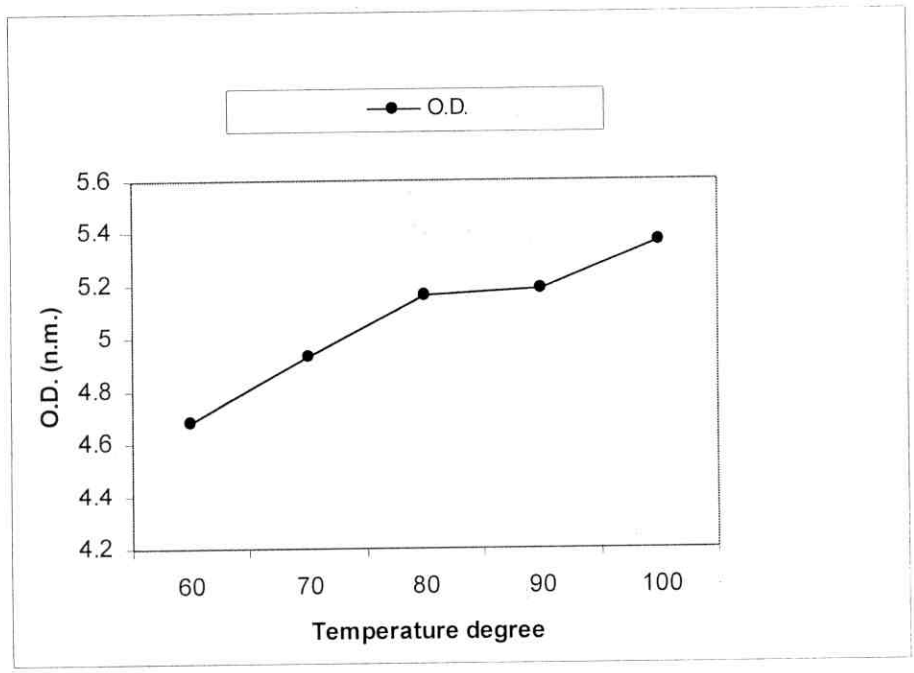
Flotation ratio of 2:1 could be regarded the best or optimum ratio, which gave maximum extractability. Furthermore, extraction under hot condition exhibited maximum extractability compared to room and semi-hot condition. Two extractions were found sufficient for the maximum recovery of tamarind pulp. These obtained results agree with those obtained by **Morton (1987)** who illustrated that the flotation ratio of 2: 1 (water: pulp) is considered the best ratio for tamarind extraction.

4.1.4.2.2. Effect of temperature degree on extraction rate of pulp of the Egyptian tamarind Aswany variety:

As shown in Table (12) and Fig. (7) Maximum T.S.S. achieved after first extraction trial at 100 °C were 26.17%, which represent about 32.28%. The 2nd re-extraction added another 12.50%, which represent 15.41%. After three successive re-extraction, T.S.S reached 43.83%, which represents 55.31% while the minimum T.S.S. achieved after first extraction at 60°C was 22.00%, which represent about 27.13%. The 2nd re-extraction added another 11.17%, which represents 13.77% of the total solids contained in pulp. After the three successive re-extraction, the maximum cumulative extraction reached 38.67%, which represent 47.69% of the total solids contained in tamarind pulp. These obtained results are parallel with those obtained by **Wong *et al.* (2003)**.

Table (12): Effect of temperature rate (hot condition) on extractability of tamarind (Aswany variety).

Extraction temperatures	Sequence of extraction	Determination		
		pH	T.S.S.	O.D.
60°C	1st	3.12±0.04	22.00±0.29	4.682±0.31
	2nd	3.23±0.10	11.17±0.29	1.967±0.11
	3rd	3.35±0.07	5.50±0.29	1.143±0.11
	Cumulative		38.67	
70°C	1st	3.09±0.02	23.00±0.29	4.934±0.31
	2nd	3.18±0.09	11.50±0.29	2.120±0.21
	3rd	3.27±0.06	5.50±0.29	1.236±0.13
	Cumulative		40.00	
80°C	1st	3.03±0.10	23.50±0.29	5.162±0.32
	2nd	3.13±0.06	12.00±0.29	2.233±0.22
	3rd	3.24±0.10	6.00±0.22	1.386±0.10
	Cumulative		41.50	
90°C	1st	2.94±0.04	24.50±0.29	5.182±0.30
	2nd	3.06±0.07	12.50±0.29	2.290±0.21
	3rd	3.18±0.04	6.50±0.29	1.473±0.10
	Cumulative		43.50	
100°C	1st	2.90±0.04	26.17±1.00	5.364±0.33
	2nd	3.02±0.10	12.50±0.50	2.302±0.17
	3rd	3.12±0.10	7.00±0.29	1.495±0.11
	Cumulative		45.67	



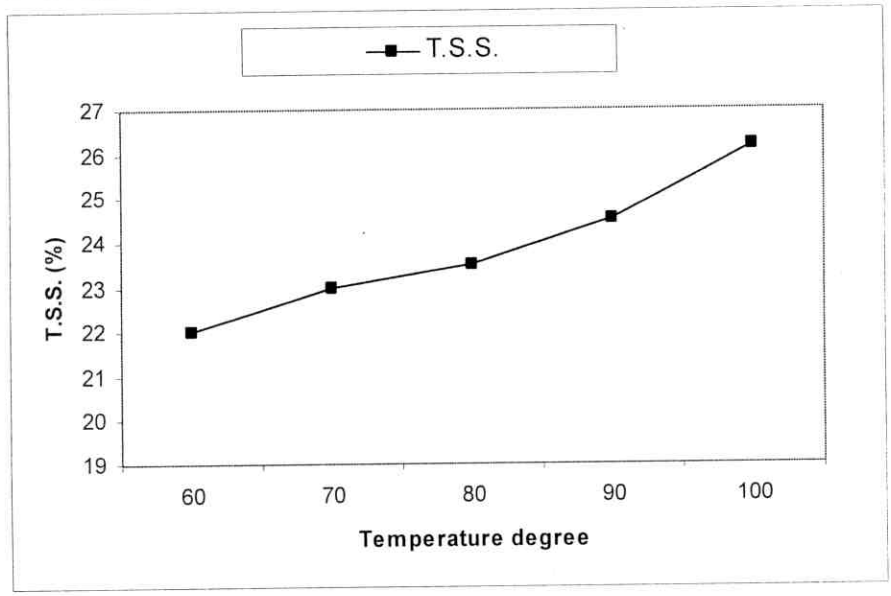


Figure (7): Effect of temperature rate (hot condition) on extractability of Egyptian tamarind components (T.S.S and O.D.) of Aswany variety.

4.1.4.2.3. Effect of extraction periods on extraction rate of the Egyptian tamarind Aswany variety:

As shown in Table (13) and Fig. (8) Maximum T.S.S. and O.D. values were achieved after extraction period for 120 min. in hot water. After first extraction, T.S.S. reached 27.00%, which represent about 33.30%. The 2nd re-extraction added another 13.50%, which represent 16.65%. After three successive re-extraction, the maximum cumulative extraction reached 46.00%, which represent 56.74% of the total solids contained in tamarind pulp. The minimum T.S.S. values were achieved after 15 min of extraction. First extraction attained only 25.50%, which represent about 31.45%. The 2nd re-extraction added another 11.50%, which represent 14.18%. After three successive re-extraction, the maximum cumulative extraction reached 42.00%, which represents 51.79% of the total solids contained in tamarind pulp. These obtained results agree with those obtained by **Zin El-Dine (1999)** who found that extraction at boiling point for 90 minutes gave higher solids content than extraction obtained by 60 minutes.

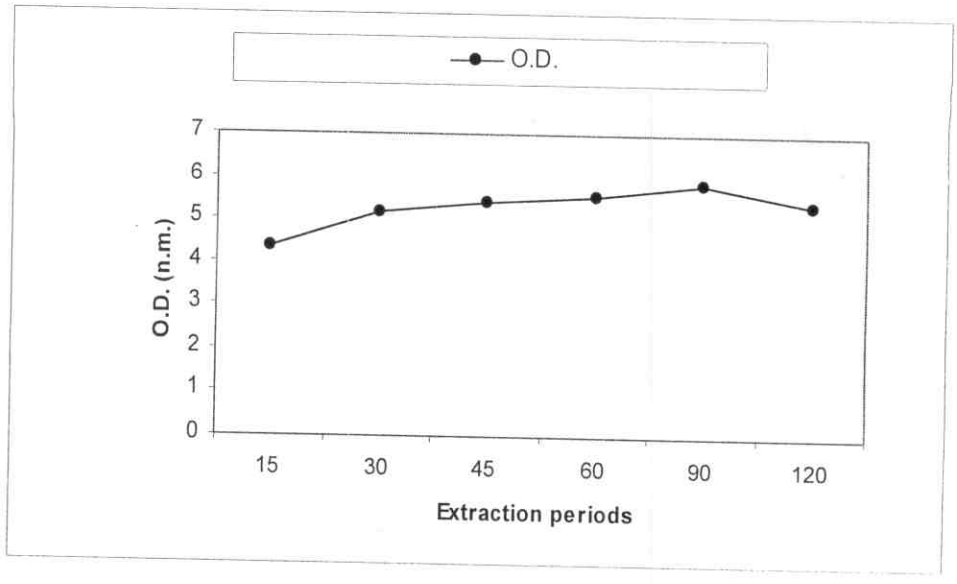
From the presented data, it could be concluded that only 30 min at hot temperature was selected as a compromise between speed of extraction and maximum extractability of components of Egyptian tamarind Aswany variety.

In longer periods of extraction under room or semi-hot condition were investigated as shown in Table (14) and Fig. (9).

There was gradual increase in values for T.S.S. and O.D. with increase in periods from 0.5 to 6 hrs. However, such increase was not pronounced with increasing period of extraction longer than two hrs, while decreased gradually.

Table (13): Effect of extraction periods at hot condition on extractability of tamarind (Aswany variety).

Extraction periods	Sequence of extraction	Determination		
		pH	T.S.S.	O.D.
15 min.	1st	3.02±0.10	25.50±0.22	4.345±0.15
	2nd	3.12±0.09	11.50±0.50	2.162±0.11
	3rd	3.17±0.05	5.00±0.40	1.060±0.07
	Cumulative		42.00	
30 min.	1st	2.92±0.11	26.00±0.50	5.142±0.20
	2nd	3.04±0.04	12.00±0.23	2.847±0.16
	3rd	3.20±0.09	5.00±0.50	0.972±0.09
	Cumulative		43.00	
45 min.	1st	2.85±0.05	26.33±0.17	5.394±0.17
	2nd	3.01±0.05	12.50±0.15	2.812±0.10
	3rd	3.16±0.06	5.50±0.50	0.946±0.08
	Cumulative		44.33	
60 min.	1st	2.80±0.10	26.50±0.50	5.564±0.19
	2nd	2.94±0.04	13.00±0.50	2.848±0.11
	3rd	3.09±0.10	6.00±0.50	1.112±0.08
	Cumulative		45.50	
90 min.	1st	2.75±0.05	27.00±0.50	5.816±0.18
	2nd	2.86±0.05	13.50±0.50	2.920±0.13
	3rd	3.11±0.10	5.50±0.20	1.261±0.08
	Cumulative		46.00	
120 min.	1st	2.71±0.09	27.00±0.50	5.348±0.17
	2nd	2.80±0.05	13.50±0.23	2.901±0.09
	3rd	3.07±0.07	6.00±0.50	1.212±0.09
	Cumulative		46.50	



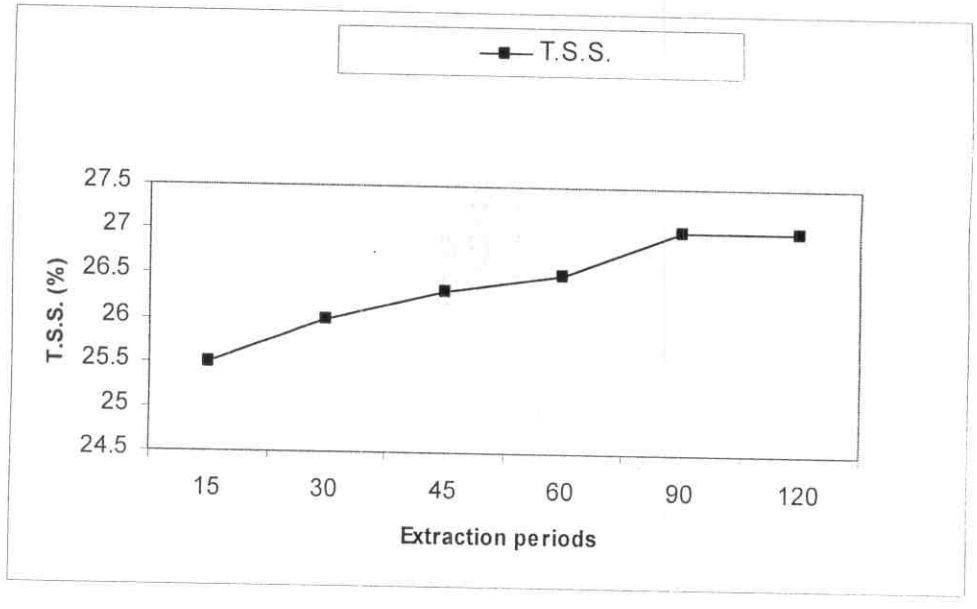


Figure (8): Effect of extraction periods at hot condition on extractability of Egyptian tamarind components (T.S.S and O.D.) of Aswany variety.

Table (14): Effect of extraction periods at room temperature and semi hot conditions on extraction rate of tamarind Aswany variety.

Extraction periods	Sequence of extraction	Methods of extraction					
		Room temperature extraction			Semi hot extraction*		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
0.5 hr.	1st	2.86 ±0.06	23.00 ±0.50	4.273 ±0.32	2.94 ±0.04	25.67 ±1.00	4.864 ±0.36
	2nd	2.98 ±0.09	12.00 ±1.00	2.495 ±0.24	3.03 ±0.04	12.50 ±0.50	2.749 ±0.23
	3rd	3.13 ±0.11	6.00 ±0.50	0.812 ±0.11	3.20 ±0.05	6.33 ±0.29	0.923 ±0.10
	Cumulative		41.00			44.50	
2 hrs.	1st	2.80 ±0.10	23.5 ±0.50	4.972 ±0.35	2.88 ±0.09	26.00 ±1.00	5.148 ±0.42
	2nd	2.91 ±0.06	12.50 ±0.50	2.632 ±0.20	2.97 ±0.06	13.00 ±0.50	2.862 ±0.21
	3rd	3.10 ±0.09	6.00 ±0.00	0.946 ±0.10	3.14 ±0.09	6.50 ±0.50	0.970 ±0.12
	Cumulative		42.00			45.50	
4 hrs.	1st	2.72 ±0.7	24.50 ±0.50	5.210 ±0.41	2.80 ±0.10	26.50 ±0.50	5.332 ±0.39
	2nd	2.83 ±0.03	13.50 ±0.50	2.822 ±0.20	2.90 ±0.06	14.00 ±0.29	2.916 ±0.21
	3rd	2.97 ±0.07	6.50 ±0.50	1.140 ±0.08	3.09 ±0.10	6.50 ±0.50	1.212 ±0.11
	Cumulative		44.50			47.00	
6 hrs.	1st	2.67 ±0.08	24.50 ±0.50	5.320 ±0.41	2.74 ±0.04	26.50 ±0.50	5.516 ±0.43
	2nd	2.78 ±0.09	14.00 ±1.00	2.941 ±0.22	2.85 ±0.05	14.50 ±0.50	3.089 ±0.28
	3rd	2.89 ±0.09	6.50 ±0.50	1.192 ±0.12	2.99 ±0.15	7.00 ±0.76	1.506 ±0.12
	Cumulative		45.00			48.00	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.

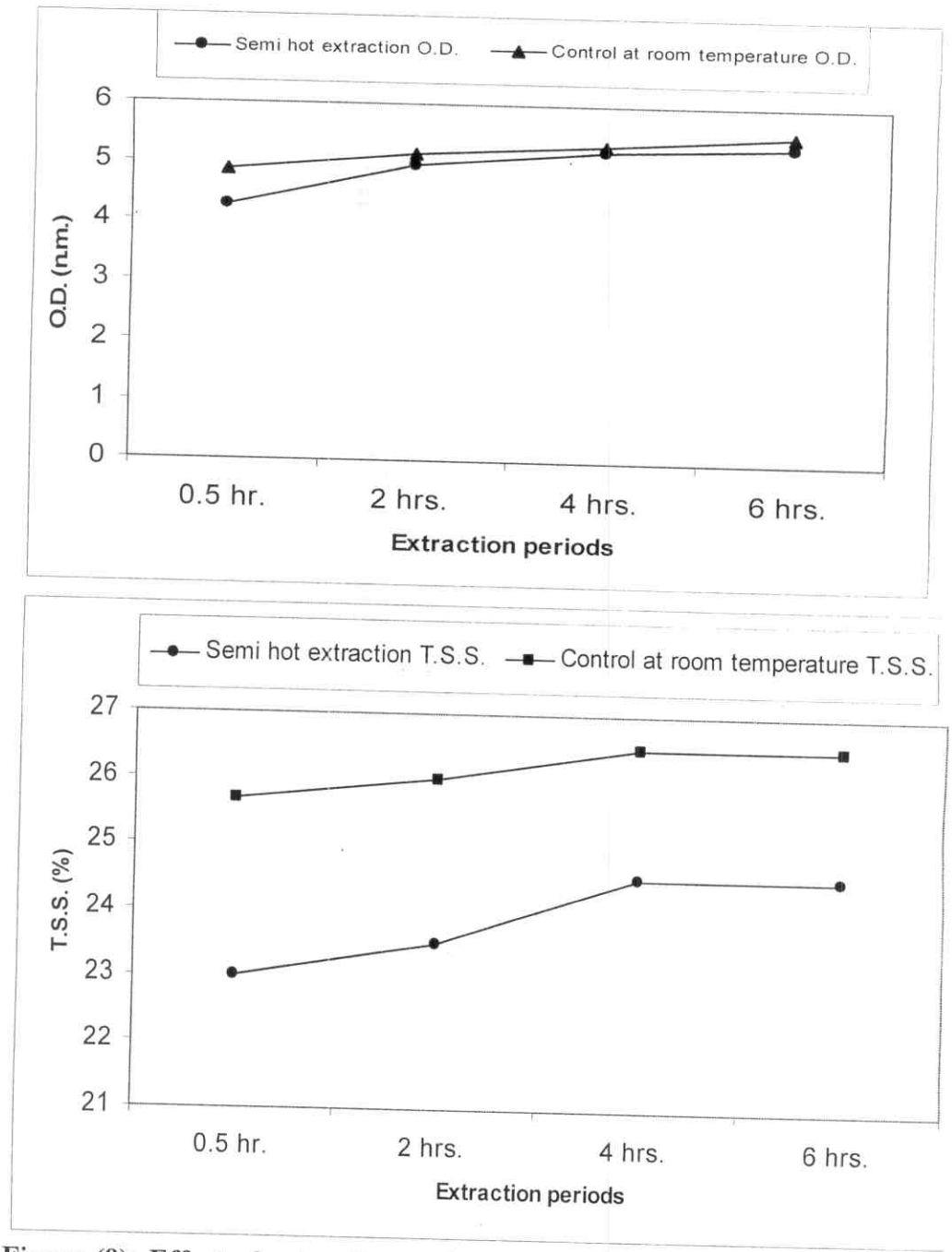


Figure (9): Effect of extraction periods at room temperature and semi hot conditions on extraction rate of Egyptian tamarind components (T.S.S and O.D.) of Aswany variety.

With semi-hot temperature, maximum T.S.S. were achieved after 6 hrs of extraction. 1st extraction revealed was 26.50% which represent about 32.68%. The 2nd re-extraction added another 14.50%, which represent 17.88%. After the three successive re-extraction, the maximum cumulative extraction reached 48.00%, which represent about 59.20% of T.S.S. contained in pulp powder.

At room temperature maximum T.S.S. were achieved after at 6 hrs the 1st extraction attained 24.50% which represent about 28.37%. 2nd re-extraction added another 12.00%, which represent 14.80%. After the three successive re-extraction, maximum cumulative extraction reached 41.00%, which represent about 50.57% of T.S.S. contained in pulp powder. These obtained results agree with those obtained by **Zin El-Dine (1999).**

Although 6 hrs extraction were found the best for maximum extractability at both room and semi-hot temperature, only two hrs extraction compromise between speed, economy and maximum extractability of tamarind components.

4.1.4.2.4. Effect of pH medium on extraction rate of tamarind pulp Aswany variety:

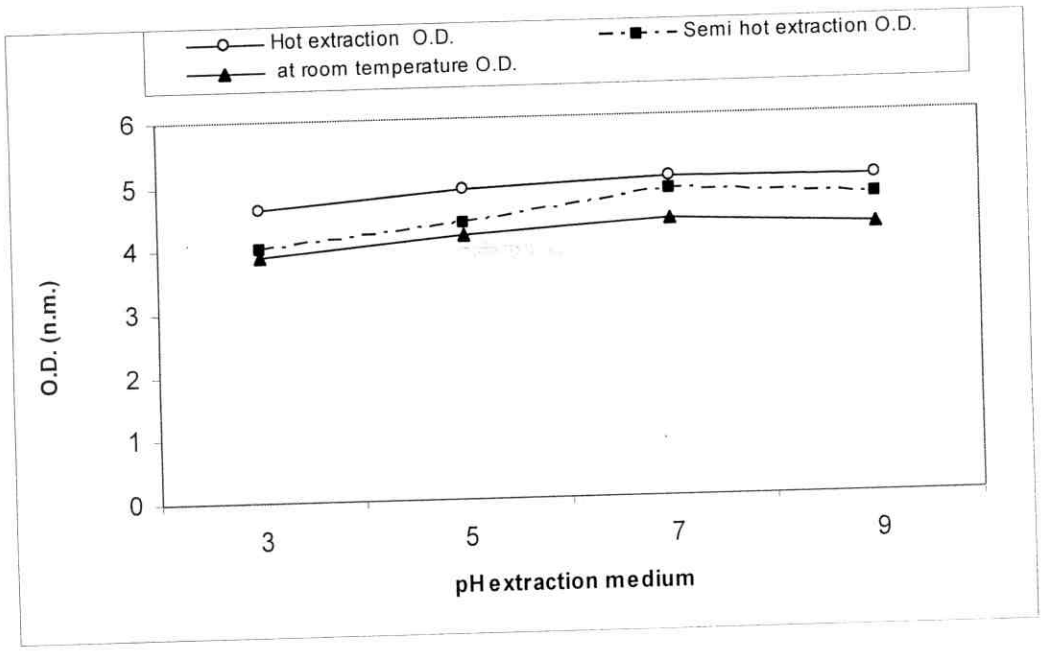
The effect of (room temperature, semi–hot and hot conditions) on extractability and re-extraction or successive extraction of components of tamarind pulp of Aswany variety was investigated and results are tabulated in Table (15) and Fig. (10).

