RESULTS AND DISCUSSION

The present study was conducted to highlight the exploitation of apple and pear fruits, which are not processed commercially in Egypt, as well as some new varieties of green beans, which are not used in dehydration industry in Egypt for in the preparation of various dehydrated products from these fruits and vegetables.

Data obtained throughout the course of the present investigation are presented and discussed under six sub-headings as follows:

Part I: Dehydration of apple and pears fruits:

1. The establishment of dehydration parameters for processing apple and pears into dry products.
2. Effect of the selected dehydration conditions on characteristics of processed apple and pear dry products.
3. Effect of storage conditions on quality of dehydrated apple and pears.

Part II: Dehydration of green beans:

1. The establishment of optimum parameters for processing green beans into dehydrated products.
2. Effect of the selected dehydration conditions on characteristics of processed green beans.
3. Effect of storage conditions on quality of dehydrated green beans.

Part I: Dehydration of apple and pears fruits:

4.1. The establishment of dehydration parameters for processing apple and pears into dry products:

4.1.1. Selection of optimum pre-drying treatment for apples and pears:

The pre-drying treatments included the application of some blanching and soaking treatments for the purpose of comparing their efficiency in stopping or decreasing the colour changes in the peeled sliced fruits until the completion of steps leading to their dehydration. The effect of soaking or blanching treatment was investigated before and after dehydration. With all soaking and/or blanching treatments, the dehydration conditions remained constant (drying at 60°C for 20 hrs in air-circulated oven).

4.1.1.1. Effect of blanching treatment on colour of dehydrated fruits:

Preliminary experiments included the application of some blanching treatments using different blanching solutions composed of separate or combined solutes at different concentrations applied to fruits at different temperatures (80-100°C) and for variable periods of time (up to 3 min). All blanched samples were dehydrated at 60°C in air-circulated oven for 20 hrs, then tested visually for the degree of coloration.

All blanching treatments did not show satisfactory results from the standpoint of colour of dehydrated-blanched fruit pieces (Tables 7 and 8). Although some solutes were

Table 17. Preliminary studies on the effect of blanching and/or soaking treatments on colour of dehydrated apple slices upon drying at 60°C for 20 hrs.[1]

Treatments	Blanching treatments							
	Blanching conditions (°C and min)				Blanching conditions (°C and min)			
	80°C for 2 min		80°C for 3 min		100°C for 2 min		100°C for 3 min	
	C[2]	T[3]	C	T	C	T	C	T
Blanching solution:								
- Citric acid (1%)+NaCl (0.5%)	+++[4]	++++[4]	++++	+++++[4]	-	-	-	-
- $Na_2S_2O_5$ (0.4% sol.)	+++	+++	++++	+++	++++	++++	+++++	+++++
- Citric acid (0.1%)+$CaCl_2$ (0.05%) and cooling in (0.4% $Na_2S_2O_5$ sol.)+$CaCl_2$ (0.2% sol.)	++++	++++	+++++	+++++	-	-	-	-
- Citric acid (0.1%)+cooling in (0.4%) sol. of $Na_2S_2O_5$	+++	+++	++++	+++	++++	++++	+++++	+++++
Soaking solution:	Soaking treatments (at room temperature)							
	Soaking period (min)							
	2 min		3 min					
- Sporix (0.05% sol.)	+++	++++	++++	++++	-	-	-	-
- Citric acid (1%)+NaCl(0.5%)	+++	+++	++++	++[4]	-	-	-	-
- Citric acid (1%)+$CaCl_2$(0.05%)	+++	++++	++++	++++	-	-	-	-

1. Detection was carried out using visual estimation. data represent average of three trials.
2. C: Control sample (no added treatment, only soaked in water for the designated period and/or blanched at the designated temperature).
3. T: Treated sample.
4. Colour scores +, Golden yellow; ++, Light yellow; +++, Faint brown; ++++, Light brown; +++++, Dark brown

Table (8): Preliminary studies on the effect of blanching and/or soaking treatments on colour of dehydrated pears slices upon drying at 60°C for 20 hrs.[1]

Treatments	Blanching treatments							
	Blanching conditions (°C and min)				Blanching conditions (°C and min)			
	80°C for 2 min		80°C for 3 min		100°C for 2 min		100°C for 3 min	
	C[2]	T[3]	C	T	C	T	C	T
Blanching solution:								
- Citric acid (1%)+NaCl(0.5%)	+++[4]	++++[4]	++++	++++	-	-	-	-
- $Na_2S_2O_5$ (0.4% sol.)	+++	+++	++++	+++	++++	++++	+++++	+++++
- Citric acid (0.1%)+$CaCl_2$ (0.05%)and cooling in (0.4% $Na_2S_2O_5$ sol.)+$CaCl_2$ (0.2% sol.)	++++	++++	+++++[4]	+++++	-	-	-	-
- Citric acid (0.1%)+cooling in (0.4%) sol. of $Na_2S_2O_5$.	+++	+++	++++	+++	++++	++++	+++++	+++++
Soaking solution:	Soaking treatments (at room temperature)							
	Soaking period (min)							
	2 min		3 min					
- Sporix (0.05% sol.)	+++	+++	++++	++++	-	-	-	-
- Citric acid (1%)+NaCl(0.5%)	+++	+++	++++	++[4]	-	-	-	-
- Citric acid (1%)+$CaCl_2$ 0.05%	+++	++++	++++	++++	-	-	-	-

1. Detection was carried out using visual estimation. data represent average of three trials.
2. C: Control sample (No added treatment, only soaked in water for the designated period and/or blanched at the designated temperature).
3. T: Treated sample.
4. Colour scores +, Golden yellow; ++, Light yellow; +++, Faint brown; ++++, Light brown; +++++, Dark brown

found effective in maintaining or enhancing the colour when used as ingredients of a preliminary dipping treatment at room temperature, they did not show any significant influence upon their use as solutes for blanching treatment, possibly because of the high temperature of blanching.