With hot temperature maximum T.S.S. were achieved when pH was 7. 1st extraction showed 25.17% which represented about 31.04%. The 2nd re-extraction added another 13.50%, which

Table (15): Effect of pH medium extraction on tamarind components (Aswany variety).

pH of extraction	Sequence of extraction	Methods of extraction								
		Hot extraction (100 °C)			Semi hot extraction*			Room temperature extraction		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
pH 3	1st	2.95 ±0.06	24.00 ±0.50	4.632 ±0.33	3.02 ±0.08	23.50 ±0.50	4.016 ±0.32	3.09 ±0.10	22.50 ±0.50	3.871 ±0.24
	2nd	3.08 ±0.09	13.00 ±1.00	2.460 ±0.23	3.13 ±0.03	12.00 ±0.50	2.108 ±0.15	3.17 ±0.18	10.50 ±0.17	1.945 ±0.09
	3rd	3.22 ±0.11	6.00 ±0.50	1.235 ±0.12	3.25 ±0.06	6.00 ±1.00	1.111 ±0.12	3.31 ±0.11	5.50 ±0.50	1.012 ±0.09
	Cumulative		43.00			41.50			38.50	
pH 5	1st	3.01 ±0.06	24.50 ±0.50	4.892 ±0.35	3.09 ±0.09	24.00 ±0.50	4.382 ±0.31	3.13 ±0.04	23.00 ±1.00	4.164 ±0.22
	2nd	3.11 ±0.07	13.17 ±0.29	2.530 ±0.17	3.16 ±0.06	12.17 ±0.29	2.236 ±0.15	3.19 ±0.05	11.00 ±0.50	2.036 ±0.16
	3rd	3.26 ±0.07	6.50 ±0.50	1.307 ±0.13	3.27 ±0.08	6.00 ±0.00	1.348 ±0.10	3.33 ±0.04	6.00 ±0.50	1.174 ±0.09
	Cumulative		44.17			42.17			40.00	
pH 7	1st	3.04 ±0.04	25.17 ±0.29	5.016 ±0.04	3.11 ±0.07	24.00 ±1.00	4.826 ±0.35	3.15 ±0.05	23.17 ±0.29	4.381 ±0.19
	2nd	3.14 ±0.11	13.50 ±1.00	2.646 ±0.21	3.18 ±0.10	12.50 ±0.50	2.413 ±0.13	3.21 ±0.10	11.17 ±0.29	2.153 ±0.13
	3rd	3.29 ±0.06	6.50 ±0.00	1.335 ±0.12	3.31 ±0.07	6.17 ±0.29	1.466 ±0.11	3.36 ±0.07	6.00 ±0.00	1.206 ±0.10
	Cumulative		45.17			42.67			40.34	
pH 9	1st	3.08 ±0.09	24.50 ±0.50	4.980 ±0.33	3.15 ±0.05	23.50 ±0.50	4.701 ±0.22	3.18 ±0.08	23.00 ±0.50	4.237 ±0.24
	2nd	3.17 ±0.05	13.17 ±0.29	2.437 ±0.19	3.20 ±0.11	12.17 ±0.29	2.327 ±0.17	3.24 ±0.04	11.17 ±0.29	2.130 ±0.24
	3rd	3.32 ±0.02	6.17 ±0.29	1.216 ±0.11	3.35 ±0.05	6.17 ±0.29	1.306 ±0.12	3.39 ±0.10	5.50 ±0.50	1.148 ±0.12
	Cumulative		43.84			41.84			39.67	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



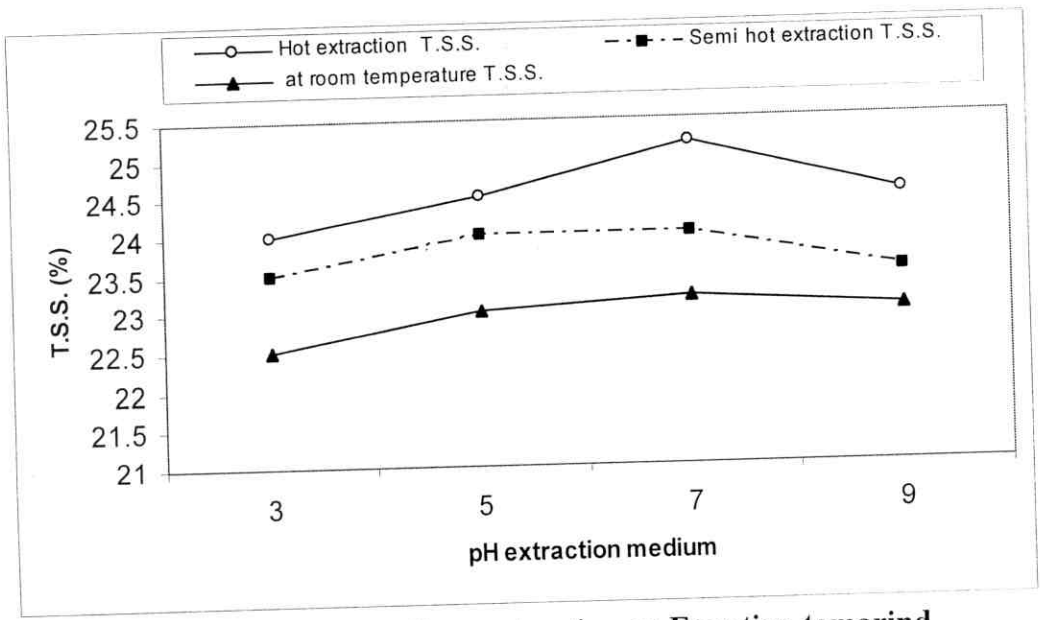


Figure (10): Effect of pH medium extraction on Egyptian tamarind components (T.S.S and O.D.) of Aswany variety.

represents 16.65%. After three successive re-extraction, it reached 45.17%, which represent about 55.71% recovery of T.S.S. contained in pulp powder.

Also at semi-hot temperature, maximum T.S.S. were achieved when pH value was (7), 1st extraction obtained 24.00% which represent about 29.60%. The 2nd re-extraction added another 12.50%, which represent 15.41%. After three successive re-extraction, the maximum cumulative extraction reached 42.67%, which represent about 52.63% of T.S.S. contained in pulp powder.

Similarly, at room temperature the maximum T.S.S. were obtained using (pH =7), 1st extraction reached 23.17% which represent about 28.58%. 2nd re-extraction added another 11.17%, which represent 13.77%. After the three successive re-extraction, the maximum cumulative extraction reached 40.39%, which represent about 49.75% of T.S.S. contained in pulp powder.

It could be concluded that an pH=7 at the different temperature conditions was selected as a compromise between speed of extraction and maximum extractability of components of the Egyptians tamarind Aswany variety.

4.1.4.3. Effect of different extraction conditions on sensory evaluation for Indian tamarind extracts:

The organoleptic properties of natural tamarind extract are generally the final guide of quality from the consumer's point of view. Thus, it is beneficial to make a comparison between sensory evaluation for different treatments (flotation ratio, temperature degree of extraction and periods of extraction) at hot, semi hot and at room temperature.

Samples of different treatments were evaluated organoleptically using ten panelists for their color, taste, odor, texture and overall acceptability where scores were given and their mean values were statistically analyzed using analysis of variance and least significant difference (LSD), as presented in Tables 16, 17 and 18.

Data in Table (16) illustrated the sensory evaluation of laboratory-made tamarind beverages prepared at different flotation ratios executed under different extraction conditions (optimum hot, semi-hot and under room temperature conditions). ANOVA indicated that there were significant differences ($P \geq 0.05$) between the different treatments for the variable flotation ratios and conditions of extraction in all scores given for taste, odor, texture and overall acceptability scores. The highest scores were given to treatment of flotation ratio (2: 1) at hot condition, which were: 23.8, 23.8, 23.1, 22.2 and 91.5, for color, taste, odor, texture and overall acceptability scores, respectively. On the other hand, the lowest scores were given flotation ratio (10: 1) at room temperature where scores given for color, taste, odor, texture and overall acceptability were, 16.9, 16.8, 16, 16.4 and 62.5, respectively.

Table (17) demonstrated sensory evaluation for laboratory-made tamarind beverages prepared at the different extraction periods executed under different extraction conditions (room temperature, semi hot and hot conditions). It was observed that high significant differences ($P \geq 0.05$) existed between the treatments of different extraction periods and methods of extraction in all scores given for color, taste, odor, texture and overall acceptability. The highest scores were attained by that

Table: (16): Sensory evaluation of tamarind beverages prepared at different flotation ratios under optimum room temperature, semi hot* and hot** conditions.

Treatment	Sensory scores attributes*																								
	Color 25					Taste 25					Odor 25					Texture 25					Overall acceptability 100				
	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10
Room temperature	21.2^{C} ±1.0	20.1c ±0.7	18.8c ±0.8	18.0c ±0.9	16.9^{C} ±1.3	21.5^{C} ±0.7	20.3^{C} ±0.9	19.1^{C} ±1.1	18.3^{C} ±0.9	16.8^{C} ±1.4	20.9^{C} ±1.1	19.7^{C} ±0.9	18.5^{C} ±0.8	17.2^{C} ±0.8	16.0^{C} ±1.3	20.1^{C} ±0.7	19.5^{C} ±0.8	18.4^{C} ±0.8	17.8c ±0.8	16.4^{C} ±1.3	82.1^{C} ±3.8	76.6^{C} ±4.3	70.8^{C} ±4.3	69.8^{C} ±5.3	62.5^{C} ±6.2
Semi-Hot	22.1^{b} ±0.7	21.0b ±0.7	19.9^{b} ±1.0	18.8^{b} ±1.0	17.6^{d} ±1.0	22.5^{b} ±0.5	21.3^{b} ±0.8	19.7^{b} ±1.1	18.8^{b} ±1.0	17.2^{b} ±0.9	21.6^{b} ±0.8	20.9^{b} ±0.7	19.7^{b} ±1.0	18.0^{b} ±0.7	16.7^{b} ±1.3	20.9^{b} ±0.7	20.3^{b} ±0.7	19.1^{b} ±1.0	18.7^{b} ±1.7	17.5^{b} ±1.7	86.0^{b} ±4.4	81.8^{b} ±3.4	77.9^{b} ±3.2	73.9^{b} ±3.6	70.0^{b} ±4.1
Hot	23.8^{a} ±1.0	22.7^{a} ±0.8	21.9^{a} ±0.9	21.0^{a} ±1.1	19.9^{a} ±0.9	23.8^{a} ±0.6	22.7^{a} ±0.8	21.7^{a} ±0.8	20.5^{a} ±0.7	19.4^{a} ±0.8	23.1^{a} ±0.7	22.0^{a} ±0.7	20.7^{a} ±0.7	19.5^{a} ±1.1	18.1^{a} ±1.2	22.2a ±0.4	21.5^{a} ±0.5	20.9^{a} ±0.7	20.2^{a} ±1.3	19.2^{a} ±1.7	91.5^{a} ±3.7	86.7^{a} ±3.4	83.4^{a} ±3.6	80.2^{a} ±3.4	76.2^{a} ±3.9
Mean	22.4 ±1.4	21.3 ±1.3	20.2 ±1.6	19.3 ±1.6	18.1 ±1.7	22.6 ±1.1	21.4 ±1.3	20.2 ±1.5	19.2 ±1.3	17.8 ±1.6	21.9 ±1.3	20.9 ±1.2	19.6 ±1.2	18.2 ±1.3	16.9 ±1.5	21.1 ±1.1	20.4 ±1.1	19.5 ±1.4	18.9 ±1.4	17.7 ±1.9	86.5 ±5.5	81.7 ±5.5	77.4 ±6.4	74.6 ±5.9	69.6 ±7.4
LSD S	0.47					0.46					0.48					0.52					2.08				
LSD T	0.37					0.36					0.37					0.40					1.61				
LSD SxT	0.82					0.80					0.84					0.90					3.61				

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.
** Hot condition: extraction in boiling water (100 °C).
*** Values represent scores of 10 panelists (Mean± S.E).
S: Methods of extraction. T: Treatments.

Table: (17): Sensory evaluation for tamarind beverages prepared at different extraction periods under room temperature, semi hot and hot conditions.

Treatment	Sensory scores attributes*																			
	Color 25				Taste 25				Odor 25				Texture 25							
	15 min.	30 min	45 min.	60 min.	15 min.	30 min.	45 min.	60 min	15 min.	30 min.	45 min	60 min.	15 min.	30 min.	45 min.	60 min.	15 min.	30 min.	45 min.	60 min.
Hot	21.3^{a} ±1.8	23.1^{a} ±1.6	22.2^{a}±1.5	22.1^{a} ±2.4	22.1^{a} ±1.6	23.0^{a} ±1.2	22.1^{a} ±1.3	20.9^{a} ±1.9	21.5^{a} ±1.5	22.1^{a} ±1.4	21.8^{ab} ±1.2	20.7^{a} ±1.8	22.0^{a} ±1.3	22.8^{a} ±2.0	21.5^{a} ±1.8	21.3^{a} ±2.5	83.1^{a} ±7.2	89.4^{a} ±6.7	84.7^{a} ±7.2	82.5^{a} ±8.2
Periods	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.
Room temperature	20.8^{a} ±1.7	22.5^{a} ±1.4	21.4^{ab} ±1.3	20.4^{bc} ±1.3	20.5^{bc} ±2.6	21.6^{ab} ±2.4	21.1^{ab} ±2.1	20.0^{a} ±2.1	20.8^{a} ±1.9	21.9^{a} ±2.0	20.8^{a} ±1.9	20.6^{ab} ±1.9	20.6^{bc} ±1.4	21.0^{ab} ±1.6	20.5^{ab} ±1.9	20.5^{ab} ±1.7	81.1^{a} ±8.6	87.4^{a} ±7.8	84.5^{a} ±7.2	79.9 ±8.0
Semi-Hot	20.8^{a} ±1.8	22.7^{a} ±1.2	21.7^{a} ±1.2	20.7^{b} ±1.3	20.5^{b} ±2.0	22.2^{a} ±1.1	21.3^{a} ±1.2	20.1^{a} ±1.4	21.1^{a} ±1.7	22.0^{a} ±1.6	21.4^{a} ±1.9	20.7^{a} ±1.3	20.9^{b} ±1.4	22.0^{a} ±1.7	21.1^{a} ±2.0	20.7^{a} ±2.0	82.8^{a} ±6.5	87.8^{a} ±5.0	84.6^{a} ±6.0	81.7^{a} ±6.3
Mean	21.0 ±1.7	22.8 ±1.4	21.8 ±1.3	21.1 ±1.8	21.0 ±2.2	22.3 ±1.7	21.5 ±1.6	20.3 ±1.8	21.1 ±1.7	22.0 ±1.7	21.3 ±1.7	20.7 ±1.6	21.2 ±1.5	21.9 ±1.7	21.0 ±1.8	20.8 ±2.0	82.3 ±7.3	88.2 ±6.4	84.6 ±6.6	81.4 ±7.4
LSD S	0.79				0.91				0.86				0.91				3.60			
LSD T	0.69				0.79				0.74				0.79				3.12			
LSD SxT	1.38				1.58				1.48				1.58				6.24			

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.
** Hot condition: extraction in boiling water (100 °C). *** Values represent scores of 10 panelists (Mean± S.E).

treatment executed at hot condition for 30 min, where the given scores for color, taste, odor, texture and overall acceptability were, 23.1, 23, 22.1, 22.8 and 89.4, respectively.

Data recorded in Table (18) illustrate sensory evaluation for laboratory-made tamarind beverages prepared at different extraction temperatures up to 100°C. It was noticed that high significant differences ($P \geq 0.05$) existed. The scores given for color, taste, odor, texture and overall acceptability. Highest scores amounted at 100 °C, to 22.70, 23.10, 23.20, 21, 70 and 90.90, respectively. The lowest scores were showed at 60°C., where they were, 17.80, 17, 80, 17.30, 18.10 and 72.20, respectively. These obtained results for extraction at hot condition agree with those obtained by **Shaker (1979)**.

From abovementioned results, it could be concluded that optimum conditions for extracting tamarind pulp into beverage, which attained the highest overall acceptability scores from the panelists, were as follows: a flotation ratio (pulp to water) of 2:1, extraction.

4.1.5. Survey study of tamarind beverage samples collected from some Egyptian local markets:

Since tamarind, beverages are considered one of the most important and widespread beverages in Egypt, the survey study employed 15 different samples collected from different local markets from different places of Egypt. Ten of these samples were recognized as natural-made beverage, while the other five samples were known to be synthetic or commercial beverages.

Table (18): **Sensory evaluation for tamarind beverages prepared at different temperatures up to 100°C.**

Temperature of extraction	Sensory scores attributes*				
	Color 25	Taste 25	Odor 25	Texture 25	Overall acceptability 100
60 °C	17.8±1.4^{e}	17.8±0.9^{e}	17.3±1.6^{e}	18.1±0.9^{e}	72.2±6.2^{e}
70°C	18.8±1.1^{d}	19.1±1.1^{cd}	18.7±1.4^{d}	18.9±1.0^{d}	77.3±6.1^{d}
80°C	19.6±1.0^{c}	19.6±0.8^{c}	19.8±1.4^{c}	19.6±1.2^{c}	81.8±5.1^{c}
90°C	21.1±1.b^{b}	21.1±1.2^{b}	21.2±1.1^{b}	20.5±0.8^{b}	86.6±4.2^{b}
100°C	22.7±0.a	23.1±0.7^{a}	23.2±0.9^{a}	21.7±0.8^{a}	90.9±4.0^{a}
LSD 5%	0.95	0.88	1.18	0.86	4.68

*Values represent scores of 10 panelists (Mean± S.E).

4.1.5.1. Survey study on natural tamarind beverages:

4.1.5.1.1. Physicochemical properties of natural tamarind beverages:

The physicochemical properties of collected natural tamarind beverages were shown in Table (19). Total sugars, ranged from 11.90 to 23.34%, while reducing sugars content ranged from 0.61 to 2.30%. These obtained results agree with those obtained by **Afifi and Hussein (2001)**.

Total solids content ranged between 12.17 and 23.62%. Tamarind beverages showed low protein values which ranged from 0.06 to 0.33%. These obtained results agree with those obtained by **El-Nahry *et al.* (1993)**.

This may be due to association of some protein content with the insoluble part of tannins present.

Titratable acidity, pH value, anthocyanin content, specific gravity and refractive index amounted to 0.05: 0.25%; 2.54: 3.89; 0.311: 0.908; 1.0476: 1.0978 and 1.3529: 1.3700, respectively. These obtained results agree with those obtained by **Nassereddin and Mohammed (2005)** who showed that ranged from 1.8 to 3.7.

4.1.5.1.2. Microbiological quality of natural tamarind beverages:

The total counts of microorganisms isolated from tamarind beverages Cairo, Egypt are presented in Table (20).

The total microbial count ranged between $9x10^3$ c.f.u./ml and $8.1x10^5$ c.f.u./ml. ranged between $4.1x10^3$ c.f.u./ml and $5.9x10^5$ c.f.u./ml.

Table (19): Physicochemical properties of native natural tamarind beverages collected from some local markets of Cairo, Egypt*.

Components**	Collected samples*									
	1	2	3	4	5	6	7	8	9	10
Moisture %	84.84±0.09	76.38±0.05	81.88±0.07	87.83±0.07	83.82±0.06	84.16±0.14	85.47±0.13	85.59±0.02	85.05±0.06	83.77±0.06
Total solids %	15.16±0.09	23.62±0.05	18.12±0.07	12.17±0.07	16.18±0.06	15.84±0.14	14.53±0.12	14.41±0.02	14.95±0.06	16.23±0.06
T.S.S. %	15.00±0.06	23.50±0.12	18.00±0.11	12.00±0.06	16.00±0.10	15.16±0.16	14.33±0.16	14±0.05	14.67±0.16	16.07±0.09
Total insoluble solids %	0.16±0.00	0.12±0.00	0.12±0.00	0.17±0.00	0.16±0.00	0.68 ±0.00	0.2±0.00	0.41±0.00	0.28±0.00	0.16±0.00
Fat %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude protein %	0.15±0.01	0.10±0.01	0.15±0.02	0.17±0.01	0.13±0.01	0.19±0.02	0.17±0.01	0.33±0.07	0.06±0.01	0.16±0.00
Ash %	0.15±0.01	0.07±0.00	0.07±0.00	0.06±0.02	0.10±0.00	0.07±0.01	0.10±0.02	0.11±0.02	0.09±0.01	0.08±0.00
Total carbohydrates %***	14.86	23.40	17.89	11.94	15.95	15.58	14.26	13.97	14.80	15.99
Total sugars %	14.58±0.1	23.34±0.09	17.84±0.06	11.90±0.05	15.80±0.16	14.88±0.05	14.07±0.05	13.68±0.01	14.37±0.01	15.95±0.19
Reducing sugars %	0.61±0.06	0.99±0.05	0.87±0.05	0.73±0.10	0.74±0.10	1.58±0.08	1.60±0.09	2.30±0.08	2.09±0.06	2.28±0.06
Non reducing sugars %	13.97±0.1	22.35±0.14	16.97±0.11	11.17±0.09	15.06±0.10	13.30±0.07	12.47±0.10	11.38±0.09	12.28±0.05	13.67±0.11
pH value	3.09±0.02	3.46±0.01	3.43±0.01	3.64±0.01	3.45±0.01	3.76±0.02	3.89±0.03	3.77±0.01	2.54±0.14	3.75±0.00
Titratable acidity %	0.22±0.01	0.15±0.00	0.15±0.00	0.07±0.02	0.07±0.02	0.07±0.01	0.05±0.00	0.07±0.01	0.25±0.02	0.07±0.00
Color index	4.19±0.09	3.19±0.05	2.96±0.10	2.30±0.09	3.87±0.04	1.77±0.08	1.70±0.06	1.63±0.18	3.93±0.01	2.68±0.04
Anthocyanin (mg/100g)	0.73±0.01	0.53±0.02	0.42±0.02	0.31±0.00	0.57±0.01	0.59±0.01	0.58±0.05	0.54±0.02	0.91±0.04	0.63±0.02
Specific gravity	1.06±0.01	1.10±0.04	1.07±0.03	1.05±0.02	1.06±0.01	1.06±0.01	1.06±0.03	1.06±0.01	1.06±0.05	1.06±0.03
Refractive index	1.35±0.06	1.37±0.12	1.36±0.11	1.35±0.06	1.36±0.10	1.36±0.10	1.35±0.09	1.35±0.02	1.36±0.08	1.36±0.04

* Origin of collected samples:
Sample (1) and (2): collected from Ramses region, Sample (3) and (4): collected from El-Sayeda Zainab region, Sample (5) and (6) collected from Toukh region, Sample (7) and (8): collected from Moshtohor region and Sample (9) and (10): collected from Shibin El-Kantar region.

** Mean of triplicate determinations ±SE.

*** Calculated by difference.

Table (20): Microbiological quality of native natural tamarind beverages collected from some local markets of Cairo, Egypt.

Microorganisms**	Collected samples*									
	1	2	3	4	5	6	7	8	9	10
Total bacterial count	$1.36X10^5$	$1.99X10^5$	$1.12X10^4$	$6.2X10^4$	$9X10^3$	$1.9X10^5$	$8.1X10^5$	$6.1X10^5$	$6.3X10^4$	$1.43X10^5$
Sporformer bacteria.	ND***	ND	ND	ND	ND	ND***	ND	ND	ND	ND
Lactic acid bacteria.	$5.3X10^4$	$1.39X10^4$	$1.05X10^3$	$2.8X10^4$	$7.2X10^2$	$1.6X10^5$	$9.5X10^3$	$1.1X10^5$	$5X10^3$	$1.39X10^5$
Psychrophylic bacteria.	$1.27X10^5$	$1.35X10^5$	$1.54X10^3$	$3.9X10^3$	$4.4X10^3$	$1.05X10^5$	$1.16X10^5$	$1.3X10^4$	$1.2X10^4$	$1.36X10^5$
Coliform group.	$7.8X10^3$	$8.85X10^2$	$4.9X10^2$	$4.05X10^2$	ND	$3.6X10^2$	ND	$2.15X10^3$	$8.95X10^2$	$3.5X10^3$
Staphylococcus.	ND	ND	ND	ND	ND	ND	ND	$4X10^3$	ND	ND
Yeasts and moulds.	$7.25X10^4$	$1.9X10^4$	$4.1X10^5$	$5X10^4$	$6.13X10^3$	$5.65X10^4$	$5.9X10^5$	$4.4X10^4$	$9.75X10^3$	$1.9X10^4$

* Origin of collected samples:
Sample (1) and (2): collected from Ramses region, Sample (3) and (4): collected from El-Sayeda Zainab region, Sample (5) and (6) collected from Toukh region, Sample (7) and (8): collected from Moshtohor region and Sample (9) and (10): collected from Shibin El-Kantar region.

* * Mean of duplicate determinations.

*** ND: Not detect.

Sporformer bacteria and *Staphylococcus*, which were not detected.*Lactic acid bacteria* count ranged from $7.2x10^2$ to $1.6x10^5$ c.f.u./ml. Furthermore, *Psychrophylic bacteria* count ranged from $1.54x10^3$ c.f.u./ml and $1.36x10^5$ c.f.u./ml.

Coliform bacteria was present in most samples and ranged from $3.6x10^2$ c.f.u./ml to $7.8x10^3$ c.f.u./ml.

The contamination observed could be attributed to various different reasons including: starting raw materials used in the preparation of beverages, improper processing, low sanitary standards, unclean handling techniques, contaminated utensils used for preparation and storage conditions under unsuitable conditions as influenced by temperature, long period of availability in selling containers, presence or absence of ice, method of cooling for beverages, ... etc.

These obtained results for microbial load examination for tamarind beverages agree with those obtained by **Afifi** and **Hussein (2001)** who found that microbiological profile of tamarind beverage samples were total bacterial count $3.4x10^3$ c.f.u./ml, *Coliform bacteria* $2.4x10^3$ c.f.u./ml, *Staph. aureus* $2.6x10^4$ c.f.u./ml and yeasts and moulds $1.1x10^3$ c.f.u./ml, and **Nassereddin and Mohammed (2005)** who showed that the mean counts for aerobic bacteria 4, lactic acid bacteria less than 1 and yeasts 5.8 log c.f.u/ml.

4.1.5.2. Synthetic tamarind beverages:

4.1.5.2.1. Physicochemical properties of synthetic tamarind beverages:

The physicochemical properties of synthetic tamarind beverages are presented in Table (21). Total sugars were found

Table (21): Physicochemical properties of synthetic tamarind beverages obtained from some local markets of Cairo, Egypt.

Components**	Collected samples*				
	1	2	3	4	5
Moisture %	86.64±0.12	85.95±0.06	85.86±0.02	88.45±0.08	85.42±0.03
Total solids %	13.36±0.12	14.05±0.06	14.14±0.02	11.55±0.08	14.58±0.03
T.S.S. %	13.00±0.08	14.00±0.07	14.00±0.10	11.50±0.04	14.50±0.03
Total insoluble solids %	0.36±0.00	0.05±0.00	0.14±0.00	0.05±0.00	0.08±0.00
Fat %	0.00	0.00	0.00	0.00	0.00
Crude protein %	0.00	0.00	0.00	0.00	0.00
Ash %	0.02±0.00	0.01±0.00	0.02±0.00	0.02±0.00	0.02±0.00
Total carbohydrates %***	13.34	14.03	14.12	11.53	14.56
Total sugars %	12.92±0.41	13.91±0.01	13.85±0.05	11.38±0.02	14.27±0.09
Reducing sugars %	0.52±0.09	0.67±0.08	1.35±0.14	1.89±0.06	1.06±0.09
Non reducing sugars %	12.40±0.32	13.24±0.07	12.50±0.20	9.49±0.03	13.21±0.05
pH value	3.15±0.02	3.66±0.03	3.13±0.01	3.51±0.04	3.12±0.06
Titratable acidity %	0.26±0.10	0.17±0.02	0.28±0.02	0.21±0.00	0.29±0.00
Color index	1.522±0.05	1.096±0.19	1.136±0.11	1.285±0.14	1.468±0.13
Specific gravity	1.05±0.10	1.06±0.06	1.06±0.04	1.05±0.09	1.06±0.02
Refractive index	1.35±0.12	1.35±0.06	1.35±0.10	1.35±0.04	1.36±0.03

* Origin of collected samples:

Sample (1) and (2): collected from Ramses region.
Sample (3) and (4): collected from El-Sayeda Zainab region.
Sample (5): collected from Toukh region.

** Mean of triplicate determinations ±SE.

*** Calculated by difference

the main component in synthetic tamarind beverages, which ranged from 11.38 to 14.27%, while
the highest total sugars content was 11.38: 4.27%. Reducing sugars ranged from 0.52 to 1.89%, and moisture content ranged from 85.42% to 88.45%, while T.S.S ranged from 11.50% to 14.50%. On the other hand, all synthetic tamarind beverages did not record any values for crude protein and fat contents.

Ash content in ranged from 0.01 to 0.02%. Ttitratable acidity ranged from 0.17 to 0.29%, while pH value ranged from 3.12 to 3.66. Values for specific gravity and refractive index were (1.05 to 1.06) and 1.35 to 1.36, respectively.

4.1.5.2.2. Microbiological quality of synthetic tamarind beverages:

The total counts of microorganisms isolated from synthetic tamarind beverages are presented in Table (22).

The total microbial load ranged between $4.85x10^4$ c.f.u./ml and $1.1x10^6$ c.f.u./ml. Yeasts and molds ranged from $2.7x10^3$ to $7.4x10^5$ c.f.u./ml. *Sporformer bacteria* and *Staphylococcus bacteria* were not detected.

Lactic acid bacteria ranged from $4.5x\ 10^2$ to $8.3\ x10^4$ c.f.u./ml. These obtained results are found parallel with those obtained by **Salem (2004)**.

From the above obtained results it could be concluded that the highest microbial load and contamination of tamarind locally-made beverages may be attributed to numerous reasons, ie., raw materials, additives ,preparation conditions, handling, utensils, vectors , water during preparation, storage and display. These beverages are often kept at ambient temperatures that

Table (22): Microbiological quality of synthetic tamarind beverages obtained from some local markets of Cairo, Egypt*.

Microorganisms**	Collected samples*				
	1	2	3	4	5
Total bacterial count	$8.05x10^5$	$1.1x10^6$	$4.85 x10^4$	$1.56 x10^5$	$6x10^5$
Sporformer bacteria	ND***	ND	ND	ND	ND
Lactic acid bacteria	$4.5x 10^2$	$8.4x 10^3$	$3.55x 10^3$	$8.3 x10^4$	$7.55 x10^3$
Psychrophylic bacteria	$1.04 x10^5$	$5.7 x10^3$	$2.2 x10^3$	$1.47 x10^5$	$1.59 x10^5$
Coliform group	$3.95 x10^2$	$3.85 x10^3$	$4 x10^2$	$5.2 x10^3$	$5.9 x10^3$
Staphylococcus	ND	ND	ND	ND	ND
Yeasts and moulds	$7.9x 10^4$	$7.4x 10^5$	$2.7x 10^3$	$1.38x 10^4$	$9.9x 10^3$

* Origin of collected samples:

Sample (1): collected from Ramses region.
Sample (2): collected from El-Sayeda Zainab region.
Sample (3): collected from Toukh region.
Sample (4): collected from Moshtohor region.
Sample (5) collected from Shibin El-Kantar region.

** Mean of duplicate determinations.

*** ND: Not detect.

permit microbial growth, especially when cooling or refrigeration conditions are not available, especially that these beverages could be displayed for long periods, perhaps throughout the entire day.

4.1.5.3. Comparison between characteristics of collected survey natural and synthetic tamarind beverage:

Comparison between characteristics of natural and synthetic tamarind beverages is considered of special importance and interesting subject for the Egyptian consumers who might be not aware of the presence of a synthetic beverages in the market. The synthetic tamarind samples were found to be characterized by intense color and sharp and tangent flavor

As shown in Table (23), one could observe that there are many factors, which could be taken as parameters to differentiate between natural and synthetic tamarind beverages. The higher total carbohydrates (15.86%) in natural tamarind beverage while the lower 13.51% in synthetic tamarind beverages. Higher total sugars content (15.64%) in natural while the lower content (13.27%) in synthetic tamarind beverages. Higher reducing sugars content (1.38%) in natural while lower (1.09%) in synthetic tamarind beverages.

Total ash content was the effective factor in differentiation between natural and synthetic tamarind beverages. The higher ash content 0.09% was found in natural while was 0.01% in synthetic beverages.

Crude protein was present (0.16%) in natural tamarind beverages while were free from crude protein. In the same direction, anthocyanin pigments showed a mean value of 0.58 mg/100g, while those synthetic were free.

Table (23): Differentiation between natural and synthetic tamarind beverages.

Components	Tamarind beverages*	
	Natural beverage	Synthetic beverage
Total carbohydrates	15.86	13.51
Total sugars	15.64±0.08	13.27±0.12
Reducing sugars	1.38±0.07	1.09±0.09
Non reducing sugars	14.26±0.10	12.18±0.13
Crude protein	0.16±0.01	0.00
Total ash	0.09±0.02	0.01±0.00
Anthocyanin	0.58±0.02	0.00

* Mean of triplicate determinations ±SE.

From the previous composition, one could conclude that concentration of some chemical constituents could be taken as distinguished marks for synthetic tamarind beverages. Furthermore, Synthetic tamarind was found to be characterized always by intense color, sharp and tangent flavor.

4.1.6. Essential minerals of tamarind pulp:

The present study comprised of analysis for nine essential elements, five macro-elements (Calcium, Magnesium, Phosphorus, Sodium and Potassium) and four microelements (Iron, Copper, Manganese and Zinc) which are present in the starting materials for making tamarind beverage. Minerals analysis of Ca, K, Mg, Na, Fe, Mn, Cu and Zn were performed using flame atomic absorption spectroscopy and spectrophotometric determination of phosphorous. The essential minerals in tamarind pulp of various varieties are demonstrated in Table (24)

From the results presented in Table (24), all tamarind samples investigated were found to contain appreciable content of mineral matter. However, it could be noticed that the Indian compressed packaged tamarind of Makham waan variety contained the highest mineral matter content compared to Aswany variety. However, tamarind pulp contained appreciable high amounts of calcium, sodium and phosphorus.

Macro-elements were ranked, in a decreasing order of abundance, as follows: calcium, sodium, phosphorus, potassium and magnesium.

Calcium constituted the first major essential macro element in tamarind pulp. The maximum content of calcium

Table (24): Spectrophotometeric determination of essential mineral content of expermintal tamarind pulp samples.

Main group of essential minerals	Minerals	Tamarind varieties	
		Makham waan	Aswany
Macro elements	Calcium	438.21	157.34
	Sodium	114.33	76.41
	Potassium	85.30	51.00
	Magnesium	78.40	48.22
	Phosphorus	106.10	54.60
Micro elements	Iron	3.50	1.70
	Copper	20.64	16.18
	Manganese	ND*	ND
	Zinc	0.70	0.30

* ND: Not detected.

(438.21 mg/100g) was in Indian tamarind variety while the minimum content (157.34 mg/100g) was in Aswany variety. The content of only 200g of tamarind pulp could satisfy or cover most of the daily requirements for adult humans from calcium as indicated by **WHO and FAO (2004).**

Sodium constituted the second major essential macro element in tamarind pulp. The highest content of sodium (114.33mg/100g) was registered for the Indian tamarind while the lowest content (76.41mg/100g) was in Aswany variety. The content of only 200g of tamarind pod could satisfy or cover half of RDA for adult humans from sodium as indicated by **RDAs (2009).**

Phosphorus constituted the third major essential macro element which showed (106.10 mg/100g) for the Indian tamarind while minimum content (54.60 mg/100g) was in Aswany variety. The content of only 200g of tamarind pulp could satisfy or cover $1/6^{th}$ daily requirements for adult humans from phosphorus as indicated by **WHO and FAO (2004).**

Potassium constituted the fourth major essential macro element tamarind pulp as it amounted to (85.30 mg/100g) in Indian tamarind while the minimum content (51.00 mg/100g) was in Aswany variety. The content of only 200g of tamarind pulp could satisfy or cover1/10 RDA for adult humans from potassium as indicated by **RDAs (2009).**

Magnesium constituted the last macro element in tamarind pulp. Maximum content of magnesium (78.40 mg/100g) was for Indian tamarind while minimum content (48.22 mg/100g) was for the Aswany variety. The content of

only 200g of tamarind pulp could satisfy or cover 1/2 daily requirements for adult humans from magnesium as indicated by **WHO and FAO (2004).**

Essential micro minerals in tamarind pulp ranked, in a decreasing order of abundance as follows: copper, iron, zinc and manganese.

Copper constituted the first major essential micro-element which (20.64 mg/100g) for the Indian tamarind while minimum content (16.18 mg/100g) was for Aswany variety.

Iron constituted the second major essential micro-element which ranged (3.50 mg/100g) for Indian tamarind variety while minimum content (1.70 mg/100g) was for Aswany variety. Only 200g of tamarind pulp could satisfy or cover most of the daily requirements for children's and half that for adult humans from iron at 15% bioavailability as indicated by **WHO and FAO (2004).**

Zinc constituted the third essential micro-element which (0.70 mg/100g) in the Indian tamarind while minimum content (0.30 mg/100g) was in the Aswany variety. 200g of tamarind pulp could satisfy or cover 1/2 the daily requirements for children's at low bioavailability of zinc and $1/5^{th}$ that for adult humans at high bioavailability as indicated by **WHO and FAO (2004).**

Manganese was not detected in different tamarind varieties.

Results of the present study of macro and micro elements were agree with those obtained by **Ishola *et al.* (1990)** and **El-Nahry *et al.* (1993)** and **Afifi and Hussein (2001).**

4.1.7. Study of volatiles components of tamarind pulp:

Aroma characteristics are the important quality attributes for tamarind beverages with their distinct pleasant flavor, which is greatly liked by Egyptian people. Therefore, the various volatiles distributed in the concentrates derived from two tamarind types, Indian and Aswany variety were investigated by the combined technique of gas chromatography-mass spectroscopy (GC-MS).

Data obtained are tabulated in Tables (25 and 26) and Figs. (11 and 12) that considerable overlapping occurred among some of the compounds. In such cases, identification was accomplished solely from their mass spectral profiles since the retention indices of un resolved components were observed to deviate slightly from those expected for single compounds and show the volatile components fractionated from experimental samples of the Aswany and Indian tamarind variety. The quantities and qualitative data depended on retention time (Rt) data. The identification of the separated components of their respective (Rt) and their respective mass spectra with those of the authentic compounds. It appeared that about 22 volatile constituents were fractionated from the aroma concentrate of the Egyptian tamarind of which sixteen volatile components were only identified and 6 fractionated peaks were not. The identified volatile compounds were to ranke, in order of decreasing abundance, as follows: 2-furancarboxaldehyde (58.11%), di-(2-ethyl hexyl phthalate (16.53%), 5-methyl furfural (4.61%), phenol (4.29%), Limonene (3.28%),1,2- benzenedicarboxylic acid (1.58%), phenyl acetaldehyde (1.55%), 2,6 di(t-butyl 0.65%), 1-Nonadecane (0.53%), Tetradecane (0.45%),

Table (25): Quantitative determination by GC/MS for volatile constituents of Egyptian tamarind (Aswany variety).

Peak No.	Components	Rt (min.)	Peak area (%)
1	2-Furancarboxaldehyde	2.44	58.11
2	Unknown	2.79	2.43
3	5-Methyl furfural	4.09	4.61
4	Unknown	4.28	0.25
5	Unknown	4.35	0.20
6	Unknown	4.42	0.15
7	Phenyl acetaldehyde	5.49	1.55
8	Limonene	5.68	3.28
9	Tetradecane	11.82	0.45
10	2,6 di(t-butyl)	13.07	0.65
11	Phenol 2,6-bis	13.74	4.29
12	1-Hexadecane	14.80	0.23
13	Unknown	14.79	0.90
14	Hexadecane	14.89	0.33
15	Heptadecane	16.30	0.21
16	1-Octadecane	17.56	0.18
17	Octadecane	17.65	0.45
18	Unknown	18.92	0.07
19	1,2-Benzenedicarboxylic acid	19.82	1.58
20	Pentadecane	20.13	0.43
21	1-Nonadecane	21.16	0.53
22	di-(2-ethylhexyl) phthalate	26.09	16.53

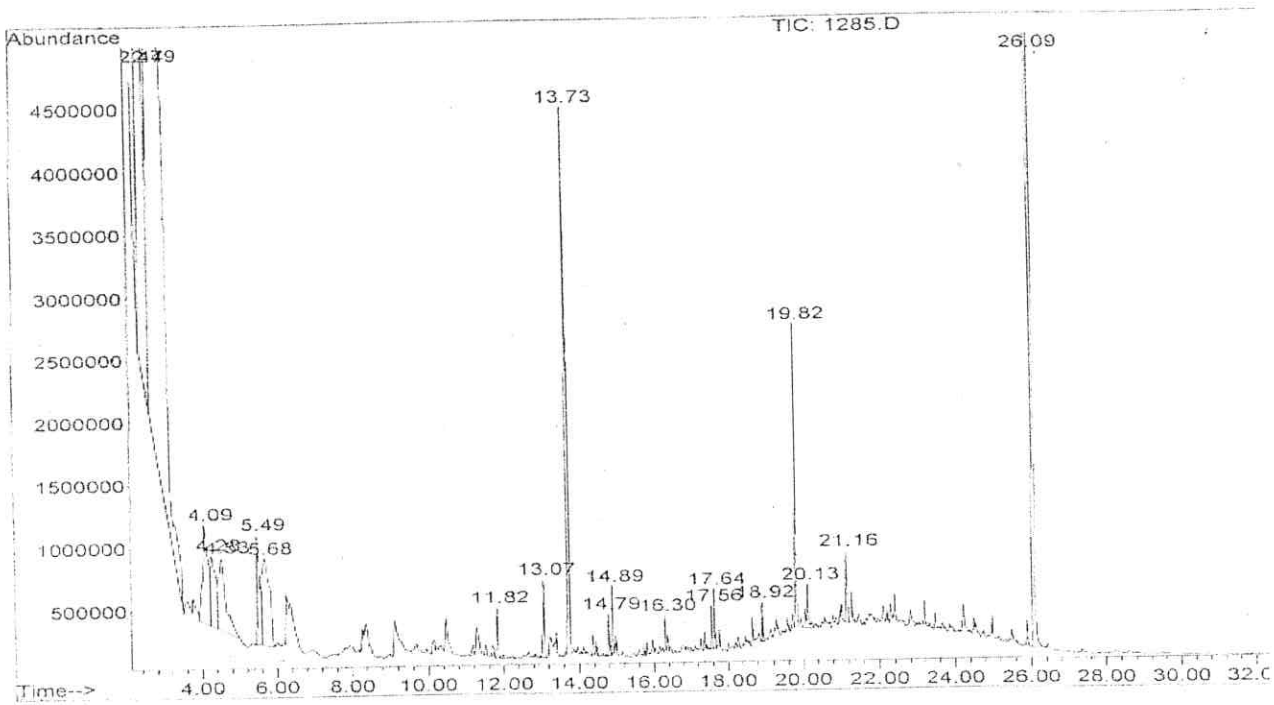


Figure (11): GC-MS chromatograms of volatiles components separated from the Egyptian tamarind pulp of Aswany variety.

Table (26): Quantitative determination by GC/MS for volatile constituents of Indian tamarind (Makham waan variety).

Peak No.	Components	Rt (min.)	Peak area (%)
1	Ethyl acetate	2.23	0.07
2	2-Furancarboxaldehyde	2.81	13.23
3	Unknown	3.74	1.06
4	Unknown	4.17	1.13
5	Hexanoic acid	4.57	15.56
6	Unknown	4.58	1.12
7	Unknown	4.72	1.13
8	Benzeneacetaldehyde	5.48	0.75
9	Limonene	5.74	4.23
10	1-propanone	6.38	5.17
11	Octanoic acid	8.05	3.37
12	4-Hydroxy-5-methoxypyrimidine	9.08	3.98
13	Propanal	9.28	0.88
14	Phenol	10.31	1.61
15	5-Acetoxymethyl-2-furaldehyde	10.47	0.78
16	Unknown	11.29	0.05
17	Tetradecane	11.83	0.35
18	Unknown	13.77	0.32
19	1-Hexadecane	14.80	0.39
20	Hexadecane	14.89	0.34
21	1-Octadecane	17.56	0.52
22	Octadecane	17.65	0.25
23	Methyl-3-(3,5-ditertbutyl-4-hydroxyphenyl)	19.58	0.32
24	Hexadecanoic acid	19.72	0.57
25	Dibutyl phthalate	19.82	2.24
26	Unknown	20.13	0.09
27	9-Methylnonadecane	21.13	0.25
28	9-Octadecenoic acid	21.80	1.08
29	Hexadecanamide	22.29	1.28
30	Heptadecane	22.41	0.41
31	Butyl citrate	23.20	0.42
32	9-Octadecenamide	24.22	1.43
33	Unknown	24.49	0.10
34	Unknown	24.98	0.04
35	1,2-Benzenedicarboxylic acid	25.89	19.39
36	Unknown	26.09	1.65

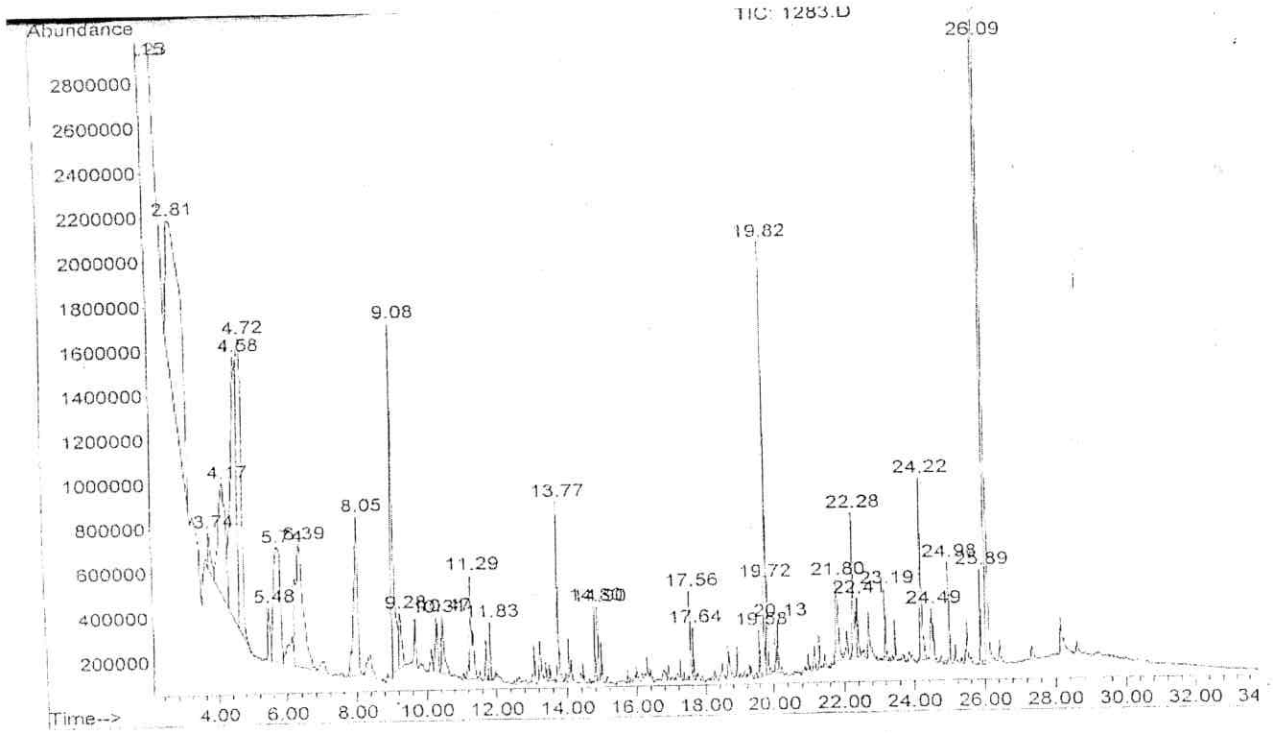


Figure (12): GC-MS chromatogram of volatiles components separated from the Indian tamarind pulp (Makam waan variety)

Octadecane (0.45%), Pentadecane (0.43%), Hexadecane (0.33%), 1-Hexadecane (0.23%), Heptadecane (0.21%) and 1-Octadecane (0.18%).

Total fractionated volatile constituents from Indian variety were 36 compounds of which 26 volatile components were only identified and 10 fractionated peaks were not. The major identified constituents ranked, in order of decreasing abundance as follows: 1, 2- benzendicarboxylic acid (19.39% of the total volatiles), hexanoic acid (15.56%), 2- furancarboxaldehyde (13.23%), 1- propanone (5.17%), Limonene (4.23%), 4-hydroxyl-5-methoxyprimidine (3.98%), octanoic acid (3.37%), Dibutyl phthalate (2.24%), Phenol (1.61%), 9- Octadecenamide (1.43%), Hexadecanamide (1.28%), 9-Octadecenoic acid (1.08%), Propanal (0.88%), 5-Acetoxymethyl-2-furaldehyde (0.78%), Benzeneacetaldehyde (0.75%), Hexadecanoic acid (0.57%), 1-Octadecane (0.52%), Butyl citrate (0.42%), Heptadecane (0.41%), 1-Hexadecane (0.39%), Tetradecane (0.35%), Hexadecane (0.34%), Methyl-3-(3,5-ditertbutyl-4-hydroxyphenyl (0.32%), Octadecane (0.25%), 9-Methylnonadecane (0.25%) and Ethyl acetate (0.07).