With most of the tested blanching solutes, dehydrated fruits previously blanched at 80°C were found comparable to their control samples from the standpoint of colour.

Many workers have tried blanching treatment prior to dehydration with combination of various dipping solutions. Lazar et al. (1963) investigated the effect of steam-blanching (200-212°F for 1.5 to 6 min) of apples and pears after a partial dehydration of these fruits and then completion of dehydration to the desired moisture level. In addition to producing superior dehydrated product, they stated that their method reduced product losses.

Moreover, because of the very active enzyme system, especially in apples, Bolin and Steele (1987) stated that it is possible that some enzyme activity would remain in apple even after blanching (steam-blanching for 1.5 min), and they suggested many non-sulfite compounds as dipping solution after blanching for 2-4 minutes to inhibit such activity and to keep the colour.

In contrast to the findings of the aforementioned workers, blanched-dehydrated fruit slices prepared from cultivars grown in Egypt were not superior to other tested treatments from the standpoint of colour of final dehydrated product.

4.1.1.2. Selection of optimal soaking treatment for maintaining colour of fruit products:

Soaking treatments included the application of different dipping solutions composed of various solutes at different concentrations, either separately or in combination with others (Tables 7,8,9and 10) for variable periods of time (2-20 min) at room temperature. The effect of soaking treatment was investigated before and after dehydration step.

A. Effect of soaking treatments on colour of peeled sliced fruits (before dehydration):

After applying the designated soaking treatments, visual estimation of the soaked peeled fruit pieces (flesh) revealed that using solution of 1% citric acid + 0.5% NaCl for 5 min of dipping gave the best result from the standpoint of stability of colour (Tables 9 and 10). However, increasing dipping period more than 10 min showed some degree of colour changes. The substitution of NaCl by $CaCl_2$ in the citric acid solution did not improve colour. Solution of $Na_2S_2O_5$ showed comparable results, however, increasing concentration of $Na_2S_2O_5$ up to 0.4% (but not more) improved colour especially when soaking period increased to 10 min for apples and 15 min for pears. The addition of $CaCl_2$ to either $Na_2S_2O_5$ or citric acid did not improve flesh colour to a significant degree. With $Na_2S_2O_5$ solution, increasing soaking period up to 20 min showed certain degrees of colouration except in case of 0.5% $Na_2S_2O_5$ solution, where colour of soaked flesh remained unchanged by increasing the dipping period.

Table (9): Preliminary study on the effect of soaking pretreatment on colour of apples (before dehydration)[1].

Soaking solution and its concentration[2]	Change in colour of peeled sliced fruit (flesh)					
	Period of soaking					
	2 min	3 min	5 min	10 min	15 min	20 min
Citric acid (1%) + NaCl (0.5% sol.)	+++	++	+[2]	++[2]	+++[2]	++++[2]
Citric acid (1%) + $CaCl_2$ (0.05% sol.)	++++	++++	+++	++++	+++++[2]	+++++
$Na_2S_2O_5$ (0.1%)	-	-	+++	+++	++++	+++++
$Na_2S_2O_5$ (0.2%)	-	-	+++	+++	+++++	+++++
$Na_2S_2O_5$ (0.3%)	-	-	+++	+++	+++++	+++++
$Na_2S_2O_5$ (0.4%)	-	-	+++	++	+++	+++
$Na_2S_2O_5$ (0.5%)	-	-	+++	+++	+++	+++
$Na_2S_2O_5$ (0.4%)+$CaCl_2$ (0.5% sol.)	-	-	+++	+++	++++	++++
Sporix (0.05% sol.)	++++	++++	-	-	-	-

1. Detection was carried out using visual estimation, data represent average of three trials.
2. +, Golden yellow; ++, Light yellow; +++, Faint brown; ++++, Light brown; +++++, Dark brown.

Table(10): Preliminary study on the effect of soaking pretreatment on colour of pears (before dehydration)[1].

Soaking solution and its concentration[2]	Change in colour of peeled sliced fruit (flesh)					
	Period of soaking					
	2 min	3 min	5 min	10 min	15 min	20 min
Citric acid (1%) + NaCl (0.5% sol.)	+++[2]	++[2]	+[2]	++	++++[2]	++++
Citric acid (1%) + $CaCl_2$ (0.05% sol.)	++++	++++	+++	+++	++++	+++++[2]
$Na_2S_2O_5$ (0.1%)	-	-	+++	++++	++++	+++++
$Na_2S_2O_5$ (0.2%)	-	-	+++	+++	+++++	+++++
$Na_2S_2O_5$ (0.3%)	-	-	++++	+++	++++	+++++
$Na_2S_2O_5$ (0.4%)	-	-	+++	+++	++	+++
$Na_2S_2O_5$ (0.5%)	-	-	+++	+++	+++	+++
$Na_2S_2O_5$ (0.5%)+$CaCl_2$ (0.5% sol.)	-	-	+++	+++	+++	+++
Sporix (0.05% sol.)	+++	++++	-	-	-	-

1. Detection was carried out using visual estimation, data represents average of three trials.
2. +, Golden yellow; ++, Light yellow; +++, Faint brown; ++++, Light brown; +++++, Dark brown.

B. Effect of soaking treatments on colour of dehydrated peeled fruits:

Preliminary experiments were performed using various dipping treatments at room temperature prior to dehydration of peeled sliced fruits (Tables 9 and 10). Another experiment was conducted to study the effect of using 0.05% Sporix, 1% citric acid and 0.5% NaCl and 1% citric acid + 0.05% $CaCl_2$ solution as soaking treatments for peeled sliced fruits on colour of dehydrated material (dried at 60°C for 20 hrs). Results (Tables 7 and 8) demonstrated that these treatments were unsatisfactory from the standpoint of colour of dry material compared to their corresponding dehydrated control samples, previously soaked only in water. However, with both apple and pears, increasing soaking period to only 3 min using 1% citric acid and 0.5% NaCl improved colour of dehydrated fruit material compared to their corresponding control water treatments.

In view of the obtained results that some soaking solutions were found effective in maintaining the colour of peeled sliced fruits (flesh) prior to dehydration (Tables 9 and 10) another experiment was conducted to study the effect of the most promissing dipping solutions on enhancing colour of dehydrated fruit. Such soaking treatments were composed mainly of either $Na_2S_2O_5$ (graded concentration) or 1% citric acid + 0.5% NaCl solution and applied at room temperature for different soaking intervals between 5 to 20 min (Table 11). Dipping in 1% citric acid + 0.5% NaCl solution did not produce good colour with both dehydrated fruits despite of the superiority of

Table (11): Effect of soaking sliced fruits in different solutions for different periods of time on colour of the dehydrated material upon drying at 60°C for 20 hrs.[1]

Soaking solution and its concentration	Period of soaking treatment (Min)							
	5		10		15		20	
	A[3]	P[4]	A	P	A	P	A	P
$Na_2S_2O_5$ (0.1%)	+++[2]	+++	++[2]	+++	++++[2]	+++	+++++[2]	++++
$Na_2S_2O_5$ (0.2%)	+++	++	++	++	++++	+++	+++++	+++++
$Na_2S_2O_5$ (0.3%)	+++	+++	++	++	++++	+++	+++++	++++
$Na_2S_2O_5$ (0.4%)	++	++	+[2]	++	+++	+	++++	++++
$Na_2S_2O_5$ (0.5%)	+++	+++	++	++	++++	++++	+++++	++++
$CaCl_2$(0.5%) + $Na_2S_2O_5$ (0.4%)	++++	+++	++++	+++	+++++	++++	+++++	++++
Citric acid (1%) + NaCl (0.5%)	+++	++	++++	+++	+++++	++++	+++++	++++

1. Detection was carried out using visual estimation, data represent average of three trials.
2. +, Golden yellow; ++, Light yellow; +++, Faint brown; ++++, light brown; +++++, dark brown.
3. A: Apple.
4. P: Pears.

such soaking solution to other treatments (including $Na_2S_2O_5$ solutions) in maintaining colour of peeled fruit slices before dehydration (Tables 9 and 10). On the other hand, solutions of $Na_2S_2O_5$ (alone) were found more effective than $Na_2S_2O_5$ combined with $CaCl_2$ solution in producing better colour for dehydrated material, with all soaking period tested. Meanwhile, increasing concentration of $Na_2S_2O_5$ up to 0.4% (but not more) in soaking solution, especially with soaking intervals of 10 and 15 min, seemed to improve colour. In general, increasing soaking period more than 15 min did not improve colour of dehydrated material. A soaking solution of 0.4% $Na_2S_2O_5$ at room temperature applied for 10 and 15 min for peeled sliced apple and pears, respectively, induced the best colour in dehydrated materials.

In agreement with results of the present study, Lazar et al. (1963) indicated that dipping apples and pears pieces in 1% sodium bisulfite or 1% sodium bisulfite plus 0.5% citric acid for 5-7.5 min and 0.5% sodium chloride plus 1% citric acid prevented surface darkening during the initial drying. In addition, Bolin and Steel (1987) indicated that a dipping solution of $CaCl_2$ for 4 min before drying apple at 32°C produced lower rate of darkening in dehydrated products, especially with the use of 0.5% $CaCl_2$ dip solution.

In contrast, results of the present study showed that soaking apples and pears in 0.05% Sporix, an acidic polyphosphate which was described as having a three dimensional net work structure, before dehydration at different periods of time gave the

worest results from the point ofcolour changes occurred in dehydrated materials tested. Sporix has been reported (Sapers et al. 1989) to inhibit enzymatic browning in fruits and vegetables and the browning inhibition induced by Sporix combinations was attributed to two effects: a greatly extended lag time compared to that obtained with the individual inhibitors, as seen in juice, and a reduced rate of browning once the lag time has been exceeded.