There were differences between the aroma profile of Egyptian and Indian varieties, not only the number of constituent volatiles identified, but also in volatile identified. However, the first major constituent was also different. The first major constituent in the Egyptian Aswany variety was 2-furancarboxaldehyde which constituted 62.11% of the total volatiles identified, while in Indian variety, the first major constituent was 1,2- benzendicarboxylic acid which constituted 26.08%. Generally, the characteristic constituent reported to be

reason of fruity and honey-like odor, was 2- Phenyl acetaldehyde. There was a variation in the concentration of this important aroma component where 1.55% was found in the Aswany and 4.23% in Indian variety. On the other hand, the 2-Phenylacetaldehyde was reported to have the sweet character and caramel-like flavor. These compounds, together with 5-methylfurfural recorded 4.61% in the Aswany while were absent in the Indian one. These two compounds are usually formed as a degradation product of ascorbic acid and sugar **(Pino *et al.* 2004).**

The results of this study suggested that the overall aroma of tamarind consisted of warm spice-like flavors with some roasted character. All of these compounds were found also in pulp of most tamarind varieties as investigated by **(Lee *et al.* 1975, Askar *et al.* 1987,** and **Pino *et al.* 2004).**

Part II:

4.2. Carob:

Two carob starting materials were employed which included whole pods and crushed pods of Cyprian carob (Tylliria variety). Whole carob pods were carefully separated into their constituents: pulp and the enclosed seeds where used for the morphological, technological and other analylitical methods. In contrast, the crushed carob experimental samples were found to be free from seeds.

4.2.1. Physicochemical analysis of carob materials used in the experimental preparation of beverages:

4.2.1.1. Proximate chemical composition:

Total solids content is an important factor in technology production and quality of carob beverage since it is well known that the higher the total solids the better will be the quality of the end product.

As mentioned in Table (27) there was nearly no significant difference between whole and crushed carob in moisture, total soluble and total carbohydrates. Whole pods had 7.96, 92.04 and 78.53%, and crushed obtained 7.97, 92.03 and 79.22%, respectively. These results agree with **El-Nahry *et al.* (1993) and Haber (2002)**.

Crude fat, crude protein, ash and fibers were 0.98, 3.14, 3.06 and 7.50% in whole pods and 0.74, 3.79, 3.25 and 6.14% in crushed, respectively, which agree with **Olleros *et al.* (1999)**, **Owen *et al.* (2003)** and **Duke (1981).**

Table (27): Physicochemical properties of examined natural carob pulp*.

Components*	Types			
	Whole carob		Crushed carob	
	On wet basis	On dry basis	On wet basis	On dry basis
Moisture %	7.96±0.19		7.97±0.08	
Total solids %	92.04±0.19		92.03±0.08	
Crude fat %	0.90±0.15	0.98	0.68±0.01	0.74
Crude protein %	2.89±0.14	3.14	3.49±0.11	3.79
Ash %	2.8223±0.01	3.06	2.9873±0.01	3.25
Total carbohydrates %**	78.53	85.32	79.22	86.08
Crude fibers%	6.90±0.10	7.50	5.65±0.22	6.14
Total sugars %	49.90±0.24	54.22	47.30±0.20	51.40
Reducing sugars %	13.40±0.11	14.56	14.50±0.13	15.76
Non reducing sugars %	33.90±0.21	36.83	35.40±0.18	38.47
pH value	4.84±0.01		4.80±0.03	
Titratable acidity %	0.53±0.02		0.66±0.02	
Tannins%	2.71±0.12		2.18±0.15	
Color index	1.225±0.21		1.383±0.15	
Anthocyanin (mg/100g)	0.531±0.08		0.597±0.05	

* Mean of triplicate determinations ±SE.

** Calculated by difference.

4.2.1.2. Total, reducing and non-reducing soluble sugars:

Total sugars in whole pod amounted to 54.22% were higher than crushed of 51.40%. Contrary reducing and non-reducing sugars were higher in crushed pod as they gave 15.76 and 38.83% higher than those in whole pod which were 14.56 and 36.83%, respectively. These obtained results agree with those obtained by **Leung and Foster (1993)**.

4.2.1.3. Titratable acidity and pH value:

Acidity and pH value are considered important quality factors, which directly affect taste acceptability.

pH value was nearly the same in both pods, however acidity was higher in crushed as it reached 0.66% than whole pod of 0.53%, which agree with **Binder (1959).**

4.2.1.4. Color index and anthocyanin content:

The color index values (O.D. at 420 nm.) for whole pods and crushed carob were 1.225 to 1.383, respectively, while anthocyanin contents were 0.531 and 0.597 mg/100g. Which agree with **Yousif and Alghzawi (2000)**.

4.2.2. Microbiological quality of carob pulp:

The Total bacterial count, Yeasts and molds, *Sporformer bacteria, Lactic acid bacteria, Psychrophylic bacteria, Coliform bacteria* and *Staphylococcus* were determined in both types of carob and obtained data are illustrated in Table (28).

A higher total bacterial count ($4.37x10^4$ c.f.u./g) was observed in crushed, but lower count ($9.45x10^3$ c.f.u./g) in whole carob. Furthermore, higher ($8.21x10^3$ c.f.u./g) of yeasts and

Table (28): Microbiological quality of examined natural carob pulp*.

Microorganisms	Types	
	Whole carob	Crushed carob
Total bacterial count	$9.45x10^3$	$4.37x10^4$
Sporformer bacteria	ND**	ND
Lactic acid bacteria	ND	ND
Psychrophylic bacteria	ND	ND
Coliform group	$1.1x10^2$	$9.4x10^3$
Staphylococcus	ND	ND
Yeasts and moulds	$3.4x10^3$	$8.21x10^3$

* Mean of duplicate determinations.

**ND: Not detected.

molds count were in crushed, but lower ($3.4x10^3$ c.f.u./g) in carob whole pods.

On the other hand, lower *Coliform group* count ($1.1x10^2$ c.f.u./g) was noted in whole pods, but higher ($9.4x10^3$ c.f.u./g) in carob crushed pods. *Sporeformer bacteria, Lactic acid bacteria, Psychrophylic bacteria* and *Staphlococcus* were not detected in all carob samples.

It could be concluded from the abovementioned data on microbial load that crushed carob contain higher microorganisms than whole carob pods of the same Tylliria variety. Several possible reasons for such variation in microbial load could be related to the differences in varieties, pre and after harvest treatments, handling, crushing processing, packaging conditions, storage conditions etc. These obtained results agree with those reported by **Tassou *et al.* (1997).**

4.2.3. Chemical analysis of carob seeds:

4.2.3.1. Proximate chemical composition:

Carob seeds were analysed and results are shown in Table (29). Moisture amounts to 8.89% while total carbohydrates reached 70.07%. Crude fat, crude protein, ash, crude fibers, total sugars, reducing and non-reducing sugars were, 6.28, 12.75, 2.81, 8.09, 12.35, 7.84 and 4.51% on dry basis, respectively which agree with Duke (1981) and Avallone et al. (1997).

From the abovementioned data, it could be concluded that carob seeds contain considerable amounts of carbohydrates, crude protein and crude fat. For example, one kilogram of carob seeds would contain 638.4 g, 116.2 g and 57.2 g, respectively, which could support the possibility of using carob seeds as food

Table (29): Chemical composition of carob seeds*.

Components	Whole carob	
	On wet basis	On dry basis
Moisture %	8.89±0.08	
Total solids %	91.11±0.08	
Crude fat %	5.72±0.46	6.28
Crude protein %	11.62±0.20	12.75
Ash %	2.5637±0.11	2.81
Total carbohydrates %**	63.84	70.07
Crude fibers%	7.37±0.17	8.09
Total sugars %	11.25±0.11	12.35
Reducing sugars %	7.14±0.08	7.84
Non reducing sugars %	4.11±0.04	4.51

* Mean of triplicate determinations ±SE.

** Calculated by difference.

and feeds as well. The use of carob seeds in some unconventional technology should be explored.

4.2.4. Establishment of optimum extraction conditions of carob pulp:

4.2.4.1. Extractability of the Cyprian whole carob pods of Tylliria variety:

4.2.4.1.1. Effect of flotation ratio (water: pulp) on extraction rate of pulp of whole carob:

The effect of flotation ratio (water: pulp) from 2:1 to 10:1 on water extraction rate at room temperature and re-extraction of components were investigated and results are tabulated in Table (30).

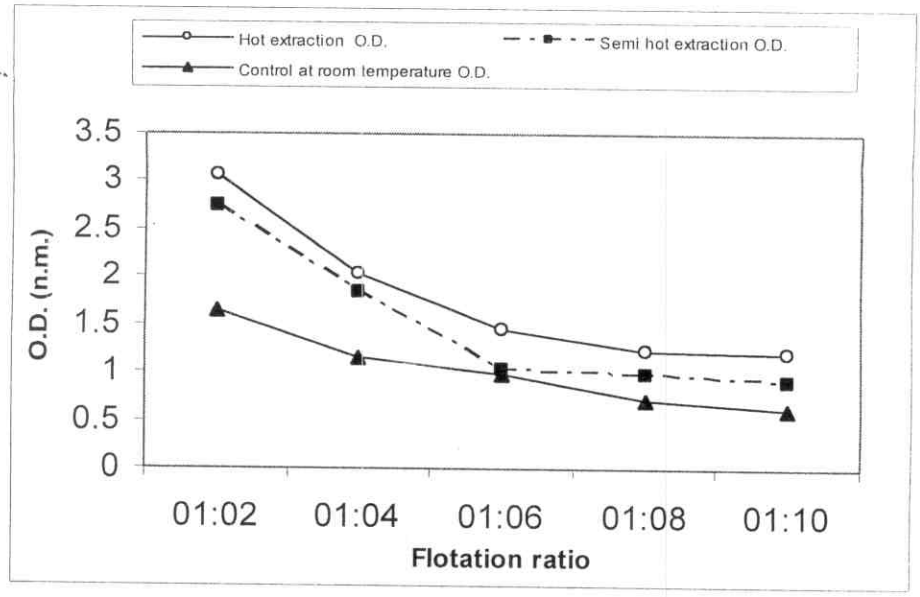
Data in Table (30) illustrate trend of gradual decrease in total soluble solids (T.S.S.) and optical density (O.D.) with the increase in flotation ratio from 2:1 to 10:1. In contrast, the pH value of extraction medium, increased gradually with increase in flotation ratio. The highest values for total soluble solids and optical density (20.83% and 1.631, respectively) were attained with flotation ratio of 2:1. On the other hand, the lowest values for T.S.S and O.D. (5.17% and 0.612, respectively) were attained at flotation ratio of 10:1.

With all flotation ratios tested, similar trend was observed that the first extraction trial always exhibited the highest proportion of extracted total soluble solids and optical density (O.D.), followed by the second re-extraction, while the 3rd successive extraction showed the least values. In contrast, pH values showed a general behavior of increase with the repetition of the three successive extractions.

Table (31): Effect of flotation ratio on hot* conditions of whole carob.

Flotation ratio Water: pulp	Sequence of extraction	Methods of extraction								
		Hot extraction (100 °c)			Semi hot extraction			Control at room temperature		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
2:1	1st	4.66 ±0.05	24.83 ±0.17	3.056 ±0.41	4.68 ±0.06	22.67 ±0.50	2.749 ±0.33	4.71 ±0.11	20.83 ±0.25	1.631 ±0.15
	2nd	4.70 ±0.03	10.33 ±0.27	1.577 ±0.20	4.73 ±0.02	10.00 ±0.29	1.132 ±0.31	4.67 ±0.03	9.33 ±0.17	0.787 ±0.10
	3rd	4.82 ±0.01	4.17 ±0.29	0.931 ±0.08	4.84 ±0.05	3.50 ±0.25	0.842 ±0.24	4.86 ±0.07	2.83 ±0.50	0.610 ±0.09
	Cumulative		39.33			36.17			32.99	
4:1	1st	4.67 ±0.08	14.67 ±0.76	2.031 ±0.22	4.70 ±0.03	13.50 ±0.45	1.824 ±0.11	4.76 ±0.08	12.83 ±1.00	1.156 ±0.08
	2nd	4.71 ±0.04	3.67 ±0.50	1.451 ±0.21	4.75 ±0.06	3.50 ±0.17	0.982 ±0.08	4.78 ±0.05	3.17 ±0.76	0.671 ±0.15
	3rd	4.90 ±0.06	0.67 ±0.15	0.875 ±0.25	4.91 ±0.03	0.50 ±0.25	0.686 ±0.23	4.92 ±0.08	0.17 ±0.00	0.469 ±0.13
	Cumulative		19.01			17.50			16.17	
6:1	1st	4.76 ±0.05	9.67 ±0.29	1.454 ±0.24	4.77 ±0.05	9.00 ±0.17	1.026 ±0.11	4.78 ±0.06	8.67 ±0.12	0.973 ±0.08
	2nd	4.79 ±0.06	0.83 ±0.29	0.653 ±0.18	4.80 ±0.09	0.83 ±0.00	0.612 ±0.07	4.81 ±0.07	0.67 ±0.00	0.566 ±0.17
	3rd	4.96 ±0.03	0.00 ±0.00	0.548 ±0.30	4.99 ±0.03	0.00 ±0.00	0.467 ±0.12	5.07 ±0.02	0.00 ±0.00	0.334 ±0.01
	Cumulative		10.50			9.83			9.34	
8:1	1st	4.78 ±0.08	7.17 ±0.50	1.222 ±0.22	4.79 ±0.05	7.00 ±0.17	0.968 ±0.09	4.80 ±0.04	6.33 ±0.34	0.717 ±0.11
	2nd	4.82 ±0.07	0.33 ±0.00	0.538 ±0.14	4.84 ±0.06	0.17 ±0.00	0.496 ±0.15	4.87 ±0.08	0.00 ±0.00	0.446 ±0.17
	3rd	5.00 ±0.06	0.00 ±0.00	0.469 ±0.08	5.12 ±0.03	0.00 ±0.00	0.388 ±0.17	5.25 ±0.07	0.00 ±0.00	0.326 ±0.10
	Cumulative		7.50			7.17			6.33	
10:1	1st	4.79 ±0.04	5.67 ±0.17	1.211 ±0.11	4.80 ±0.06	5.50 ±0.17	0.898 ±0.10	4.81 ±0.02	5.17 ±0.50	0.612 ±0.14
	2nd	4.86 ±0.05	0.00 ±0.00	0.515 ±0.20	4.88 ±0.03	0.00 ±0.00	0.450 ±0.08	4.91 ±0.06	0.00 ±0.00	0.331 ±0.06
	3rd	5.05 ±0.02	0.00 ±0.00	0.441 ±0.10	5.20 ±0.05	0.00 ±0.00	0.373 ±0.10	5.37 ±0.07	0.00 ±0.00	0.299 ±0.06
	Cumulative		5.67			5.50			5.17	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



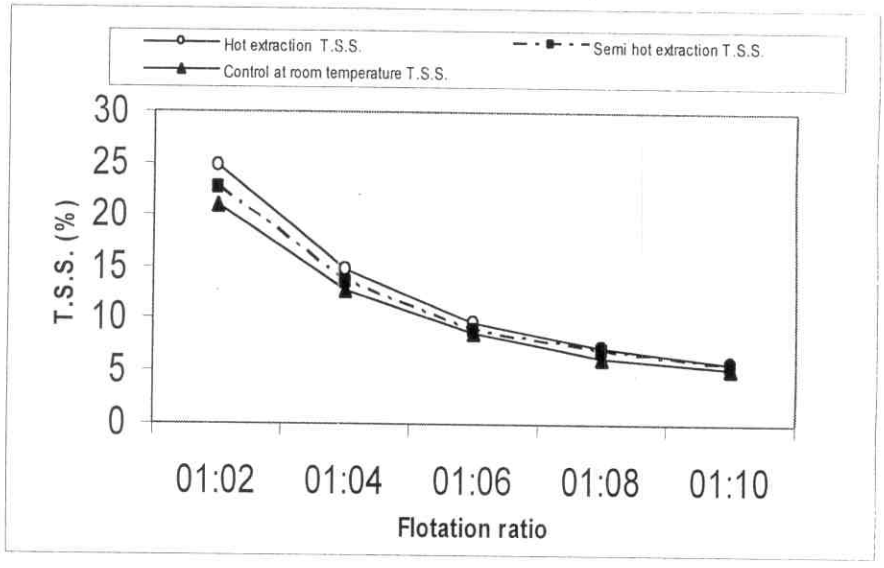


Figure (13): Effect of flotation ratio on extraction rate at hot and semi hot conditions of whole carob components (T.S.S. and O.D.).

With Semi-hot, maximum, T.S.S. achieved after first extraction at (2:1) was 22.67%, which represent about 24.63%. 2nd re-extraction added another 10.00% which represent 10.86%. After three successive re-extraction, the maximum cumulative extraction reached 36.17%, which represent about 39.29% of T.S.S. contained in pulp powder.

Maximum T.S.S. of 3rd extraction were only 3.50% which represent about 3.80%.

With all temperature conditions, progressive increase in pH with the re-extraction trials and with increase in flotation ratio more than 2:1 could be attributed dilution of media with water.

In general, the flotation ratio of 2:1 could be regarded the best or optimum ratio, which gave maximum extractability under the three temperature conditions. Furthermore, extraction under hot condition exhibited maximum extractability compared to room and semi-hot condition. These obtained results agree with those obtained by **Zin El-Dine (1999).**

4.2.4.1.2. Effect of temperature degrees on extraction rate:

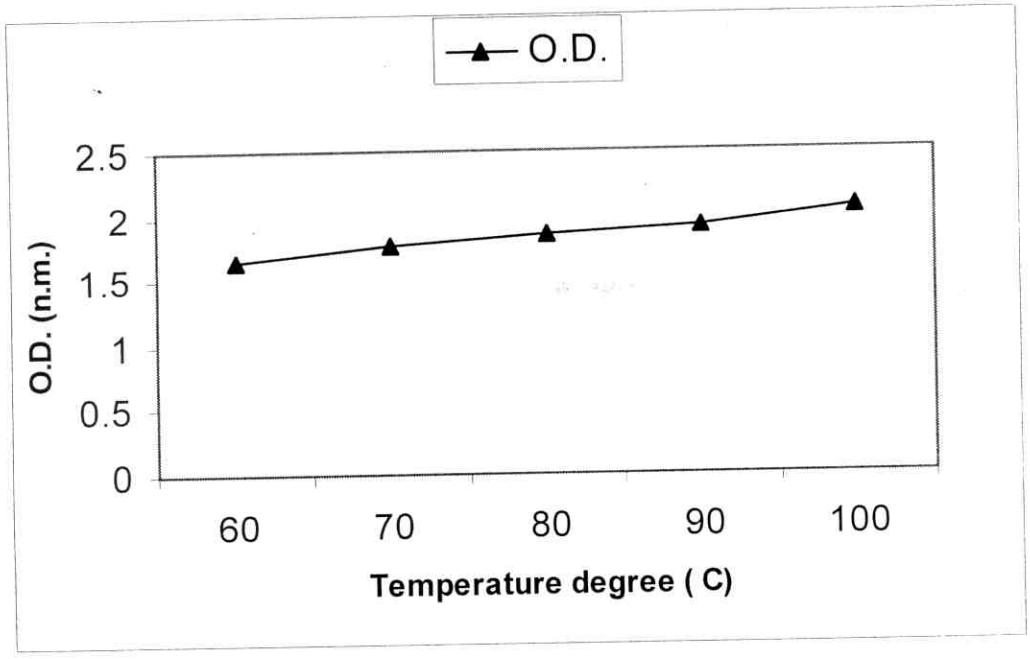
The effect of applying different degrees of temperature from 60 to 100°C (60, 70, 80, 90 and 100 °C) on extraction rate and re-extraction or successive extraction of components of carob pulp of Tylliria variety were investigated and results are tabulated in Table (32) and Fig. (14).

As a general rule, when temperature of extraction increased total soluble solids content and optical density increased. In contrast, pH value decreased with increase in degree of temperature. Maximum T.S.S. achieved after first

Table (32): Effect of temperature degree (up to 100 °C) on extractability of whole carob.

Extraction temperatures	Sequence of extraction	Determination*		
		pH	T.S.S.	O.D.
60°C	1st	4.81±0.05	23.17±0.29	1.646±0.21
	2nd	4.88±0.12	9.50±0.29	0.884±0.11
	3rd	4.91±0.07	3.83±0.29	0.528±0.13
	Cumulative		36.50	
70°C	1st	4.76±0.02	23.17±0.29	1.773±0.31
	2nd	4.86±0.09	9.67±0.15	1.128±0.21
	3rd	4.88±0.06	4.17±0.20	0.775±0.13
	Cumulative		37.01	
80°C	1st	4.73±0.10	23.67±0.22	1.855±0.32
	2nd	4.85±0.06	9.67±0.29	1.305±0.22
	3rd	4.86±0.10	4.67±0.21	1.013±0.10
	Cumulative		38.01	
90°C	1st	4.72±0.04	23.83±0.19	1.918±0.30
	2nd	4.83±0.07	10.17±0.22	1.376±0.21
	3rd	4.84±0.04	5.17±0.29	1.180±0.10
	Cumulative		39.17	
100°C	1st	4.66±0.04	24.83±1.00	2.056±0.33
	2nd	4.70±0.10	10.33±0.20	1.577±0.17
	3rd	4.82±0.10	5.17±0.19	1.201±0.11
	Cumulative		40.33	

*Mean of triplicate determinations ±SE.



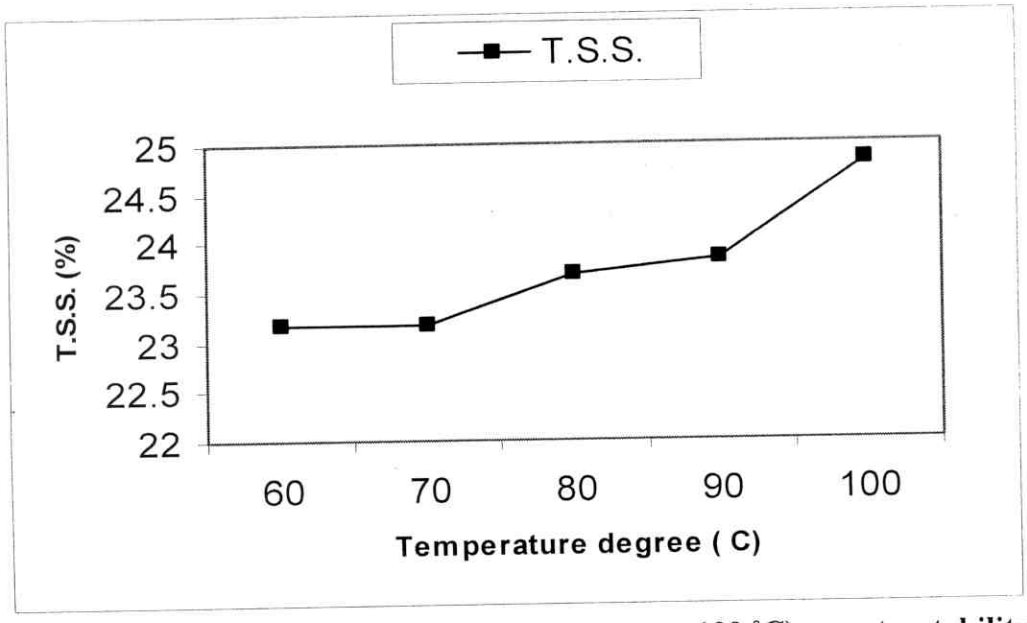


Figure (14): Effect of temperature degree (up to 100 °C) on extractability of whole carob components (T.S.S. and O.D.)

extraction at 100 °C was 24.83%, which represent about 26.97%. 2nd re-extraction added another 10.33% which represent 11.22%. After three successive re-extraction, maximum cumulative extraction reached 40.33%, which represent 43.81% while minimum T.S.S. achieved after first extraction at 60°C was 23.17%, which represent about 25.17%. The 2nd re-extraction added another 9.50%, which represent 10.32%. After three successive re-extraction, the maximum cumulative extraction reached 36.50%, which represent 39.65% of the total solids contained in carob pulp. These obtained results were parallel with those obtained by **Sharf (2003)** and **Roseiro *et al.* (1991)**.