4.1.2. Selection of optimum dehydration conditions of apples and pears:

4.1.2.1. Sun-drying of apple fruits:

In view of the simplicity of the sun drying, experiment was conducted to test the suitability of two cultivars of apples grown in Egypt, namely Baladi and Anna, to sun-drying. Peeled sliced apples were dried for a period of 7 days for Baladi and 2 days for Anna cultivar depending on time and temperature of dehydration rather than the variety of apples. However, organoleptic evaluation of sun-dried products (Table 12; Fig. 1) indicated that they had lower scores than those which were artificially dehydrated and that scores for Anna variety were higher than those for Baladi (Tables 12 vs. 14). Application of dipping treatment of 0.4% $Na_2S_2O_5$ solution for peeled slices before drying did not improve the organoleptic scores. It seemed that sun-dried apples (with or without dipping treatments) did not give satisfactory results from the standpoint of organoleptic properties (samples No. 13, 14, 15 , Fig 1) compared to the artificially dehydrated samples (Samples No. 1-12 and 16-32, Table 14 and Fig. 1).

Table (12): Organoleptic evaluation of sun dried apple slices.[1]

Sample[2] No.	Variety	Predrying treatment	Dehydration conditions	Organoleptic scores			
				Colour scores (40)	Texture score (30)	Flavour score (30)	Overall score (100)
13	Balady	No treatment	Sun drying 7 days at 32±2°C	10	23	12	45
14	Anna	No treatment	Sun drying 2 days at 38°C±2	12	22	18	52
15	Anna	Dipping in 0.4% $Na_2S_2O_5$ before drying.	Sun drying 2 days at 38°C±2	12	22	18	52

1. Data obtained represent average scores for 7 trained panelists for three dehydration trials.
2. See Figure 1 in the present study, P. 161.

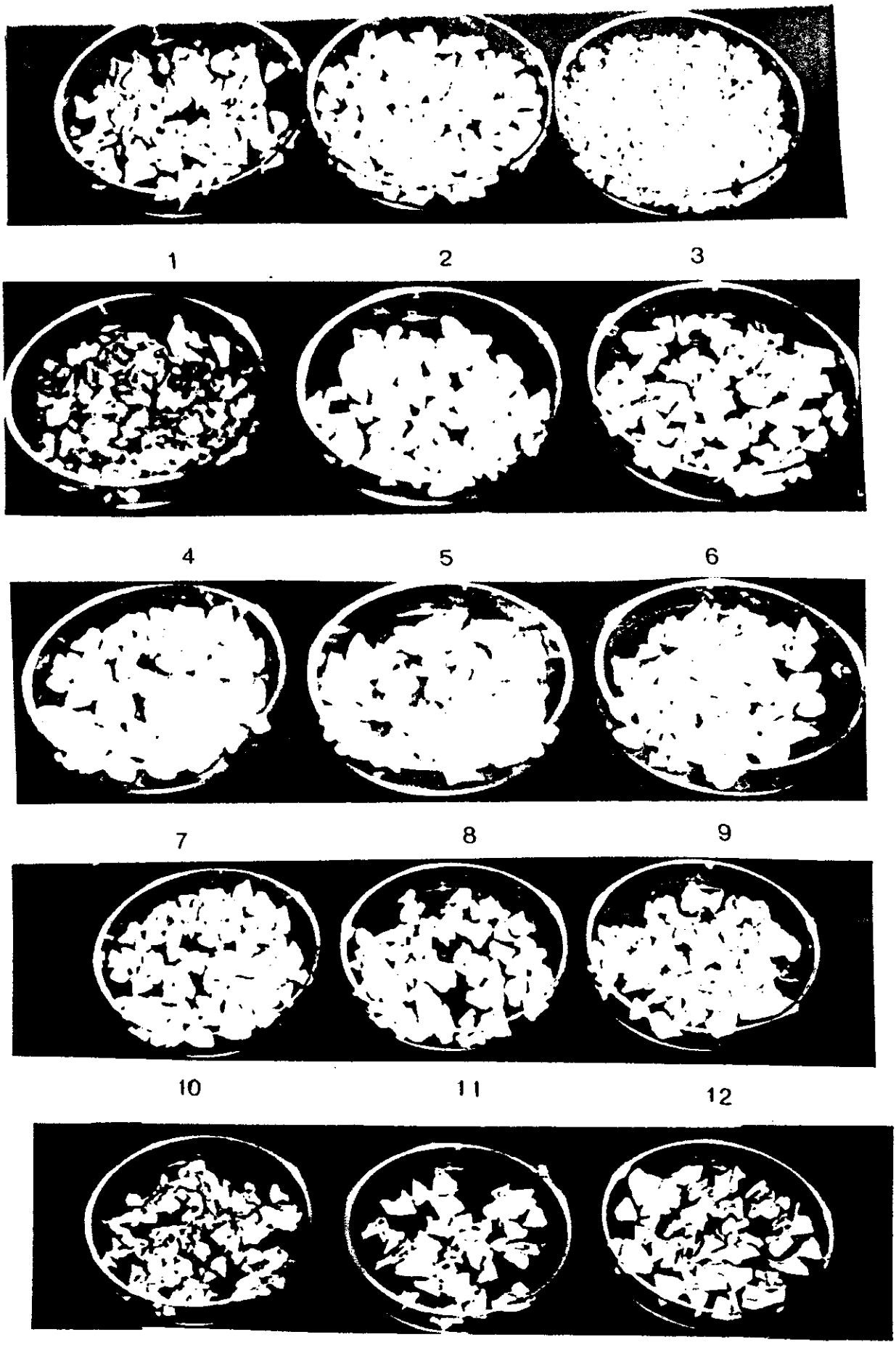
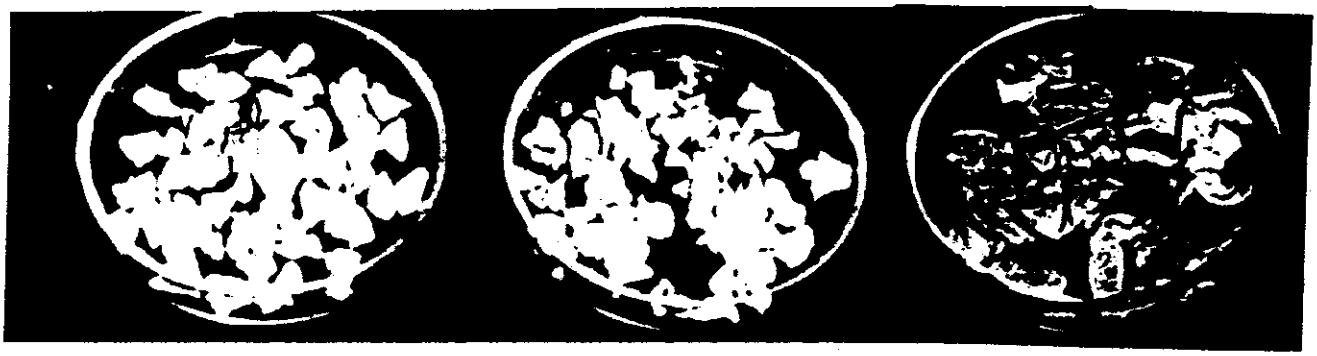


Fig. (1): External appearance of the dehydrated and rehydrated apple samples dried under the experimental conditions indicated in table 14.

16 17 18

19 20 21

22 23 24



25 26 27

28 29 30

4.1.2.2. Artificial dehydration of apple and pears:

After the selection of optimum soaking treatment for peeled sliced apple and pears from the standpoint of producing less colour changes in dehydrated fruits, the optimum conditions for dehydration temperature and duration of the dehydration period were investigated. Four degrees of dehydration (50, 60, 70 and 80°C) were compared upon the application of three different drying intervals (10, 15 and 20 hrs), while the soaking pretreatment was constant (0.4% $Na_2S_2O_5$ for 10 min with apple and 15 min with pears).

Increasing temperature of dehydration than 70°C influenced colour of both dehydrated fruits with all the drying periods tested except in case of using 80°C for 10 hrs, Increasing period of dehydration influenced colour only upon using higher dehydration temperatures of 75 and 80°C, (Table 13).

4.1.2.3. Organoleptic evaluation of dehydrated apples and pears:

Overall evaluation of most of the dehydration trials performed throughout the present study from the point of organoleptic properties was carried out with the aid of trained judges. Scores were given for colour, texture and flavour to make the final score out of 100 for about 32 samples of apples (Table 14) and 19 samples of pears (Table 15).

A combination of predrying treatments and dehydration conditions were applied to compare the organoleptic properties of dehydrated fruit products. Dipping solutions used prior to dehydration were 0.1-0.5% $Na_2S_2O_5$ (1% citric acid +

Table (13): Effect of dehydration conditions (temperature of dehydration and drying period) on the organoleptic scores of dehydrated peeled sliced fruits.

Temperature of dehydration	Period of dehydration (hrs)											
	10 hrs				15 hrs				20 hrs			
	Organoleptic scores											
	Colour score (40)	Texture score (30)	Flavour score (30)	Overall score (100)	Colour score (40)	Texture score (30)	Flavour score (30)	Overall score (100)	Colour score (40)	Texture score (30)	Flavour score (30)	Overall score (100)
	Apples (Variety Anna)[1]											
50°C	38	25	28	91	32	24	24	80	34	25	26	85
60°C	32	25	24	81	33	24	24	81	35	25	25	85
70°C	35	22	28	85	33	27	27	87	30	26	26	82
75°C	32	25	24	81	32	25	24	81	28	26	23	77
80°C	32	23	27	82	30	22	26	78	27	22	26	75
	Pears (Variety Lecont)[2]											
50°C	38	30	25	93	37	26	18	81	37	30	20	87
60°C	36	24	20	80	36	25	20	81	38	30	18	86
70°C	34	23	25	82	33	26	26	85	28	26	23	77
75°C	31	26	24	81	31	26	24	81	28	26	23	77
80°C	34	23	25	82	31	25	24	80	30	25	23	78

1. Dipped in 0.4% sodium metabisulfite for 10 min.
2. Dipped in 0.4% sodium metabisulfite for 15 min.

Table (14): Predrying treatments, dehydration conditions and sensory evaluation data for experimental dehydrated samples of two apple cultivars grown in Egypt.1