4.2.4.1.3. Effect of extraction periods on extraction rate of whole carob pulp Tylliria variety:

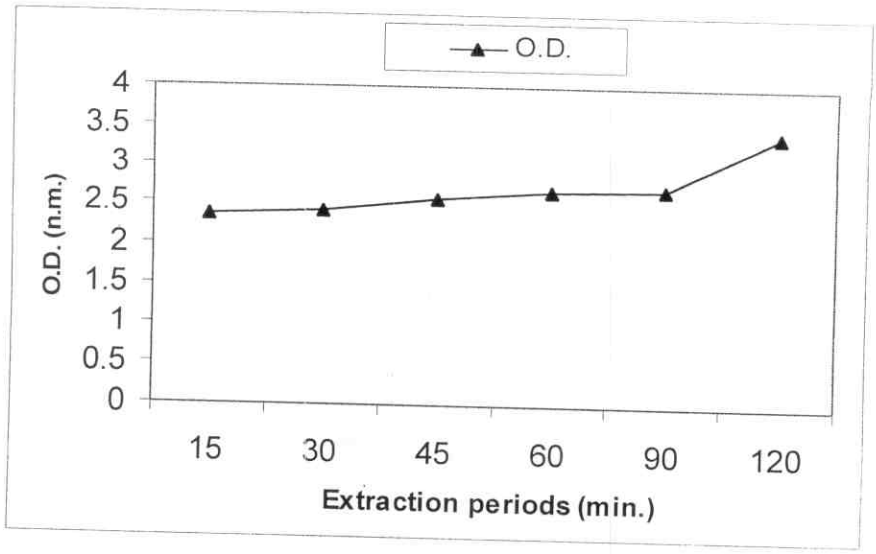
The effect of duration of extraction (from 15 min to 120 min) at (100°C) on extractability and re-extraction or successive extraction of carob components of pulp was investigated and results are presented in Table (33) and Fig. (15).

In a general rule, as duration of extraction increased total soluble solids content and optical density increased. However, such increase was not pronounced with increasing period of extraction longer than 30 min. In contrast, pH value decreased.

Maximum T.S.S. and O.D. values were achieved after extraction period for 120 min in hot water. After first extraction, T.S.S. reached 25.00%, which represent about 27.16%. 2nd re-extraction added another 12.00%, which represent 13.03% After three successive re-extraction maximum cumulative extraction reached 42.50%, which represent 46.17% of the total solids contained in carob pulp. The minimum T.S.S. value was achieved after15 min of extraction; where the first extraction

Table (33): Effect of extraction periods at hot condition on extraction rate of whole carob.

Extraction periods	Sequence of extraction	Determination		
		pH	T.S.S.	O.D.
15 min.	1st	4.72±0.11	22.33±0.50	2.340±0.14
	2nd	4.83±0.09	9.67±0.29	1.281±0.10
	3rd	4.92±0.06	4.17±0.50	0.671±0.07
	Cumulative		36.17	
30 min.	1st	4.70±0.10	24.17±0.50	2.395±0.14
	2nd	4.78±0.04	10.33±0.22	1.561±0.12
	3rd	4.85±0.07	4.33±0.76	0.672±0.09
	Cumulative		38.83	
45 min.	1st	4.68±0.05	24.50±0.17	2.560±0.15
	2nd	4.75±0.05	11.67±0.76	1.744±0.10
	3rd	4.81±0.06	4.83±0.50	0.721±0.08
	Cumulative		41.00	
60 min.	1st	4.67±0.10	24.67±0.16	2.665±0.19
	2nd	4.71±0.04	12.17±0.15	1.821±0.11
	3rd	4.78±0.10	5.17±0.50	1.169±0.08
	Cumulative		42.01	
90 min.	1st	4.64±0.06	25.00±0.17	2.680±0.18
	2nd	4.66±0.07	12.17±0.50	2.444±0.13
	3rd	4.70±0.11	5.33±0.25	1.663±0.08
	Cumulative		42.50	
120 min.	1st	4.61±0.08	25.00±0.11	3.403±0.17
	2nd	4.66±0.06	12.00±0.17	1.792±0.05
	3rd	4.69±0.04	5.50±0.50	1.694±0.09
	Cumulative		42.50	



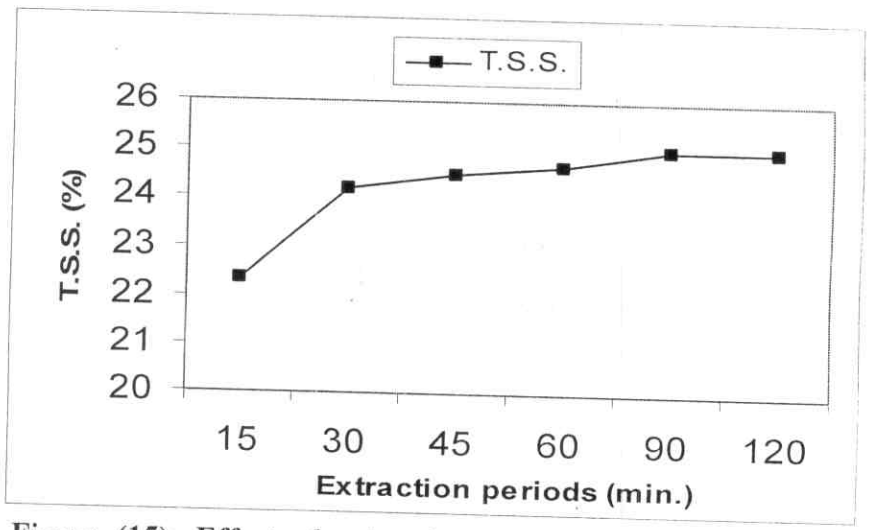


Figure (15): Effect of extraction periods at hot condition on extraction_rate of whole carob components (T.S.S. and O.D).

attained only 22.33% represent a recovered about 10.50%. 2nd re-extraction added another 9.67%, which represent 14.10%. After three successive re-extraction trials, the maximum cumulative extraction reached 36.17%, which represent 39.29% of the total solids contained in carob pulp. These obtained results agree with those obtained by **(Zin El-Dine, 1999** and **Roseiro *et al.*, 1991).**

From the presented data, it could be concluded that an optimum extraction period of only 30 min at high temperature was selected to compromise between speed of extraction and maximum extractability.

Longer periods of extraction under room or semi-hot condition were investigated.

Table (34) and Fig. (16) Illustrate the effect of applying longer duration of extraction (from 0.5 hrs to 6 hrs) on extractability rate and re-extraction or successive extraction of components of carob pulp.

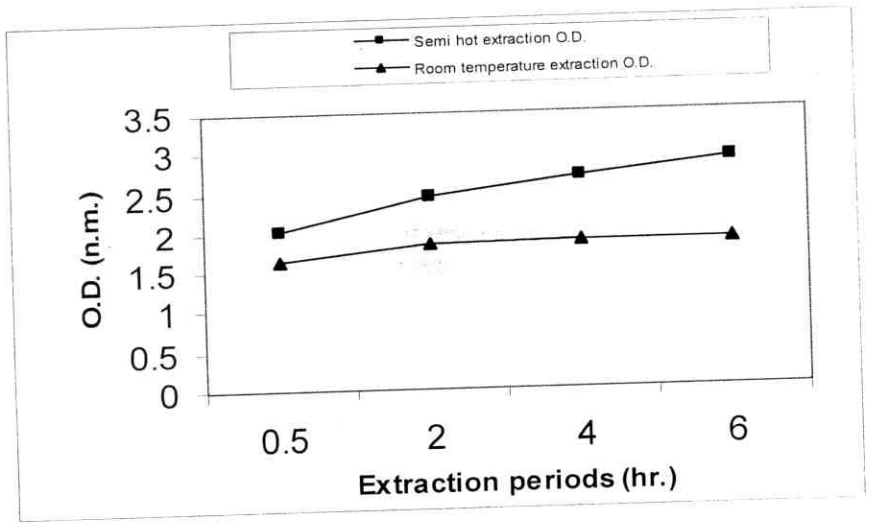
There was gradual increase in values for T.S.S. and O.D. with increase in duration from 0.5 hrs to 6 hrs. However, such increase was not pronounced with increasing period of extraction longer than two hrs. In contrast, the pH of extraction medium decreased gradually.

With semi-hot conditions, maximum T.S.S. were achieved after 6 hrs of extraction, where after the 1st extraction reached 25.00%, which represent about 27.16%. 2nd re-extraction added another 11.00 % which represent 11.95%. After three successive re-extraction, the maximum cumulative extraction was 41.00%, which represent about 44.54% of T.S.S. contained in pulp powder.

Table (34): Effect of extraction periods at room temperature and semi hot conditions on extraction rate of whole carob.

Extraction periods	Sequence of extraction	Methods of extraction					
		Room temperature extraction			Semi hot extraction*		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
30 min.	1st	4.81±0.05	21.00±0.29	1.631±0.20	4.75±0.04	23.00±0.22	2.021±0.36
	2nd	4.86±0.09	9.33±0.30	0.787±0.24	4.80±0.08	10.00±0.30	1.140±0.23
	3rd	4.88±0.10	2.83±0.50	0.610±0.11	4.86±0.05	3.50±0.29	0.624±0.10
	Cumulative		33.16			36.50	
2 hrs.	1st	4.80±0.12	22.83±0.22	1.842±0.35	4.73±0.05	23.17±1.00	2.432±0.42
	2nd	4.82±0.07	10.00±0.20	0.793±0.20	4.78±0.06	10.50±0.50	1.167±0.21
	3rd	4.85±0.09	4.17±0.00	0.645±0.10	4.84±0.08	4.50±0.50	0.845±0.12
	Cumulative		37.00			38.17	
4 hrs.	1st	4.77±0.30	23.67±0.50	1.863±0.31	4.70±0.11	24.67±0.21	2.673±0.39
	2nd	4.80±0.06	10.50±0.25	0.843±0.20	4.75±0.06	10.67±0.29	1.276±0.21
	3rd	4.82±0.07	4.33±0.50	0.684±0.09	4.80±0.10	5.00±0.50	1.002±0.11
	Cumulative		38.50			40.34	
6 hrs.	1st	4.74±0.06	23.67±0.50	1.870±0.32	4.68±0.07	25.00±0.30	2.886±0.40
	2nd	4.77±0.09	10.83±1.00	0.922±0.20	4.72±0.05	11.00±0.50	1.378±0.20
	3rd	4.79±0.07	4.67±0.30	0.742±0.12	4.77±0.10	5.00±0.76	1.323±0.11
	Cumulative		39.17			41.00	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



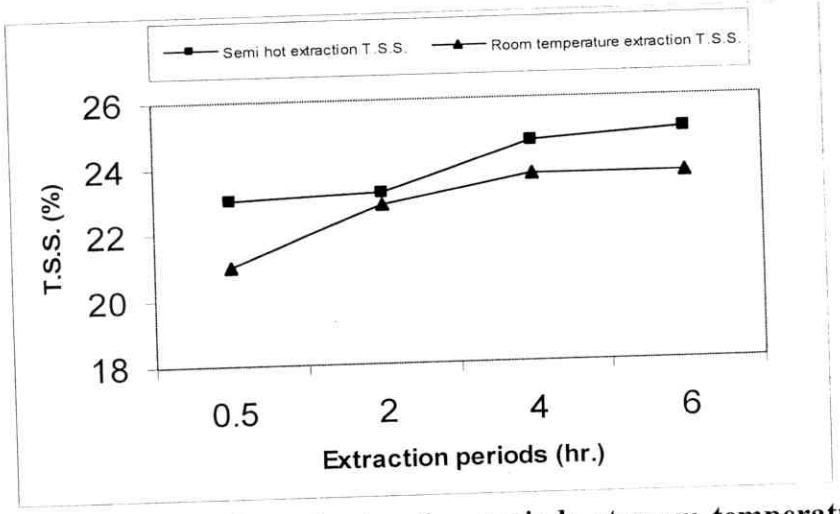


Figure (16): Effect of extraction periods at room temperature and semi hot conditions on extraction rate of whole carob components (T.S.S. and O.D.).

At room temperature, the maximum T.S.S. were achieved also after at 6 hrs where the 1st extraction attained 23.67% which represent about 25.71%. 2nd re-extraction added another 10.83% which represent 11.76%. After three successive re-extraction, the maximum cumulative extraction reached 39.17%, which represent 42.55% of T.S.S. contained in pulp powder.

Although the period of extraction of 6 hrs was found the best for maximum extractability at both room and semi-hot conditions, extraction period of only two hrs was selected compromise between speed, economy of extraction and maximum extractability of carob components.

4.2.5.1.4. Effect of pH medium on extraction rate:

The effect of variation in pH medium of extraction (from pH 3 to pH 9) under different temperature conditions on extractability and re-extraction or successive extraction of components of carob pulp was investigated and results are tabulated in Table (35) and Fig. (17).

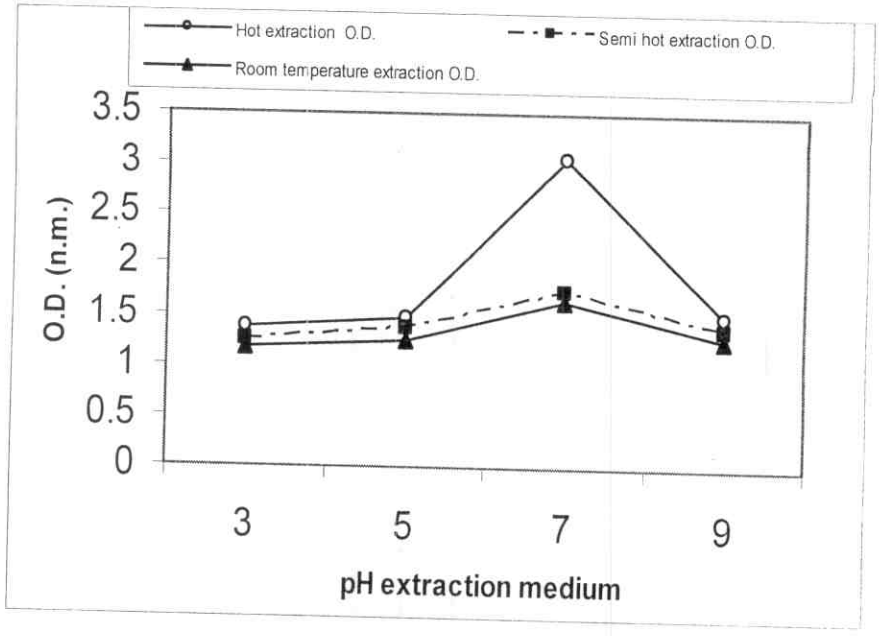
With hot condition, maximum T.S.S. were achieved when pH value was pH= 7, where the 1st extraction reached 24.83% which represent about 26.97%. 2nd re-extraction added another 10.33%, which represent 11.22%. After three successive re-extraction, the maximum cumulative extraction reached 39.49%, which represent about 42.90% recovery of T.S.S. contained in pulp powder.

With semi-hot condition, maximum T.S.S. were achieved when pH was 7 (pH =7), where the 1st extraction reached 24.00% which represent about 26.07%. 2nd re-extraction added another 10.00%, which represent 10.86%. After three successive

Table (35): Effect of pH of extraction medium on whole carob components.

pH of medium	Sequence of extraction	Methods of extraction								
		Hot extraction (100 °c)			Semi hot extraction*			Room temperature extraction		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
pH 3	1st	4.61 ±0.04	23.67 ±0.21	1.362 ±0.33	4.63 ±0.08	23.00 ±0.20	1.253 ±0.32	4.60 ±0.10	20.50 ±0.50	1.155 ±0.25
	2nd	4.65 ±0.09	9.83 ±1.00	1.211 ±0.23	4.68 ±0.03	9.00 ±0.50	0.874 ±0.15	4.71 ±0.18	8.33 ±0.50	0.579 ±0.09
	3rd	4.73 ±0.11	3.83 ±0.50	0.746 ±0.11	4.75 ±0.06	3.50 ±0.25	0.518 ±0.12	4.76 ±0.11	3.17 ±0.50	0.372 ±0.09
	Cumulative		37.33			35.50			32.00	
pH 5	1st	4.63 ±0.09	23.67 ±0.50	1.468 ±0.30	4.65 ±0.09	23.17 ±0.20	1.371 ±0.31	4.68 ±0.04	21.17 ±1.00	1.232 ±0.21
	2nd	4.68 ±0.07	10.00 ±0.29	1.216 ±0.12	4.70 ±0.06	9.00 ±0.29	0.953 ±0.15	4.74 ±0.15	8.33 ±0.50	0.614 ±0.16
	3rd	4.77 ±0.07	4.33 ±0.50	0.824 ±0.13	4.78 ±0.08	4.00 ±0.00	0.680 ±0.10	4.79 ±0.04	3.17 ±0.50	0.385 ±0.09
	Cumulative		38.00			36.17			32.67	
pH 7	1st	4.66 ±0.04	24.83 ±0.29	3.056 ±0.34	4.68 ±0.07	24.00 ±1.00	1.726 ±0.35	4.71 ±0.05	21.17 ±0.29	1.631 ±0.18
	2nd	4.70 ±0.11	10.33 ±1.00	1.577 ±0.21	4.74 ±0.10	10.00 ±0.50	1.114 ±0.13	4.76 ±0.10	9.33 ±0.29	0.787 ±0.14
	3rd	4.79 ±0.02	4.33 ±0.00	0.901 ±0.12	4.79 ±0.07	4.00 ±0.29	0.764 ±0.11	4.80 ±0.07	3.17 ±0.00	0.610 ±0.10
	Cumulative		39.49			38.00			33.67	
pH 9	1st	4.69 ±0.09	24.00 ±0.50	1.486 ±0.33	4.72 ±0.05	23.67 ±0.50	1.374 ±0.22	4.88 ±0.08	20.33 ±0.50	1.262 ±0.24
	2nd	4.75 ±0.05	9.67 ±0.29	1.352 ±0.19	4.77 ±0.11	9.00 ±0.29	1.139 ±0.17	4.91 ±0.04	8.83 ±0.29	0.784 ±0.12
	3rd	4.88 ±0.03	4.17 ±0.29	0.868 ±0.11	4.90 ±0.05	3.67 ±0.29	0.643 ±0.12	4.94 ±0.10	3.33 ±0.50	0.482 ±0.11
	Cumulative		37.84			36.34			32.49	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



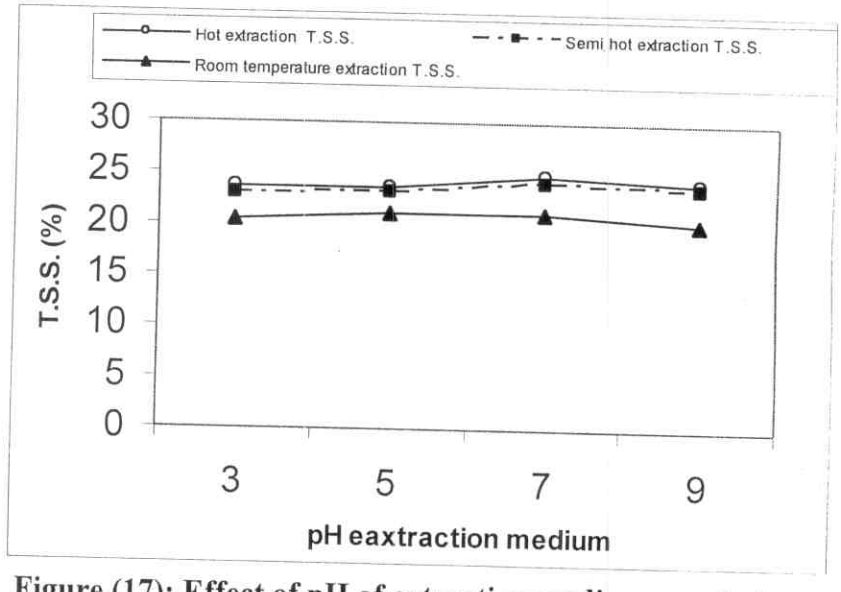


Figure (17): Effect of pH of extraction medium on whole carob components (T.S.S. and O.D.).

re-extraction, the maximum cumulative extraction reached 38.00%, which represents about 41.28% of T.S.S. contained in pulp powder.

Similarly, at room temperature condition, maximum T.S.S. were attained using pH of 7(pH =7), where the 1st extraction reached 21.17% which represent about 23.00%. 2nd re-extraction added another 9.33%, which represent 10.13%. After three successive re-extraction, the maximum cumulative extraction reached 33.67%, which represent about 36.58% of T.S.S. contained in pulp powder.

From the presented data it could be concluded that optimum pH medium of extraction of pH =7 was selected to compromise between speed of extraction and maximum extractability of components which agree with those obtained by **Roseiro *et al.*, (1991)** who found that the best pH medium for extraction was pH 6.8.

4.2.4.2. Extractability of the Cyprian crushed carob Tylliria variety:

4.2.4.2.1. Effect of flotation ratio (water: pulp) on extraction rate of crushed carob pulp:

The effect of flotation ratio (water: pulp) from 2:1 to 10:1 on water extraction rate at room temperature of and the re-extraction successive of components for carob pulp was investigated and results are tabulated in Table (36).

Data in Table (36) illustrate gradual decrease for (T.S.S.) and (O.D.) with increase in flotation ratio from 2:1 to 10:1. In contrast, pH value, increased gradually with increase in flotation ratio. The highest values for total soluble solids and optical density (19.00% and 1.447, respectively) were obtained with

Table (36): Effect of flotation ratio at room temperature on extraction rate of crushed carob.

Flotation ratio (Water: pulp)	Sequence of extraction	Determination		
		pH	T.S.S.	O.D.
2:1	1st	4.72±0.03	19.00±0.20	1.447±0.32
	2nd	4.80±0.06	8.00±1.00	0.645±0.21
	3rd	4.92±0.07	2.50±0.50	0.412±0.11
	Cumulative		29.50	
4:1	1st	4.74±0.06	11.50±0.50	1.148±0.21
	2nd	4.82±0.07	2.50±0.5	0.627±0.09
	3rd	4.93±0.09	0.50±0.00	0.392±0.07
	Cumulative		14.50	
6:1	1st	4.77±0.05	8.00±0.29	0.914±0.26
	2nd	4.83±0.05	0.50±0.40	0.505±0.08
	3rd	4.96±0.06	0.00±0.00	0.283±0.07
	Cumulative		8.50	
8:1	1st	4.78±0.02	6.00±0.00	0.684±0.14
	2nd	4.85±0.1	0.00±0.00	0.391±0.08
	3rd	4.97±0.1	0.00±0.00	0.236±0.07
	Cumulative		6.00	
10:1	1st	4.79±0.08	4.17±1.00	0.587±0.16
	2nd	4.87±0.03	0.00±0.00	0.320±0.08
	3rd	5.00±0.08	0.00±0.00	0.248±0.05
	Cumulative		4.17	

flotation ratio of 2:1. On the other hand, the lowest values (4.17% and 0.587, respectively) were obtained at flotation ratio of 10:1 (carob water: pulp).

Maximum T.S.S. achieved after first extraction were 19.00%, which represent about 20.64%. 2nd re-extraction added another 8.00%, which represent 8.69%. After three successive re-extraction trials, the maximum cumulative extraction reached 29.50%, which represent about 32.05% recovery of T.S.S. contained in pulp powder.

Increasing the flotation ratio more than 2:1 did not improve the extractability of carob pulp components. Similarly, increasing re-extraction more than double did not improve the extractability of carob pulp components where the maximum T.S.S. of 3rd extraction achieved was only 2.50% which represent about 2.71% recovery of T.S.S. contained in pulp powder.

Table (37) and Fig. (18) demonstrate the effect of flotation ratio under different extraction conditions on water extraction rate of pulp.

Extraction at hot temperature resulted in highest values for T.S.S. and O.D., while at room temperature resulted lowest values.