Sample No.	Description of sample	Predrying treatment	Dehydration conditions	Organoleptic scores			
				Color scores (40)	Texture score (30)	Flavour score (30)	Overall score (100)
1	Variety. Balady	No treatment	60°C for 10 hrs	15	20	26	61
2	Variety. Balady	Blanching in 0.4% $Na_2S_2O_5$ sol.	60°C for 10 hrs	15	20	26	61
3	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	60°C for 15 hrs	33	24	24	81
4	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	80°C for 15 hrs	30	22	26	78
5	Variety. Balady	Soaking in 0.4% $Na_2S_2O_5$ sol.	60°C for 20 hrs	26	18	23	67
6	Variety. Anna	No treatment	50°C for 20 hrs	22	20	26	68
7	Variety. Balady	Soaking in 0.3% $Na_2S_2O_5$ sol.	60°C for 20 hrs	25	19	19	63
8	Variety. Balady	No treatment	60°C for 20 hrs	25	18	18	61
9	Variety. Balady	Soaking in 0.05% S. sporix sol.	60°C for 20 hrs	27	17	20	64
10	Variety. Balady	Soaking in 0.2% $Na_2S_2O_5$ sol.	60°C for 20 hrs	24	18	19	61
11	Variety. Balady	No treatment	60°C for 20 hrs	24	16	19	61
12	Variety. Balady	Soaking in 0.5% $Na_2S_2O_5$ sol.	60°C for 20 hrs	24	18	19	61
16	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	50°C for 10 hrs	38	25	28	91
17	Variety. Anna	No treatment	70°C for 15 hrs	18	22	21	61
18	Variety. Anna	Soaking in 0.05% S. Sporix sol.	70°C for 15 hrs	22	22	21	65
19	Variety. Anna	Soaking in 0.5% $Na_2S_2O_5$ sol.	50°C for 20 hrs	18	22	17	57
20	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	50°C for 20 hrs	34	25	26	85
21	Variety. Anna	Soaking in 0.3 $Na_2S_2O_5$ sol.	70°C for 10 hrs	32	25	24	81
22	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	80°C for 10 hrs	32	23	27	82
23	Variety. Anna	Soaking in 0.2 $Na_2S_2O_5$ sol.	70°C for 10 hrs	28	22	22	72
24	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	70°C for 10 hrs	35	22	28	85
25	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	60°C for 20 hrs	35	25	25	85
26	Variety. Anna	No treatment	60°C for 20 hrs	22	17	22	61
27	Variety. Anna	No treatment	80°C for 10 hrs	22	18	22	62
28	Variety. Anna	Soaking in 0.4% $Na_2S_2O_5$ sol.	60°C for 20 hrs and rehydration	38	28	27	93
29	Variety. Anna	Soaking in 0.3% $Na_2S_2O_5$ sol.	80°C for 15 hrs	22	17	16	55
30	Variety. Anna	Soaking in 1% Citric acid + 0.5% NaCl	70°C for 15 hrs	22	18	18	58
31	Variety, Anna	Soaking in 0.4% $Na_2S_5O_5$ sol.	70°C for 15 hrs	33	27	27	87
32	Variety, Anna	Soaking in 0.4% $Na_2S_5O_5$ sol.	70°C for 20 hrs	30	26	26	82

1. Data obtained represents average scores for 7 trained panelists for three dehydration trials.

Sample No.	Predrying treatment	Dehydration condition	Organoleptic scores			
			Color scores (40)	Texture score (30)	Flavour score (30)	Overall score (100)
1	Soaking in 0.4% $Na_2S_2O_5$ sol.	70°C for 15 hrs	33	26	26	85
2	No treatment.	60°C for 20 hrs	22	18	17	57
3	Soaking in 0.4% $Na_2S_2O_5$ sol.	60°C for 20 hrs	38	30	18	86
4	Blanching in water (no treat.)	60°C for 20 hrs	18	18	16	52
5	Blanching in 0.4% $Na_2S_2O_5$ sol.	60°C for 20 hrs	18	18	16	52
6	Soaking in 0.3% $Na_2S_2O_5$ sol.	60°C for 20 hrs	32	21	26	79
7	Soaking in 0.2% $Na_2S_2O_5$ sol.	70°C for 15 hrs	20	18	20	58
8	No treatment .	60°C for 20 hrs	17	18	18	53
9	No treatment .	70°C for 15 hrs	17	18	16	51
10	Soaking in 0.5% $Na_2S_2O_5$ sol.	70°C for 15 hrs	32	21	26	79
11	Soaking in 0.5% $Na_2S_2O_5$ sol.	60°C for 20 hrs	23	18	18	59
12	Soaking in 0.3% $Na_2S_2O_5$ sol.	70°C for 15 hrs	22	18	20	60
13	Soaking in 0.4% $Na_2S_2O_5$ sol.	60°C for 20 hrs and rehydration 60°C for 20 hrs	38	26	28	92
14	Soaking in 1% Citric acid + 0.5% NaCl sol.		17	18	18	53
15	Soaking in 0.1% $Na_2S_2O_5$ sol.	70°C for 15 hrs	22	18	15	55
16	Soaking in 0.4% $Na_2S_2O_5$ sol.	50°C for 10 hrs	38	30	25	93
17	Soaking in 0.4% $Na_2S_2O_5$ sol.	50°C for 20 hrs	37	30	20	87
18	Soaking in 0.4% $Na_2S_2O_5$ sol.	70°C for 10 hrs	34	23	25	82
19	Soaking in 0.4% $Na_2S_2O_5$ sol.	80°C for 10 hrs	34	23	25	82

1. Data obtained represent average scores for 7 trained panelists for three dehydration trials.

0.5% NaCl) and 0.05% Sporix solution. Temperature of dehydration tested were 50, 60, 70 and 80°C, while dehydration periods were 10, 15 and 20 hrs.

Organoleptic scores (Tables 14 and 15) as well as the visual estimation of these dehydrated products (Figs. 1 & 2) indicated that Anna apple variety was found more acceptable than Baladi apple and that artificial dehydrated apple were superior to sun-dried ones. A dipping solution of 0.4% $Na_2S_2O_5$ induced the highest organoleptic scores with both dehydrated apple and pears.

In view of the comparable results obtained for various dehydration trials tested, from the standpoint of appearance, organoleptic properties and induced colour changes in dehydrated material, (Tables 14, 15 and figures 1 and 2), it was decided to continue research on the effect of some selected optimum dehydration conditions on some aspects of physical properties as well as chemical composition of the obtained dehydrated materials directly after processing and after certain periods of storage.

All treatments which induced an overall organoleptic score higher than 82 were selected (13 treatments) which included those employed 0.4% $Na_2S_2O_5$ as dipping solution before dehydration followed by artificial drying at temperatures of 50, 70, 80° for 10 hrs; 70°C for 15 hrs, in case of both fruits, and those dehydrated at 50, 60 and 70°C for 20 hrs in case of apples, and 50 and 60°C for 20 hrs in case of pears.

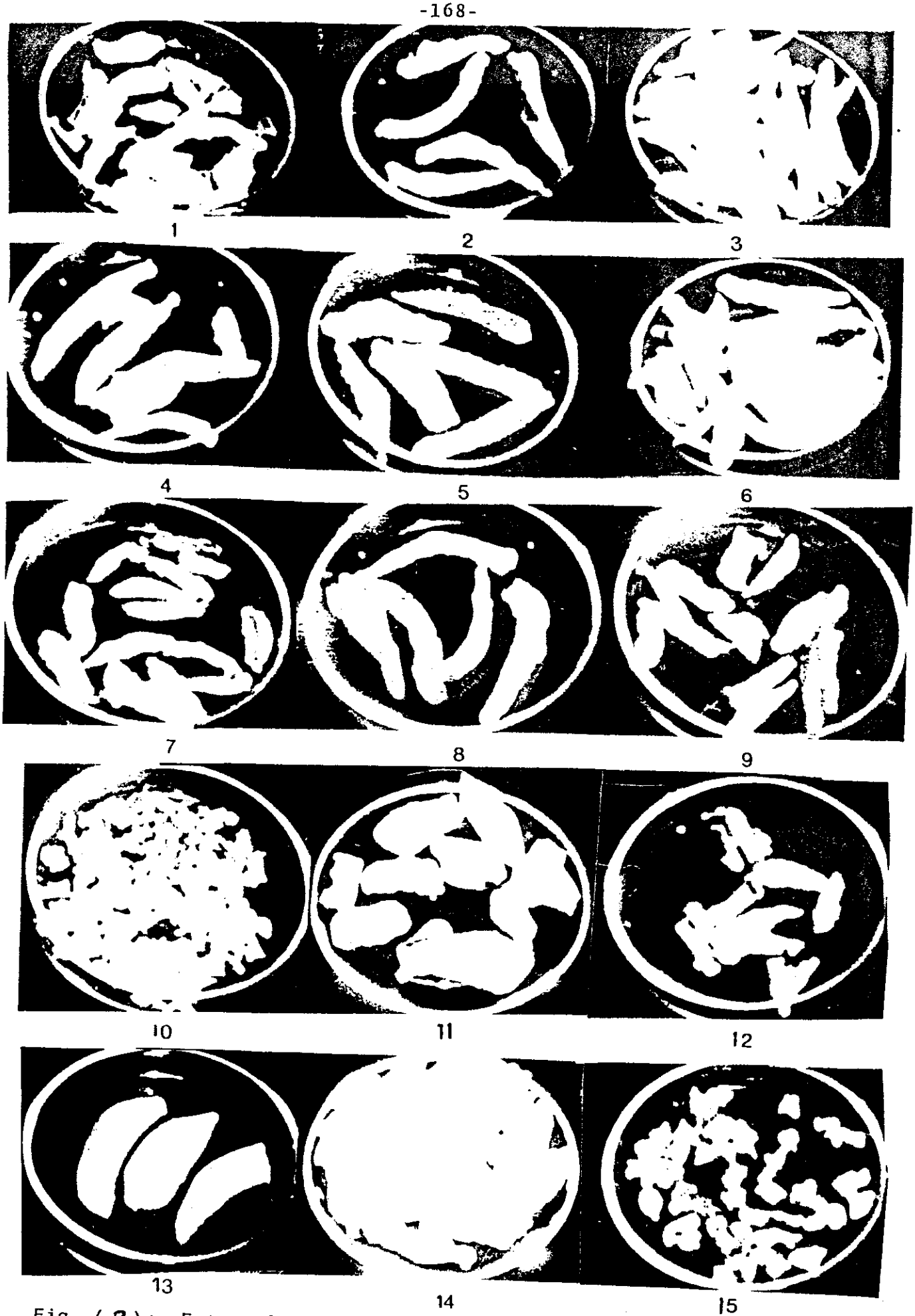


Fig. (2): External appearance of the dehydrated and rehydrated pear samples dried under the experimental conditions indicated in table 15