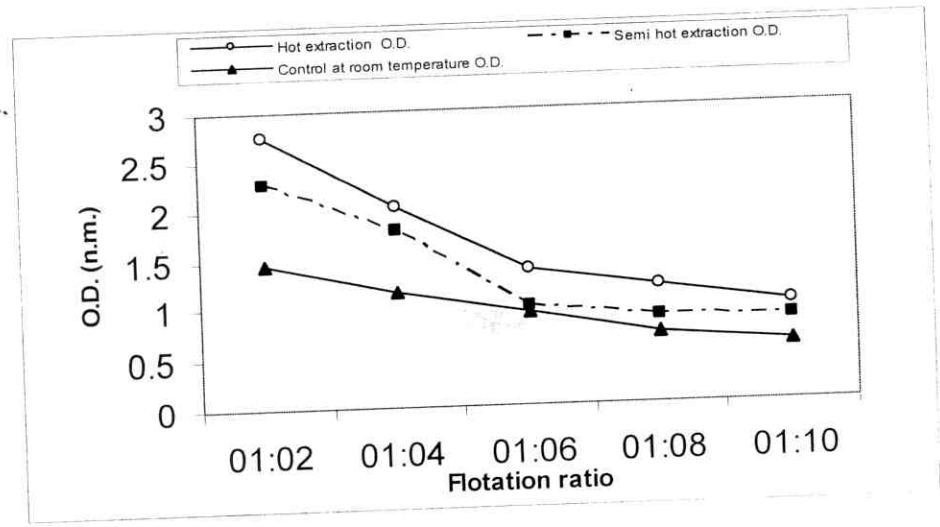
Table (37) illustrates gradual decrease in values for T.S.S. and O.D. with increase in flotation ratio from 2:1 to 10:1, while increased gradually.

First extraction always exhibited the highest proportion of extracted T.S.S. and O.D., followed by second re-extraction, while the 3rd successive extraction showed the least values. In contrast, pH values showed increase.

Table (37): Effect of flotation ratio at hot and semi hot* conditions on extractability of crushed carob.

Flotation ratio (Water: pulp)	Sequence of extraction	Methods of extraction								
		Hot extraction (100°c)			Semi hot extraction			Control at room temperature		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
2:1	1st	4.69 ±0.02	23.5 ±0.20	2.754 ±0.30	4.70 ±0.08	22.00 ±0.30	2.263 ±0.35	4.72 ±0.03	19.00 ±0.20	1.447 ±0.32
	2nd	4.76 ±0.05	9.00 ±0.30	1.261 ±0.33	4.78 ±0.08	8.50 ±0.40	1.182 ±0.21	4.80 ±0.06	8.00 ±1.00	0.645 ±0.21
	3rd	4.87 ±0.05	4.00 ±0.50	0.638 ±0.12	4.89 ±0.06	3.50 ±0.00	0.490 ±0.11	4.92 ±0.07	2.50 ±0.50	0.412 ±0.11
	Cumulative		36.50			34.00			29.50	
4:1	1st	4.71 ±0.05	13.00 ±0.29	2.016 ±0.69	4.72 ±0.11	12.17 ±0.20	1.786 ±0.29	4.74 ±0.06	11.50 ±0.50	1.148 ±0.21
	2nd	4.78 ±0.08	3.00 ±0.00	0.973 ±0.11	4.80 ±0.1	2.50 ±0.00	0.817 ±0.1	4.82 ±0.07	2.50 ±0.5	0.627 ±0.09
	3rd	4.89 ±0.07	0.50 ±0.29	0.564 ±0.08	4.90 ±0.09	0.50 ±0.00	0.523 ±0.08	4.93 ±0.09	0.50 ±0.00	0.392 ±0.07
	Cumulative		16.50			15.17			14.50	
6:1	1st	4.73 ±0.08	9.17 ±0.29	1.361 ±0.24	4.75 ±0.05	8.67 ±0.29	0.987 ±0.39	4.77 ±0.05	8.00 ±0.29	0.914 ±0.26
	2nd	4.79 ±0.01	0.50 ±0.00	0.604 ±0.08	4.82 ±0.1	0.50 ±0.5	0.572 ±0.08	4.83 ±0.05	0.50 ±0.40	0.505 ±0.08
	3rd	4.91 ±0.04	0.00 ±0.00	0.513 ±0.06	4.94 ±0.1	0.00 ±0.00	0.416 ±0.08	4.96 ±0.06	0.00 ±0.00	0.283 ±0.07
	Cumulative		9.67			9.17			8.50	
8:1	1st	4.74 ±0.06	7.00 ±0.29	1.184 ±0.14	4.76 ±0.06	6.50 ±0.29	0.854 ±0.17	4.78 ±0.02	6.00 ±0.00	0.684 ±0.14
	2nd	4.81 ±0.04	0.33 ±0.00	0.518 ±0.09	4.83 ±0.06	0.17 ±0.29	0.390 ±0.09	4.85 ±0.1	0.00 ±0.00	0.391 ±0.08
	3rd	4.93 ±0.06	0.00 ±0.00	0.435 ±0.06	4.95 ±0.03	0.00 ±0.00	0.309 ±0.06	4.97 ±0.1	0.00 ±0.00	0.236 ±0.07
	Cumulative		7.33			6.67			6.00	
10:1	1st	4.76 ±0.08	5.00 ±0.5	0.985 ±0.30	4.78 ±0.12	4.50 ±0.5	0.842 ±0.12	4.79 ±0.08	4.17 ±1	0.587 ±0.16
	2nd	4.83 ±0.1	0.00 ±0.29	0.476 ±0.08	4.85 ±0.21	0.00 ±0.00	0.374 ±0.08	4.87 ±0.03	0.00 ±0.00	0.320 ±0.08
	3rd	4.94 ±0.07	0.00 ±0.00	0.390 ±0.06	4.97 ±0.05	0.00 ±0.00	0.287 ±0.08	5.00 ±0.08	0.00 ±0.00	0.248 ±0.05
	Cumulative		5.00			4.50			4.17	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.



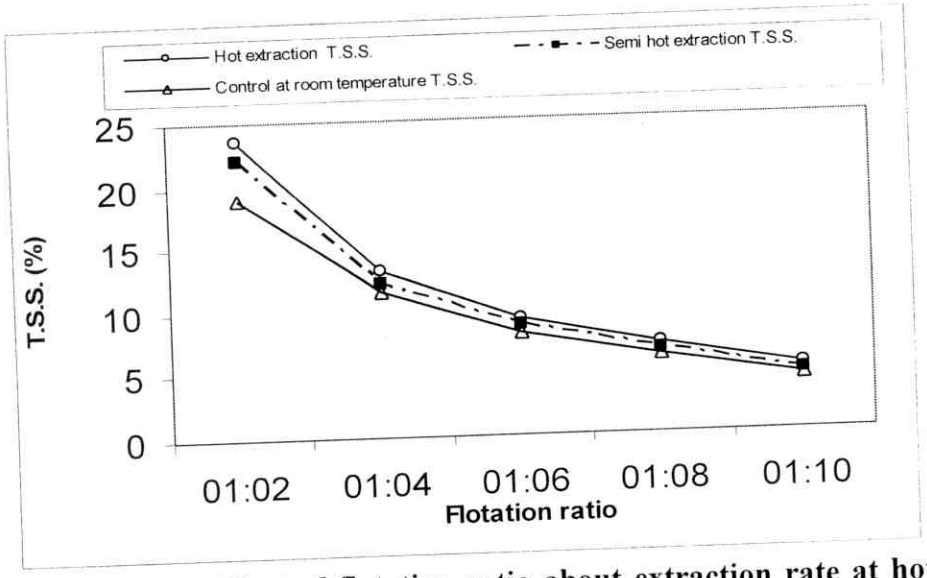


Figure (18): Effect of flotation ratio about extraction rate at hot and semi hot conditions of crushed carob components (T.S.S. and O.D.).

At 100 °C maximum T.S.S. achieved after first extraction with the optimum flotation ratio (2:1) were 23.50%, which represent about 25.53%. 2nd re-extraction added another 9.00% which represent 9.77%. After three successive re-extraction, the maximum cumulative extraction reached 36.50%, which represent about 39.66% of T.S.S. contained in pulp powder.

With semi-hot, maximum, T.S.S. achieved after first extraction with the optimum flotation ratio (2:1) were 22.00%, which represent about 23.90%. 2nd re-extraction added another 8.50%, which represent 9.23% After three successive re-extraction, the maximum cumulative extraction reached 34.00% which represent about 36.94% recovery of T.S.S. contained in pulp powder.

Increasing the flotation ratio more than 2:1 did not improve the extractability of carob pulp components. Similarly, increasing re-extraction more than double did not improve the extractability of carob pulp components where the maximum T.S.S. of 3rd extraction achieved were only 3.50% which represent about 3.80% recovery of T.S.S. contained in pulp powder.

Flotation ratio of 2:1 could be the best or optimum ratio, which gave maximum extractability. Furthermore, extraction 100°C exhibited maximum extractability compared to room and semi-hot conditions. Double successive extraction was found sufficient for the maximum recovery of the carob soluble components. These obtained results agree with those obtained by **Zin El-Dine (1999).**

4.2.4.2.2. Effect of temperature degree on extraction rate:

The effect of applying different degrees of temperature from 60°C to 100°C (60, 70, 80, 90 and 100°C) on extraction rate and re-extraction or successive extraction of components of carob pulp of were investigated and results are tabulated in Table (38) and Fig. (19).

Maximum T.S.S. achieved after first extraction at 100 °C was 22.50%, which represent about 24.44%. 2nd re-extraction added another 10.0%, which represent 10.86% After three successive re-extraction, the maximum cumulative extraction reached 36.50% which represents 39.66% of the total solids contained in carob pulp while the minimum T.S.S. achieved after first extraction trial at 60°C were 20.67% which represent about 22.46%. 2nd re-extraction added another 9.00%, which represent 9.77%. After three successive re-extraction, the maximum cumulative extraction reached 32.17%, which represent 34.95% of the total solids contained in carob pulp. These obtained results were parallel with those obtained by **Sharf (2003).**

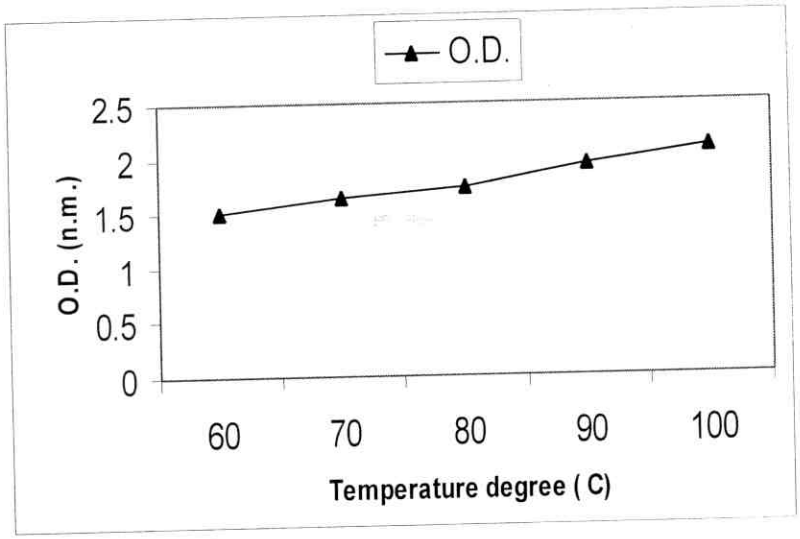
4.2.4.2.3. Effect of extraction periods on extraction rate of crushed carob pulp Tylliria variety:

The effect of periods of extraction (from 15min. to 120 min.) at (100°C) on extractability and the re-extraction or successive extraction of carob components of pulp was investigated and results are presented in Table (39) and Fig. (20).

Maximum T.S.S. and O.D. values were achieved after 120 min. After first extraction, T.S.S. reached 24.50%, which represent about 26.62%. 2nd re-extraction added another 11.50%, which represent 12.49%. After three successive re-extraction, the maximum cumulative extraction reached 41.00%, which

Table (38): Effect of temperature degree (up to 100°C) on extractability of crushed carob.

Extraction temperatures	Sequence of extraction	Determination		
		pH	T.S.S.	O.D.
60°C	1st	4.87±0.04	20.67±0.20	1.508±0.30
	2nd	4.92±0.1	9.00±0.29	0.772±0.28
	3rd	4.95±0.08	3.17±0.22	0.437±0.16
	Cumulative		32.17	
70°C	1st	4.81±0.11	21.00±0.23	1.640±0.31
	2nd	4.90±0.07	11.22±0.29	0.926±0.24
	3rd	4.93±0.07	3.50±0.25	0.635±0.1
	Cumulative		35.72	
80°C	1st	4.78±0.04	21.50±0.23	1.723±0.37
	2nd	4.88±0.12	9.50±0.29	1.036±0.26
	3rd	4.92±0.21	4.00±0.21	0.855±0.11
	Cumulative		35.00	
90°C	1st	4.76±0.06	22.00±0.20	1.918±0.40
	2nd	4.85±0.01	9.50±0.29	1.144±0.21
	3rd	4.90±0.20	4.17±0.23	0.926±0.13
	Cumulative		35.67	
100°C	1st	4.72±0.05	22.50±1	2.078±0.28
	2nd	4.81±0.07	10.00±0.5	1.236±0.20
	3rd	4.87±0.08	4.17±0.29	0.980±0.12
	Cumulative		36.50	



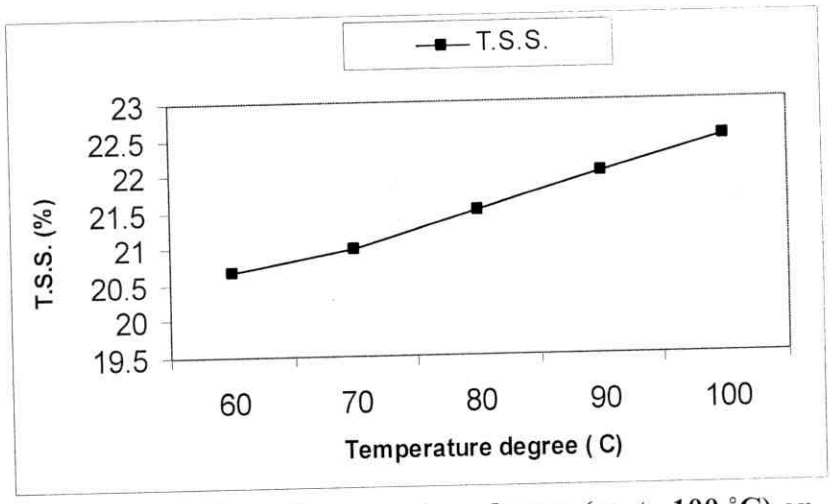
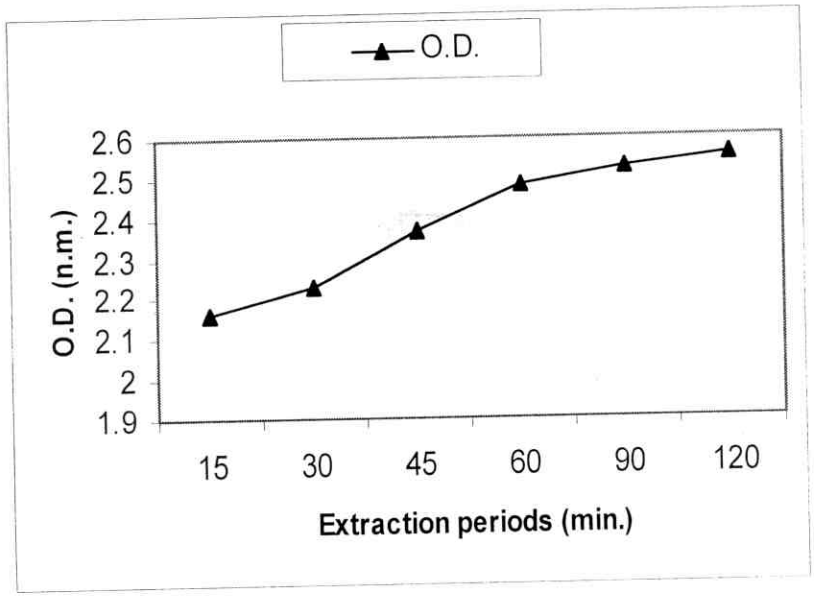


Figure (19): Effect of temperature degree (up to 100 °C) on extractability of crushed carob components (T.S.S. and O.D.).

Table (39): Effect of extraction periods at hot condition on extractability of crushed carob.

Extraction periods		Determination		
		pH	T.S.S.	O.D.
15 min.	1st	4.76±0.12	21.50±0.42	2.158±0.31
	2nd	4.87±0.04	8.50±0.29	1.065±0.32
	3rd	4.95±0.06	4.00±0.44	0.582±0.13
	Cumulative		34.00	
30 min.	1st	4.73±0.05	23.17±0.5	2.231±0.44
	2nd	4.81±0.07	9.33±1	1.175±0.31
	3rd	4.93±0.1	4.17±0.00	0.590±0.1
	Cumulative		36.67	
45 min.	1st	4.69±0.05	23.50±0.29	2.367±0.46
	2nd	4.79±0.1	10.50±0.45	1.204±0.35
	3rd	4.91±0.11	4.50±0.32	0.609±0.11
	Cumulative		38.50	
60 min.	1st	4.68±0.06	24.00±0.20	2.482±0.41
	2nd	4.74±0.02	11.17±0.5	1.268±0.33
	3rd	4.88±0.11	5.00±0.00	0.824±0.1
	Cumulative		40.17	
90 min.	1st	4.66±0.1	24.17±0.41	2.522±0.40
	2nd	4.70±0.05	11.50±0.29	1.963±0.31
	3rd	4.87±0.09	5.33±0.23	1.074±0.08
	Cumulative		41.00	
120 min.	1st	4.63±0.09	24.50±0.5	2.558±0.42
	2nd	4.68±0.06	11.50±0.21	1.735±0.27
	3rd	4.83±0.06	5.00±0.00	1.182±0.08
	Cumulative		41.00	



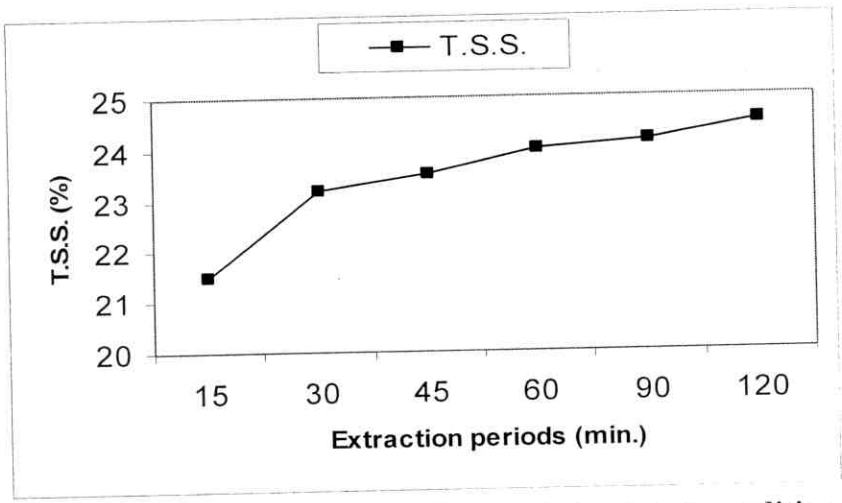


Figure (20): Effect of extraction periods at hot condition on extraction rate of crushed carob (T.S.S. and O.D.).

represent 44.55% of the total solids contained in carob pulp. The minimum T.S.S. value was achieved after 15 min. of extraction; where the first extraction attained only 21.50%, which represent about 23.36%. The 2nd re-extraction added another 8.50%, which represent 9.23%. After three successive re-extraction, maximum cumulative extraction reached 34.00%, which represent 36.94% of the total solids contained in carob pulp.

From the presented data, it could be concluded that optimum extraction period of only 30 min at 100°C was selected to compromise between speed of extraction and maximum extractability of components crushed carob.

Table (40) and Fig. (21) show the effect of applying longer duration of extraction (from 0.5 hrs to 6 hrs) in room temperature and semi–hot conditions on extractability rate and the re-extraction or successive extraction of components of carob pulp.

There was gradual increase in values for T.S.S. and O.D. with increase in duration from 0.5 hrs to 6 hrs. However, such increase was not pronounced with increasing period of extraction longer than two hrs. In contrast, the pH decreased gradually.

At semi-hot conditions, maximum T.S.S. was achieved after 6 hrs where after the 1st extraction reached 23.67%, which represent about 25.71%. 2nd re-extraction added another 10.00%, which represent 10.86%. After three successive re-extraction, the maximum cumulative extraction reached 37.84%, which represent about 41.11% of T.S.S. contained in pulp powder.

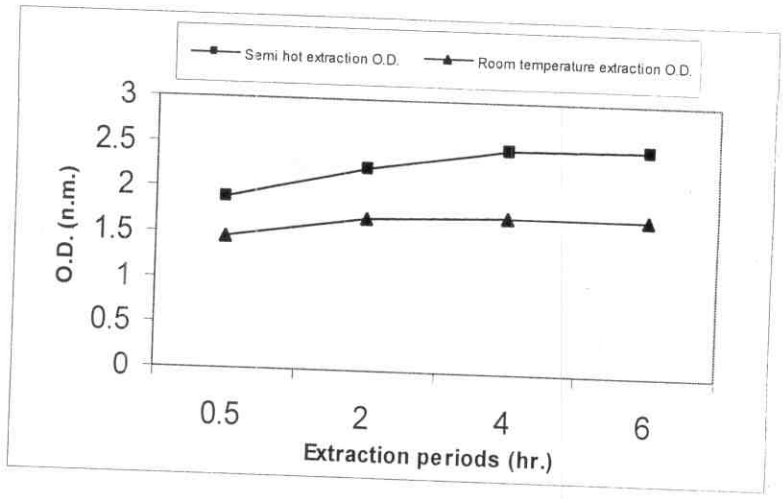
At room temperature, maximum T.S.S. was achieved also after at 6 hrs where the 1st extraction attained 22.00%, which represent about 23.90%. 2nd re-extraction added another 10.00%,

Table (40): Effect of extraction periods at room temperature and semi hot conditions* on extractability of crushed carob (Tylliria variety).

Extraction periods	Sequence of extraction	Methods of extraction**					
		Room temperature extraction			Semi hot extraction		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
30 min.	1st	4.86±0.07	19.5±0.22	1.463±0.32	4.80±0.11	20.50±0.22	1.882±0.30
	2nd	4.90±0.12	8.50±0.5	0.718±0.31	4.86±0.09	9.00±0.50	1.067±0.02
	3rd	4.93±0.03	2.00±0.29	0.476±0.09	4.90±0.04	3.00±0.21	0.560±0.10
	Cumulative		30.00			32.00	
2 hrs.	1st	4.85±0.13	21.17±0.20	1.692±0.41	4.78±0.08	22.00±0.22	2.246±0.35
	2nd	4.89±0.04	9.00±0.29	0.735±0.25	4.86±0.08	9.50±0.50	1.120±0.28
	3rd	4.91±0.02	3.00±0.22	0.514±0.16	4.88±0.05	3.50±0.00	0.683±0.11
	Cumulative		33.17			35.00	
4 hrs.	1st	4.82±0.03	22.00±0.21	1.723±0.39	4.76±0.14	23.50±0.36	2.475±0.42
	2nd	4.87±0.04	9.50±0.19	0.780±0.33	4.85±0.02	10.00±0.44	1.184±0.31
	3rd	4.89±0.07	3.50±0.00	0.572±0.12	4.87±0.06	4.00±0.50	0.847±0.12
	Cumulative		35.00			37.50	
6 hrs.	1st	4.80±0.08	22.00±0.22	1.736±0.42	4.73±0.04	23.67±0.5	2.501±0.44
	2nd	4.85±0.03	10.00±0.29	0.794±0.34	4.83±0.27	10.00±0.5	1.192±0.33
	3rd	4.87±0.03	3.17±0.00	0.583±0.11	4.85±0.05	4.17±0.5	0.874±0.14
	Cumulative		35.17			37.84	

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.

** Mean of triplicate determinations ±SE



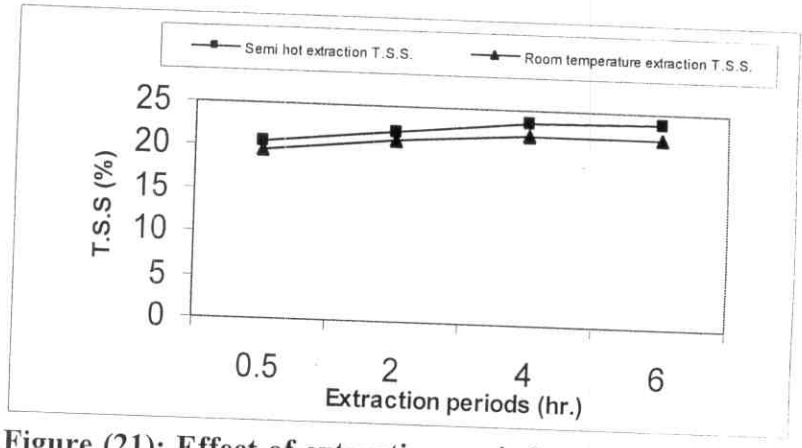


Figure (21): Effect of extraction periods at room temperature and semi hot conditions on extraction rate of crushed carob components (T.S.S. and O.D.).

which represent 10.86%. After three successive re-extraction trials, the maximum cumulative extraction reached 35.17%, which represent about 38.21% of T.S.S. contained in pulp powder.

Although the period of extraction of 6 hrs was found the best for maximum extractability at both room and semi-hot temperature extraction period of only two hrs was selected to compromise between speed, economy of extraction and maximum extractability of carob components. These obtained results agree with those obtained by **Zin El-Dine (1999).**

4.2.4.2.4. Effect of pH medium on extraction rate of crushed carob pulp:

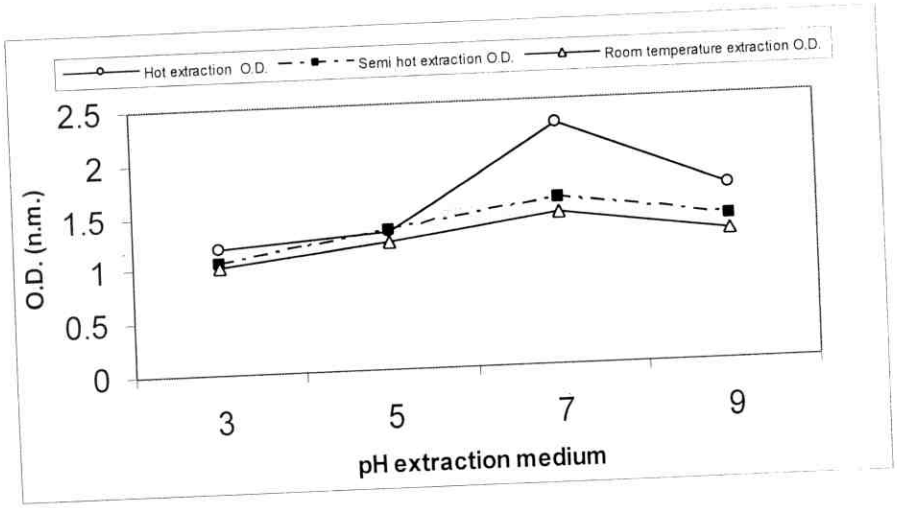
The effect of variation in pH (from 3 to 9) on extractability and the re-extraction or successive extraction of components of carob pulp was investigated and results are tabulated in Table (41) and Fig. (22).

Using 100°C, the maximum T.S.S. were attained at pH 7, where the 1st extraction reached 24.00% which represent about 26.07%. 2nd re-extraction added another 9.50%, which represent 10.32%. After three successive re-extraction, the maximum cumulative extraction reached 37.67%, which represent about 40.93% of T.S.S. contained in pulp powder.

With semi-hot condition, maximum T.S.S. was achieved when pH value of extraction medium was (pH =7), where the 1st extraction reached 23.00% which represent about 24.99%. 2nd re-extraction added another 9.50%, which represent 10.32%. After three successive re-extraction, the maximum cumulative extraction reached 36.67%, which represent about 39.94% of

Table (41): Effect of pH of extraction medium on extractability of crushed Carob.

pH of extraction	Sequence of extraction	Methods of extraction								
		Hot extraction (100 °c)			Semi hot extraction			Room temperature extraction		
		pH	T.S.S.	O.D.	pH	T.S.S.	O.D.	pH	T.S.S.	O.D.
pH 3	1st	4.66 ±0.11	22.50 ±0.29	1.186 ±0.31	4.69 ±0.05	22.00 ±0.29	1.037 ±0.32	4.72 ±0.03	20.50 ±0.25	1.001 ±0.31
	2nd	469 ±0.05	9.00 ±0.29	0.967 ±0.22	4.71 ±0.10	8.50 ±0.44	0.918 ±0.32	4.74 ±0.05	8.00 ±0.29	0.882 ±0.2
	3rd	4.77 ±0.07	3.17 ±0.29	0.620 ±0.17	4.79 ±0.03	3.50 ±0.00	0.506 ±0.12	4.83 ±0.02	3.50 ±0.5	0.351 ±0.1
	Cumulative		34.67			34.00			32.00	
pH 5	1st	4.68 ±0.11	23.00 ±0.12	1.294 ±0.44	4.70 ±0.11	22.50 ±0.5	1.314 ±0.38	4.75 ±0.09	21.00 ±0.25	1.210 ±0.37
	2nd	4.71 ±0.09	9.17 ±0.26	1.110 ±0.2	4.73 ±0.05	9.00 ±0.5	0.932 ±0.2	4.76 ±0.12	8.17 ±0.29	0.564 ±0.21
	3rd	4.79 ±0.11	4.00 ±0.19	0.804 ±0.1	4.82 ±0.04	4.00 ±0.5	0.612 ±0.14	4.85 ±0.07	4.50 ±0.00	0.362 ±0.1
	Cumulative		36.17			35.50			33.67	
pH 7	1st	4.70 ±0.03	24.00 ±0.36	2.276 ±0.38	4.72 ±0.11	23.00 ±0.29	1.568 ±0.41	4.77 ±0.03	21.50 ±0.42	1.428 ±0.32
	2nd	4.73 ±0.06	9.50 ±0.29	1.454 ±0.22	4.76 ±0.1	9.50 ±0.29	1.032 ±0.21	4.79 ±0.1	8.50 ±0.29	0.693 ±0.22
	3rd	4.81 ±0.04	4.17 ±0.29	0.926 ±0.11	4.86 ±0.1	4.17 ±0.00	0.670 ±0.12	4.87 ±0.1	4.50 ±0.29	0.424 ±0.11
	Cumulative		37.67			36.67			34.50	
pH 9	1st	4.72 ±0.04	23.50 ±0.20	1.638 ±0.45	4.74 ±0.05	22.50 ±0.5	1.348 ±0.37	4.79 ±0.08	20.00 ±0.29	1.226 ±0.35
	2nd	4.76 ±0.03	9.17 ±0.29	1.206 ±0.32	4.78 ±0.04	9.17 ±0.36	0.982 ±0.21	4.81 ±0.07	8.17 ±0.58	0.718 ±0.24
	3rd	4.83 ±0.1	4.00 ±0.00	0.835 ±0.11	4.88 ±0.04	4.00 ±0.00	0.640 ±0.11	4.90 ±0.11	4.00 ±0.29	0.416 ±0.11
	Cumulative		36.67			35.67			32.17	



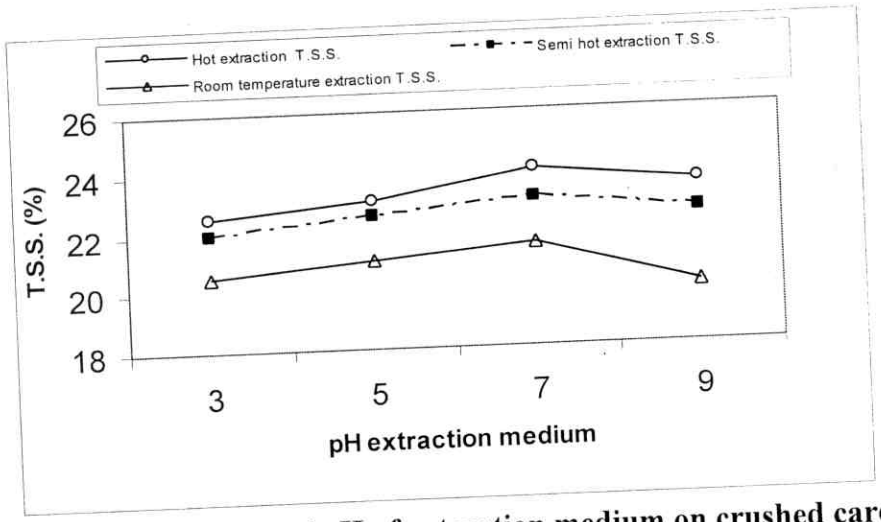


Figure (22): Effect of pH of extraction medium on crushed carob components (T.S.S. and O.D.).

T.S.S. contained in pulp powder. Similarly, at room temperature condition, the maximum T.S.S. were attained using (pH =7), where the 1st extraction reached 21.50% which represent about 23.36%. 2nd re-extraction added another 8.50%, which represent 9.23%. After three successive re-extraction, the maximum cumulative extraction reached 34.50%, which represent about 37.48% of T.S.S. contained in pulp powder.

From the presented data it could be concluded that an optimum pH medium of extraction of pH=7 at different temperature conditions was selected to compromise between speed of extraction and maximum extractability of components of crushed carob. These obtained results agree with those obtained by **Roseiro *et al.*, (1991)** who found that the best pH medium for extraction was pH 6.8.

4.2.4.3. Effect of different extraction conditions on sensory evaluation for carob extract.

Carob extracts were evaluated organoleptically using ten panelists for their color, taste, odor, texture and overall acceptability where scores given and their mean values were statistically analyzed using analysis of variance and least significant difference (LSD), as presented in Tables (42, 43 and 44).

Data in Table (42) illustrated the sensory evaluation of laboratory-made carob beverages prepared at different flotation ratios executed under different extraction conditions (optimum hot, semi-hot and under room temperature conditions). The ANOVA analysis indicated that there were significant differences ($P \geq 0.05$) between the different treatments for

Table: (42): Sensory evaluation of carob beverages prepared at different flotation ratios under optimum room temperature, semi hot* and hot** conditions.

Treatment	Sensory scores attributes*																								
	Color 25					Taste 25					Odor 25					Texture 25					Overall acceptability 100				
	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10	1:2	1:4	1:6	1:8	1:10
Room temperature	21.1^{b} ±0.7	20.4^{c} ±0.8	19.7^{b} ±0.9	18.1^{b} ±1.6	15.1^{b} ±1.7	21.5^{b} ±0.5	20.1^{b} ±1.0	19.3^{b} ±1.1	17.2^{c} ±1.3	14.7^{b} ±2.3	20.8^{b} ±1.2	20.0^{b} ±1.2	19.3^{b} ±1.6	17.6^{c} ±2.1	14.8^{c} ±2.1	20.6^{c} ±0.8	20.0^{b} ±1.1	19.5^{b} ±1.0	18.5^{b} ±1.4	15.0^{b} ±2.3	85.5^{c} ±4.4	79.0^{c} ±3.2	72.6^{c} ±3.6	65.0^{c} ±4.7	56.8^{c} ±5.8
Semi-Hot	22.6^{a} ±1.0	21.7^{b} ±1.0	20.7^{a} ±1.0	19.1^{a} ±1.6	16.6a ±5.5	22.6^{a} ±0.5	21.3^{b} ±1.3	20.3^{a} ±1.1	18.0^{b} ±1.5	15.5^{a} ±2.3	22.0^{a} ±1.5	21.3^{a} ±1.3	20.5^{a} ±1.7	18.8^{b} ±1.8	15.8^{b} ±2.4	21.8b ±0.6	21.5^{a} ±0.7	20.5^{a} ±0.9	19.6^{a} ±1.5	16.1^{a} ±2.6	89.5 ±3.6	84.4^{b} ±3.5	79.5^{b} ±3.3	73.9^{b} ±3.3	64.0^{b} ±4.7
Hot	23.4^{a} ±0.8	22.0^{a} ±0.9	21.6a ±1.1	19.8^{ab} ±1.7	17.1^{a} ±3.2	23.1^{a} ±1.4	21.6^{a} ±1.7	21.1^{a} ±1.6	19.0^{a} ±1.7	15.7a ±2.9	22.8^{a} ±1.8	21.9^{a} ±1.6	21.1^{a} ±2.0	19.3^{a} ±2.2	17.0a ±3.4	22.7^{a} 0.8	22.a ±0.9	21.1^{a} ±1.0	20.2^{a} ±1.6	16.5^{a} ±3.5	93.1^{a} ±4.2	89.3^{a} ±5.0	84.3a ±6.8	78.4^{a} ±5.2	66.5^{a} ±8.6
Mean	22.4 ±1.3	21.4 ±1.1	20.7 ±1.2	19.0 ±1.7	16.3 ±3.8	22.4 ±1.1	21.0 ±1.5	20.2 ±1.4	18.1 ±1.6	15.3 ±2.5	21.9 ±1.7	21.1 ±1.5	20.3 ±1.8	18.6 ±2.1	15.9 ±2.8	21.7 1.1	21.2 ±1.2	20.4 ±1.1	19.4 ±1.6	15.9 ±2.8	89.4 ±5.1	84.2 ±5.7	78.8 ±6.7	72.4 ±7.1	62.4 ±7.6
LSD S	1.01					0.81					0.98					0.81					2.47				
LSD T	0.78					0.63					0.76					0.63					1.91				
LSD SxT	1.75					1.41					1.70					1.40					4.27				

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.

** Hot condition: extraction in boiling water (100 °C).

*** Values represent scores of 10 panelists (Mean± S.E).

variable flotation ratios and conditions of extraction in all scores given for taste, odor, texture and overall acceptability scores. The highest scores were given to flotation ratio (2:1) at hot condition, which were 23.40, 23.10, 22.80, 22.70 and 93.10, for color, taste, odor, texture and overall acceptability, respectively. On the other hand, the lowest scores given to flotation ratio (10:1) at room temperature for color, taste, odor, texture and overall acceptability were, 15.10, 14.70, 14.80, 15.00 and 56.80, respectively.

Table (43). It was observed that high significant differences ($P \geq 0.05$) existed between the treatments of different extraction periods and methods of extraction in color for taste, odor, texture and overall acceptability. The highest scores were attained by treatment executed at 100°C for 30 min, where the given scores for color, taste, odor, texture and overall acceptability were, 22.80, 22.40, 22.60, 22.70 and 89.00, respectively.

Data recorded in Table (44) illustrated sensory evaluation for laboratory-made carob beverages prepared at different temperatures up to 100°C. It was noticed that high significant differences ($P \geq 0.05$) existed between treatments prepared under the different degrees of hot temperatures in the scores given for color, taste, odor, texture and overall acceptability. The highest scores were attained by treatment prepared at 100°C, where scores given for color, taste, odor, texture and overall acceptability were, 23.30, 23.30, 22.80, 21.90 and 91.40, respectively. The lowest scores were showed by treatment prepared at 60°C, where scores given for color, taste, odor,

Table: (43): Sensory evaluation for carob beverages prepared at different extraction periods under room temperature, semi hot* and hot **conditions.

Treatment	Sensory scores attributes*																			
	Color 25				Taste 25				Odor 25				Texture 25				Overall acceptability 100			
	15 m.	30 m.	45 m.	60 m.	15 m.	30 m.	45 m.	60 m.	15 m.	30 m.	45 m.	60 m.	15 m.	30 m.	45 m.	60 m.	15 m.	30 m.	45 m.	60 m.
Hot	20.8^{a} ±1.8	22.8^{a} ±1.8	21.5^{a} ±1.4	21.7^{a} ±1.1	20.60^{a} ±2.59	22.40^{a} ±1.90	21.20^{a} ±1.93	20.00^{a} ±3.27	20.9^{a} ±3.1	22.6^{a} ±2.4	20.7^{a} ±3.4	20.8^{a} ±4.4	20.4^{a} ±3.3	22.7^{a} ±2.2	21.3^{a} ±2.3	20.7^{a} ±1.9	79.8^{a} ±9.1	89.0^{a} ±4.3	84.3^{a} ±4.1	78.6^{a} ±8.3
Periods	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.	0.5 hr.	2 hr.	4 hr.	6 hr.
Room temperature	19.9^{b} ±0.6	21.2^{b} ±0.8	20.0b ±0.8	20.3^{b} ±0.7	19.00^{b} ±1.15	21.70^{a} ±1.49	20.70^{a} ±1.89	19.20^{a} ±2.10	19.2^{b} ±1.2	21.1^{b} ±0.7	19.6^{a} ±0.8	19.3^{b} ±2.0	18.6^{b} ±1.1	20.7^{c} ±0.9	19.6^{c} ±1.3	18.8^{bc} ±2.0	73.0^{b} ±7.8	81.6^{c} ±6.4	76.4^{c} ±5.8	75.7^{a} ±10.7
Semi-Hot	20.5^{a} ±0.9	22.3^{a} ±1.0	21.1^{c} ±1.0	21.5^{a} ±0.5	19.80^{a} ±1.75	21.70^{a} ±1.42	20.80^{a} ±1.81	19.40^{a} ±1.70	20.5^{a} ±1.4	22.3^{a} ±0.7	20.4^{a} ±1.0	20.2^{a} ±1.6	20.1^{a} ±1.4	21.5^{b} ±1.2	20.1^{b} ±1.5	19.6^{b} ±1.9	77.1^{a} ±8.1	85.0^{b} ±6.6	77.3^{b} ±5.7	77.7^{a} ±10.2
Mean	20.4 ±1.2	22.1 ±1.4	20.9 ±1.3	21.2 ±1.0	19.80 ±1.97	21.93 ±1.60	20.90 ±1.83	19.53 ±2.39	20.2 ±2.1	22.0 ±1.6	20.2 ±2.1	20.1 ±2.9	19.7 ±2.2	21.6 ±1.7	20.3 ±1.8	19.7 ±2.1	76.6 ±8.3	85.2 ±6.4	79.3 ±6.2	77.33 ±9.7
LSD S	0.56				1.01				1.12				0.94				3.82			
LSD T	0.43				0.78				0.87				0.73				2.96			
LSD SxT	0.96				1.74				1.94				1.63				6.61			

* Semi hot condition: extraction in boiling water (100 °C) followed by different periods of soaking at the same water.
** Hot condition: extraction in boiling water (100 °C).
*** Values represent scores of 10 panelists (Mean± S.E).

Table (44): Sensory evaluation for carob beverages prepared at different temperatures up to 100°C.

Extraction temperatures	Sensory scores attributes*				
	Color 25	Taste 25	Odor 25	Texture 25	Overall acceptability 100
60 °C	18.1±1.9^{e}	17.9±1.3^{e}	17.3±0.9^{e}	18.0±1.2^{e}	75.2±6.2^{e}
70°C	19.3±1.8^{d}	18.9±1.4^{d}	18.9±1.1^{d}	19.3±0.8^{d}	79.5±6.4^{d}
80°C	20.5±1.4^{c}	20.1±1.6^{c}	20.3±0.8^{c}	20.4±0.7^{c}	83.8±5.7^{c}
90°C	21.4±1.4^{b}	21.4±1.6^{b}	21.4±1.0^{b}	21.1±0.7^{b}	86.8±4.5^{b}
100°C	23.3±0.9^{a}	23.3±0.9^{a}	22.8±0.8^{a}	21.9±0.9^{a}	91.4±4.1^{a}
LSD 5%	0.14	0.12	0.08	0.08	0.49

*Values represent of 10 panelists (Mean± S.E).

texture and overall acceptability were, 18.10, 17.90, 17.30, 18.00 and 75.20, respectively.

From abovementioned results, it could be concluded that the optimum conditions for extracting carob pulp into beverage, which attained the highest overall acceptability scores from panelists: a flotation ratio of 2: 1, at 100°C for 30 min. These obtained results agree with those obtained by **Zin El-Dine (1999).**

4.2.5. Survey study of carob beverage samples collected from some Egyptian local markets:

Since carob, beverages are considered one of the most important and widespread beverages in Egypt, the survey study employed 10 different samples, which were collected from different local markets from Egypt. All samples were recognized as natural-made beverages.

These samples were collected in the early morning and analysis was performed after their arrival into without any delay.

4.2.5.1. Physicochemical properties of natural carob beverages:

The physicochemical properties of carob beverages are shown in Table (45). The total solids content of carob ranged between 12.59 and 23.91%. Total soluble sugars ranged from 11.30 to 22.67%. Reducing sugars content ranged from 0.78 to 1.81%. The non-reducing soluble sugars ranged from 10.39 to 21.00%.

However, most of samples showed low crude protein values which ranged from 0.12 to 0.54%. Ash content, ranged from 0.07 to 0.23%.

Table (45): Physicochemical properties of examined natural carob beverages.

Components**	Collected samples*									
	1	2	3	4	5	6	7	8	9	10
Moisture %	84.37±0.12	82.36±0.15	76.09±0.00	78.00±0.15	81.27±0.10	87.41±0.04	86.10±0.29	84.79±0.19	85.59±0.11	81.55±0.09
Total solids %	15.63±0.12	17.64±0.15	23.91±0.00	22±0.15	18.73±0.10	12.59±0.04	13.90±0.29	15.21±0.19	14.41±0.11	18.45±0.09
T.S.S. %	15±0.09	17±0.10	23±0.06	20.5±0.12	17±0.05	11.5±0.06	13.16±0.16	14.33±0.12	14±0.06	18.17±0.16
Total insolubie solids %	0.63±0.00	0.64±0.00	0.91±0.00	1.5±0.00	1.73±0.00	1.09±0.00	0.74±0.16	0.88±0.16	0.41±0.00	0.28±0.16
Fat %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude protein %	0.53±0.05	0.38±0.01	0.25±0.01	0.49±0.04	0.44±0.06	0.52±0.07	0.53±0.03	0.54±0.04	0.12±0.01	0.12±0.02
Ash %	0.07±0.01	0.08±0.01	0.08±0.01	0.23±0.02	0.15±0.02	0.07±0.01	0.19±0.00	0.22±0.001	0.23±0.00	0.11±0.02
Total carbohydrates%***	15.02	17.18	23.58	21.28	18.14	12.00	13.18	14.45	14.06	18.22
Total sugars %	14.52±0.07	16.56±0.16	22.67±0.07	19.87±0.30	16.68±0.12	11.30±0.01	13.08±0.09	14.20±0.09	13.41±0.1	17.92±0.04
Reducing sugars %	0.78±0.11	1.73±0.10	1.67±0.06	0.97±0.10	1.09±0.16	0.91±0.06	1.81±0.06	1.35±0.11	1.62±0.12	1.62±0.12
Non reducing sugars %	13.74±0.18	14.83±0.05	21.00±0.01	18.9±0.41	15.58±0.03	10.39±0.05	11.27±0.15	12.85±0.19	11.79±0.23	16.30±0.13
pH value	4.52±0.03	4.80±0.05	5.68±0.01	5.30±0.00	5.25±0.01	5.77±0.06	5.24±0.01	5.17±0.04	4.98±0.08	4.77±0.02
Titratable acidity %	0.09±0.00	0.08±0.00	0.03±0.00	0.04±0.00	0.05±0.00	0.02±0.00	0.05±0.00	0.06±0.00	0.07±0.00	0.08±0.00
Color index	0.899±0.09	1.112±0.06	2.890±0.14	2.107±0.10	1.811±0.05	2.197±0.08	0.889±0.02	1.478±0.04	2.484±0.02	3.036±0.14
Anthocyanin (mg/100g)	0.268±0.05	0.323±0.01	0.482±0.02	0.433±0.08	0.340±0.06	0.439±0.08	0.213±0.02	0.236±0.03	0.598±0.01	1.015±0.11
Specific gravity	1.0603±0.08	1.0689±0.06	1.0956±0.1	1.0843±0.06	1.0689±0.09	1.0456±0.11	1.0525±0.01	1.0575±0.08	1.0561±0.01	1.0740±0.0
Refractive index	1.3564±0.09	1.3594±0.10	1.3694±0.06	1.3654±0.12	1.3594±0.05	1.3504±0.06	1.3527±0.16	1.3554±0.12	1.3544±0.06	1.3613±0.1

* Origin of collected samples.

** Mean of triplicate determinations ±SE.

*** Calculated by difference.

Furthermore, titratable acidity content ranged from 0.02 to 0.09%, while pH value ranged from 4.52 to 5.77. On the other side, the values of these parameters for carob beverages ranged from 0.889 to 3.036, 0.213 to 1.015 and 1.3504 to 1.3694 for color index, anthocyanin content and refractive index, respectively. These obtained results agree with those obtained by **El-Nahry *et al.* (1993).**

4.2.6.2. Microbiological quality on natural carob beverages:

Natural carob beverages are considered to be a suitable medium for growth of various micorganisms. Higher microbial load in beverages could prove certain changes in flavor, color and over all acceptability.

The total counts of microorganisms isolated are presented in Table (46).

The total microbial count ranged between $6.1x10^2$ c.f.u./ml and $9x10^6$ c.f.u./ml. Yeast and mold counts ranged between $2.05x10^2$ to $5.05x10^5$ c.f.u./ml.

Furthermore, examination of all carob beverages illustrated that *Sporformer bacteria* were not detected. However, *Staph.* count ranged between $7.75x10^2$ to $2.31x10^5$ c.f.u./ml., *Lactic acid bacteria* count ranged from $4.35x10^2$ to $5.4x10^5$ c.f.u./ml. *Psychrophilic bacteria* count ranged from $5.65x10^2$ to $8.2x10^6$ c.f.u./ml.

Coliform bacteria count ranged from $4.1x10^3$ to $3.6x10^5$ c.f.u./ml. These obtained results agree with those obtained by **Henis *et al.* (1964)** who reported that carob beverages were high load of microorganisms.

Table (46): Microbiological quality of natural carob beverages.

Microorganisms**	Collected samples*									
	1	2	3	4	5	6	7	8	9	10
Total bacterial count	$2.21X10^6$	$2.77X10^6$	$7.95X10^4$	$1.43X10^5$	$4.9X10^5$	$6.95X10^5$	$6.1X10^2$	$5.45X10^3$	$4.95X10^4$	$9X10^6$
Sporformer bacteria.	ND***	ND	ND	ND	ND	ND***	ND	ND	ND	ND
Lactic acid bacteria.	ND	$5.3X10^5$	ND	$6.2X10^4$	$8.9X10^4$	$5.4X10^5$	$4.35X10^2$	$9.15X10^2$	$4.85X10^4$	$5.95X10^4$
Psychrophylic bacteria.	$2.49X10^5$	$2.69X10^6$	$1.99X10^4$	$4.3X10^4$	$4.45X10^5$	$5.85X10^5$	$5.65X10^2$	$5.2X10^3$	$1.09X10^4$	$8.2X10^6$
Coliform group.	$2.21X10^5$	$1.76X10^5$	ND	$4.8X10^4$	$1.7X10^4$	$1.7X10^4$	ND	$4.1X10^3$	$7.2X10^3$	$3.6X10^5$
Staphylococcus.	$2.06X10^5$	$2.31X10^5$	$2.05X10^3$	$5.4X10^4$	$3.8X10^4$	$1.85X10^4$	ND	$7.75X10^2$	$5.65X10^3$	$8.25X10^4$
Yeasts and moulds.	$3.6X10^4$	$5.05X10^5$	$1.4X10^4$	$1.28X10^5$	$1.11X10^5$	$9.55X10^4$	$2.05X10^2$	$2.3X10^3$	$4.6X10^4$	$2.35X10^5$

* Origin of collected samples.
* Mean of duplicate determinations.
*** ND: Not detect.

4.2.6. Essential minerals of carob pulp:

The present study comprised analysis of nine essential elements, five macro-elements (Calcium, Magnesium, Phosphorus, Sodium and Potassium) and four microelements (Iron, Copper, Manganese and Zinc) which are present carob beverages in Egypt. Minerals analysis of Ca, K, Mg, Na, Fe, Mn, Cu and Zn were performed using flame atomic absorption spectroscopy and spectrophotometric determination of phosphorous. The essential minerals are illustrated in Table (47).

Crushed carob contained higher mineral content than whole carob. Generally, carob pulp proved to contain appreciable high amount of potassium, calcium and magnesium.

Macro elements were ranked in a decreasing order of abundance as follows: potassium, calcium, magnesium, phosphorous and sodium.

Potassium constituted the first major essential macro-element as it ranged from 697.23 and 766.31 mg/100g. The maximum content was registered in crushed while the minimum content was in whole carob. 200g of carob pod could satisfy or cover half of the RDA for adult humans from potassium as indicated by **RDAs (2009).**

Calcium constituted the second major essential macro-element as it ranged from 312.14 and 384.26 mg/100g. The maximum content was recorded in crushed sample while the minimum content was in whole carob. The content of only 200g of carob could satisfy or cover most of the daily requirements for adult humans from calcium as indicated by **WHO and FAO (2004).**

Table (47): Spectrophotometeric determination of mineral content of expermintal carob pulp samples.

Main group of essential minerals	Minerals	Carob form	
		Carob whole	Carob crushed
Macro elements	Calcium	312.14	384.26
	Sodium	13.10	19.53
	Potassium	697.23	766.31
	Magnesium	64.73	75.82
	Phosphorus	42.31	57
Micro elements	Iron	5.40	7.11
	Copper	ND*	ND
	Manganese	ND	ND
	Zinc	0.26	0.43

* ND: Not determined.

Magnesium constituted the third major essential macro-element as it ranged from 64.73 and 75.82 mg/100g. The maximum content was found in crushed carob while the minimum content was found in whole carob. The content of only 200g of carob could satisfy or cover 1/2 of the daily requirements for adult humans from magnesium as indicated by **WHO and FAO (2004).**

Phosphorous constituted the fourth major essential macro-element as it ranged from 42.31 and 57.00 mg/100g. The maximum content was registered in crushed carob, while the minimum content was in whole carob. The content of only 200g of carob could satisfy or cover $1/11^{th}$ of the daily requirements for adult humans from phosphorus as indicated by **WHO and FAO (2004).**

Sodium constituted the fifth major essential macro-element as it ranged from 13.10 and 19.53 mg/100g. The maximum content was found in the crushed while the minimum content was in whole carob. The content of only 200g of carob could satisfy or cover $1/20^{th}$ of the RDA for adult humans from sodium as indicated by **RDAs (2009).**

Micro-elements detected in both carob pulp ranked, in a decreasing order of abundance, as follows: iron, zinc, copper and manganese.

Iron constituted the first major essential micro-element as ranged from 5.40 to 7.11 mg/100g. The maximum content was recorded for crushed carob, while the minimum content was in whole carob. The content of only 200g of carob could satisfy or cover most of the daily requirements for children's and also that

for adult humans from iron at 15% bioavailability as indicated by **WHO and FAO (2004)**

Zinc constituted the second major essential micro-element and ranged from 0.26 to 0.43 mg/100g. The maximum content was found for crushed carob while the minimum content was in whole carob. The content of only200g of carob could satisfy or cover $1/6^{th}$ the daily requirements for children's at low bioavailability of zinc and 1/16th that for adult humans from zinc at high bioavailability as indicated by WHO and FAO (2004).

On the other hand, copper and manganese were not detected in both types of carob samples investigated. These obtained results on mineral content were in agreement with those obtained by **El-Nahry *et al.* (1993)**.

4.2.7. Study of volatiles components of carob pulp:

Aroma characteristics are very important quality attributes for carob beverages with their distinct pleasant flavor, which is greatly liked by Egyptian people. Therefore, the various volatiles distributed in the concentrates derived carob were investigated by the use of the combined technique of gas chromatography/ mass spectroscopy (GC-MS).

Data obtained are presented in Tables (48 and 49) Figs. (23 and 24) that considerable overlapping occurred among some of the compounds. In such cases, identification was accomplished solely from their mass spectral profiles since the retention indices of un resolved components were observed to deviate slightly from those expected for single compounds and volatile components were fractionated. The quantities and qualitative data depended on retention time (Rt). Separated components of their respective (Rt) and their respective mass

Table (48): Quantitative determination by GC/MS for volatile constituents of crushed carob.

Peak No.	Component	Rt (min.)	Peak area (%)
1	Acetic acid	2.25	0.23
2	Propanoic acid	3.09	33.71
3	Isobutyric acid	3.93	5.81
4	Hexanoic acid	5.88	45.74
5	Unknown	6.57	1.04
6	Unknown	6.68	0.37
7	Ethanone	6.94	0.78
8	Heptanoic acid	7.08	0.35
9	Unknown	7.50	0.11
10	Octanoic acid	8.85	5.86
11	2-Octenoic acid	9.12	0.08
12	Hexanoic anhydride	9.30	0.14
13	2-Cyclohexen-1-one	9.59	0.11
14	Nonanoic acid	9.94	0.24
15	Unknown	10.19	0.44
16	Unknown	10.59	0.20
17	Eugenol	11.31	0.22
18	4-Pentylbutan-4-olide	11.39	0.16
19	Decanoic acid	11.48	0.07
20	Tetradecane	11.84	0.04
21	Furfural	13.10	0.08
22	Methylamine	13.26	0.32
23	2H-pyran-2-one	13.52	0.06
24	Butylated hydroxy toluene	13.74	0.14
25	Hexadecane	14.90	0.03
26	Octadecane	17.65	0.03
27	7,9-di-tert-butyl-1-oxaspiro	19.33	0.05
28	Hexadecanoic acid	19.73	0.04
29	Dibutyl phthalate	19.82	0.16
30	1-Hexadecane	21.16	0.08
31	Hexadecanamide	22.29	0.07
32	9-Octadecenamide	24.23	0.14
33	1,2-Benzenedicarboxylic acid	25.89	2.74

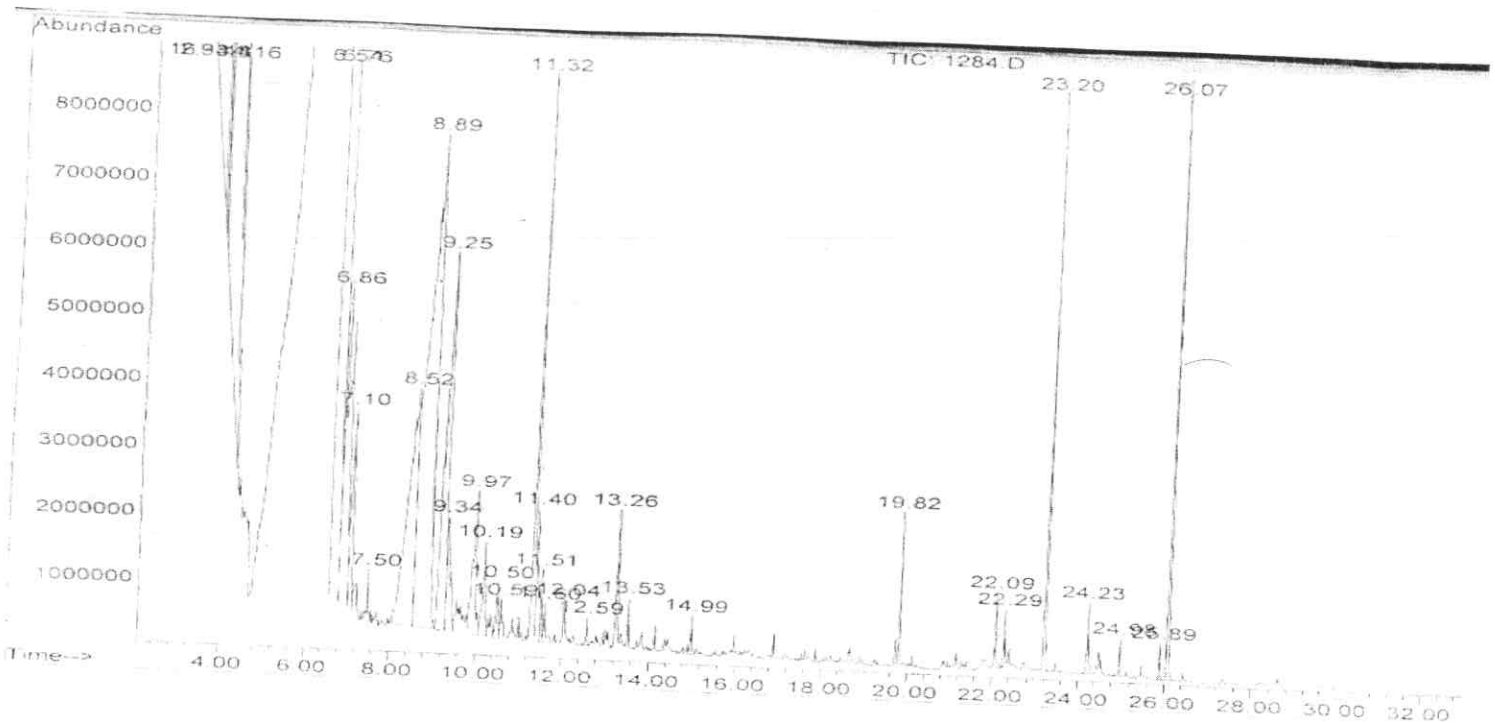


Figure (23): GC-MS chromatograms of volatiles components separated from crushed carob pulp.

Table (49): Quantitative determination by GC/MS for volatile constituents of whole carob.

Peak No.	Component	Rt (min.)	Peak area (%)
1	Propanoic acid	2.16	33.43
2	Isobutyric acid	3.80	10.26
3	Unknown	5.68	.95
4	Hexanoic acid	6.54	37.85
5	Ethanone	6.86	1.20
6	Unknown	6.94	0.37
7	Heptanoic acid	7.10	0.41
8	4H-pyran-4-one	7.50	0.07
9	Octenoic acid	8.52	5.65
10	Unknown	8.85	2.05
11	2-Furancarboxaldehyde	9.25	1.33
12	Benzaldehyde	9.34	0.34
13	Nonanoic acid	9.97	0.41
14	Phenol	10.19	0.20
15	5-Cetoxymethyl-2-furaldehyde	10.50	0.09
16	Eugenol	11.33	0.84
17	2(3H)-furanone	11.40	0.26
18	n-Decanoic acid	11.51	0.09
19	9-Decanoic acid	11.60	0.06
20	Unknown	11.84	0.07
21	Furfural	12.04	0.08
22	2H-pyran-2-one	13.26	0.20
23	Unknown	13.52	0.09
24	Unknown	13.74	1.14
25	1,2-Benzenedicarboxylic acid	14.99	0.04
26	Unknown	17.64	0.13
27	Dibutyl phthalate	19.82	0.14
28	Unknown	21.16	0.20
29	1-Propene	22.09	0.09
30	Hexadecanamide	22.29	0.06
31	Tributyl acetylcitrate	23.20	0.54
32	9-Octadecenamide	24.22	0.10

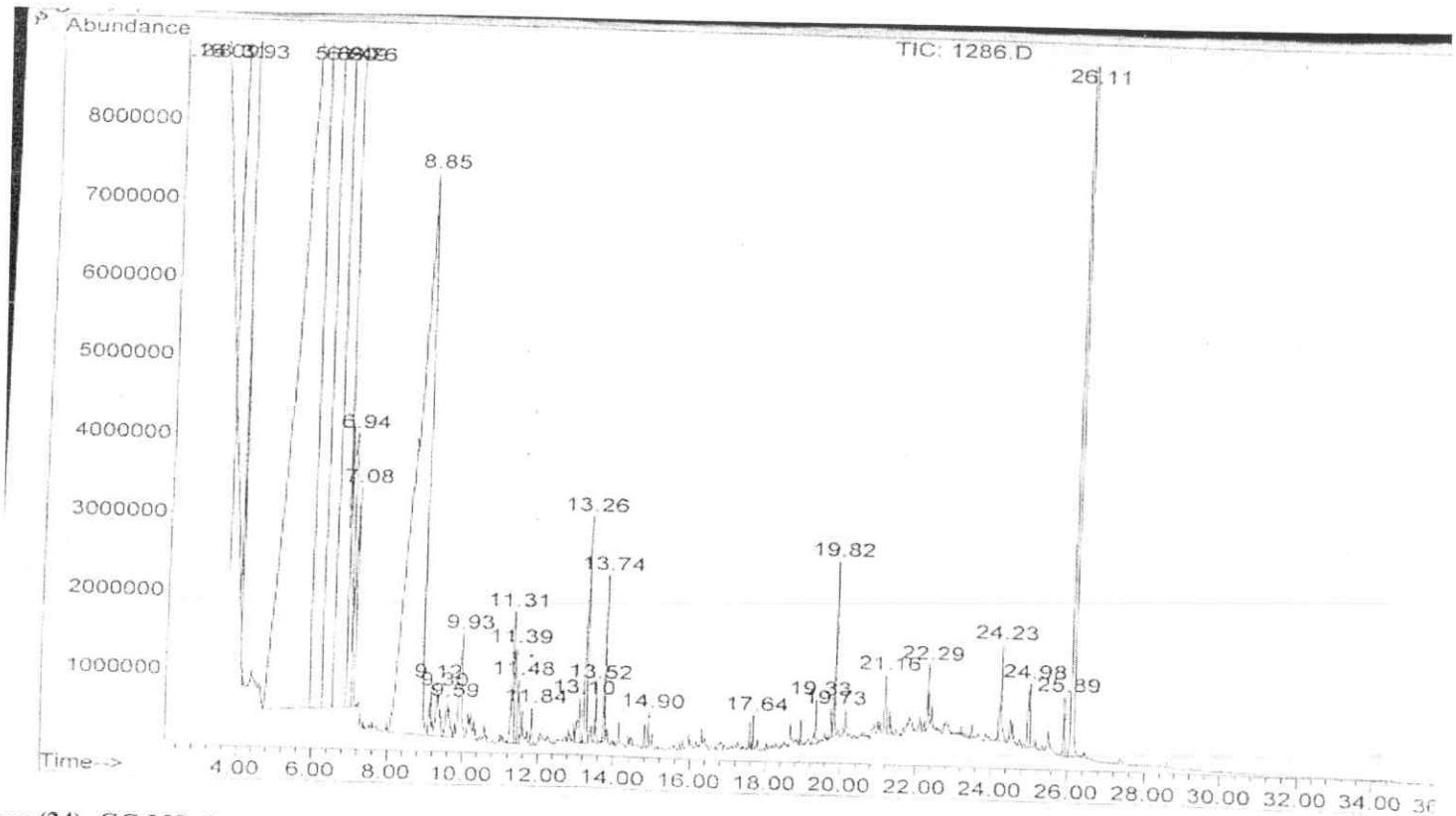


Figure (24): GC-MS chromatograms of volatiles components separated from whole carob pulp.

spectra with those of the authentic compounds were identified. It appeared that 33 volatile components were fractionated of which only 28 were identified in the aroma concentrate isolated from crushed carob. In order of decreasing abundance these identified volatile in aroma concentrate of crushed carob were arranged and ranked as follows: hexanoic acid (45.74% of the total volatiles), propanoic acid (33.71%), octanoic acid (5.86%), isobutyric acid (5.81%), 1,2-benzenedicarboxylic acid (2.74%), Ethanone (0.78%), Heptanoic acid (0.35%), Methylamine (0.32%), Nonanoic acid (0.24%), Acetic acid (0.23%), Eugenol (0.22%), 4-Pentylbutan-4-olide (0.16%), Dibutyl phthalate (0.16%), Hexanoic anhydride (0.14), Butylated hydroxy toluene (0.14%), 9-Octadecenamide (0.14%), 2-Cyclohexen-1-one (0.11%), furfural (0.08%), 1-Hexadecane (0.08%), Decanoic acid (0.07%), Hexadecanamide (0.07%), 2H-pyran-2-one (0.06%), 7,9-di-tert-butyl-1-oxaspiro (0.05%), Tetradecane (0.04%), Hexadecanoic acid (0.04%), Hexadecane (0.03%) and Octadecane (0.03%).

On the other hand, 32 total volatile components were fractionated from aroma concentrate of whole carob of which only 24 volatile compounds were identified. The major identified constituents in whole carob were arranged and ranked, in order of decreasing abundance as follows: hexanoic acid (37.85% of the total volatiles), propanoic acid (33.43%), isobutyric acid (10.26%), octanoic acid (5.56%), 2-furancarboxaldehyde (1.33%), ethanone (1.20%), Eugenol (0.84%), Tributyl acetylcitrate (0.54%), Heptanoic acid (0.41%), Nonanoic acid (0.41%), Benzaldehyde (0.34%), 2(3H)-furanone (0.26%), Phenol (0.20%), 2H-pyran-2-one (0.20%), Dibutyl phthalate

(0.14%), 9-Octadecenamide (0.10), 5-Cetoxymethyl-2-furaldehyde (0.09%), n-Decanoic acid (0.09%), 1-Propene (0.09%), furfural (0.08%), 4H-pyran-4-one (0.07%), 9-Decanoic acid (0.06%), Hexadecanamide (0.06%) and 1,2-Benzenedicarboxylic acid (0.04%).

An immediate observation was the present of an extraordinarily high level of alipbatic fatty acids (88.17 and 82.85%, respectively) in the aroma volatiles. The major contributors in crushed and whole carob pods were hexanoic acid (47.9% and 42.85%); propanoic acid (33.71% and 33.43%); octanoic acid (5.86% and 5.56%); isobutyric acid (5.81% and 10.26%); heptanoic acid (0.35% and 0.41%); and nonanoic acid (0.24% and 0.41%).

The non-acid fraction in crushed and whole carob pods aroma extracts occupied 11.83 and 17.42%, respectively of the total peak area. Of the identified constituents, furfural represented only 0.08% in carob. It is reported to be formed from the high sugar content of carob and is likely to contribute to the caramel character of the aroma perceived (**Siliha, 1994**).

It is worthy to mention that there was differences in number of volatile components and also their contribution to total fractionated volatiles. Furthermore, four components were missing from aroma profile for the concentrate of whole carob compared to that of crushed carob sample. These missing volatile components were: Methylamine (0.32%), Acetic acid (0.23%), 4-Pentylbutan-4-olide (0.16%) and Butylated hydroxy toluene (0.14%).

The separated volatile constituents of aroma concentrate were previously reported to impart a characteristic aroma which

was described as sweet, buttery, caramel, estery and slightly oily/fatty, with unpleasant sulphurous and rancid/sweaty overtones **Macleod and Forcen (1992)**

These obtained results of volatile components were in general agreement with those obtained by **Stubbs *et al.* (1985); Macleod and Forcen (1992)** and **Siliha (1994)**.

4.2.8. Technological feasibility for producing new products from tamarind and carob:

Preliminary experiments were conducted to prepare some unconventional products from tamarind and carob, which are not familiar to Egyptian customers. These tried products included the following:

1. Bottled tamarind and carob syrup: using tamarind or carob extract with adding sucrose, citric acid and sodium benzoate then concentrate until total soluble solids reach 65%, total acidity 1.5% and pH value 3.23. These product characteristics are ready to serve taking of fresh natural beverages properties.
2. Bottled tamarind and roselle syrup mixture: using tamarind mixed by roselle extract with adding sugar, citric acid and sodium benzoate then concentrate until total soluble solids reach 65%. These product characteristics ready to serve taking of fresh natural beverages properties.
3. Aroma extract of tamarind pulp or carob: Tamarind or carob powders were homogenized and mixed with water then distilled by a

simultaneous steam distillation. The volatile aroma compounds were extracted using dichloromethane solvent. The aroma extract was dried over anhydrous sodium sulfate and concentrated using rotary evaporator. This product could be utilized as flavor agent to bakery, confectionary, medicine and beverages.

4. Concentrated liquor or aroma concentrate of tamarind and carob extracts: Water extracts of tamarind and carob were concentrated using rotary evaroptor under 60°C until T.SS reached about 40%. This product could be also utilized as flavor agent to bakery, confectionary, medicine and beverages.
5. Freeze-dried tamarind and carob concentrates using carrier materials: Which prepared from 100 ml of concentrated aroma extract sample and placed on a stainless steel tray? The trays were placed in a freeze dryer and the blast-freezing process was started at -40 °C for 180 min. under $80x10^{-3}$ Torr constant pressure, the drying process was programmed starting at -20 °C for 120 min, then -10 °C for 120 min, 0 °C for 120 min, 10 °C for 120 min, 20 °C for 120 min and finally 30 °C for 120 min. After that, freeze-dried flasks were milled into fine powder then packed with aluminum lamination polyethylene packaging material. Special stabilizers such as maltodextrin or trehalose (2 or 3 g/100 ml

extract) were experienced. Freeze-drying of the extract solution without a stabilizer was also included as control. A list carrier materials such as xanthin gums, Arabic gum etc. were about to be tried.

6. Spray dried powder of tamarind and carob concentrates: was performed by first maceration of 400 g sample with 800 ml distilled water in a Waring blender for 1 min prior to dehydration using a co-current spray dryer. Inlet hot drying air was controlled at 160°C and outlet temperature maintained at 85 °C under atomization at 3 bar pressure. The dried powder collected was packed with aluminum lamination polyethylene packaging material.

However, the complete procedure and precise technology for such new products are needed to be further investigated on sound basis in the near future. The preliminary trials indicated processing feasibility and consumer acceptability of such new products.