4.1.3. Effect of the selected dehydration conditions on characteristics of processed apple and pear dry products:

4.1.3.1. Drying ratio:

As shown in tables 16 and 17, both the increase in degrees of temperature and also period of dehydration during prccessing resulted in higher drying ratio with all dehydrated products prepared under the conditions of the present study. Drying ratio of freshly dehydrated samples ranged between 1:6.2 to 1:6.5 (average 1:6.4) in case of apples and between 1:5.3 to 1:5.5 (average 1:5.4) in case of pears. Regardless of the dehydration period and temperature of dehydration, it is apparent that the average drying ratio for apple slices was slightly higher than the corresponding ratio for pear slices by about 15%.

Drying yield for pears fruit was reported to range between 12 to 17%based on the weight of the fresh fruit while the yield for apple fruit (10-15%) varied according tc variety and locality in which they grown (Von Loesecke, 1955).

4.1.3.2. Moisture content of dehydrated products:

Moisture content is considered an important factor for controlling the tenderness of fresh fruits and the keeping quality after their dehydration. As shown in tables 16 and 17, both the increase in degrees of temperature and in period of dehydration during processing resulted in lower moisture ccntent with all dehydrated products prepared under the conditions of the present study. Moisture content of freshly dehydrated samples ranged between 14.98 to 11.45 (average 12.65%) in case of apples and between 12.908 to 9.989 (average 11.10%) in case of pears which means that about 71.29 to 74.82%, and from 70.69 to 73.61% of water was lost by dehydration of apples and

Table (16): Dehydration and rehydration ratioes of apples processed under different conditions.

Analysis	Time (min)	Dehydration period: 10 hrs			15 hrs		20 hrs		Average
		Temperature of dehydration: 50°C	70°C	80°C	70°C	50°C	60°C	70°C	
- Moisture of dehydrated sample (%)	-	14.98	13.72	12.40	12.23	12.11	11.69	11.45	12.65
- Drying ratio	-	1:6.2	1:6.3	1:6.4	1:6.4	1:6.4	1:6.4	1:6.5	1:6.4
- Rehydration ratio	1 hr	1:3.0	1:2.9	1:2.4	1:2.2	1:2.2	1:2.1	1:2.0	2.4
	2 hrs	1:4.0	1:3.9	1:3.4	1:3.1	1:3.0	1:2.9	1:2.8	3.3
	3 hrs	1:4.8	1:4.3	1:4.1	1:3.9	1:3.9	1:3.8	1;3.7	4.1
- Coefficient of rehydration	1 hr	0.48	0.46	0.37	0.34	0.34	0.33	0.31	0.38
	2 hrs	0.65	0.62	0.53	0.48	0.47	0.45	0.43	0.52
	3 hrs	0.78	0.69	0.64	0.61	0.61	0.59	0.57	0.65
- Moisture content in rehydrated sample (%)	1 hr	71.7	70.3	63.3	60.0	60.0	58.1	55.5	63.8
	2 hrs	78.8	77.9	74.1	71.6	70.7	69.7	68.2	73.6
	3 hrs	82.3	80.0	78.5	77.4	77.4	76.8	75.9	78.8

1. Average of duplicate analysis.

Table (17): Dehydration and rehydration ratioes of dehydrated pear slices processed under various different conditions.

Analysis[1]	Time (min)	Dehydration period						Average
		10 hrs			15 hrs	20 hrs		
		Temperature of dehydration						
		50°C	70°C	80°C	70°C	50°C	60°C	
- Moisture content of dehydrated sample %	-	12.908	11.991	10.998	10.701	10.008	9.989	11.10
- Drying ratio	-	1:5.3	1:5.4	1:5.4	1:5.4	1:5.5	1:5.5	1:5.4
- Rehydration ratio	1 hr	1:2.9	1:2.4	1:2.2	1:2.1	1:2.1	1:1.9	1:2.3
	2 hrs	1:3.8	1:3.3	1:3.0	1:2.9	1:2.9	1:2.8	1:3.1
	3 hrs	1:4.6	1:4.2	1:3.9	1:3.8	1:3.8	1:3.6	1:4.0
- Coefficient of rehydration	1 hr	0.55	0.45	0.41	0.39	0.38	0.35	0.42
	2 hrs	0.72	0.62	0.55	0.53	0.53	0.51	0.57
	3 hrs	0.87	0.78	0.72	0.70	0.69	0.66	0.74
- Moisture content in rehydrated sample %	1 hr	70.0	63.3	59.5	57.6	57.1	52.6	61.3
	2 hrs	77.1	73.3	70.3	69.3	69.0	67.9	71.3
	3 hrs	81.1	79.0	77.2	76.6	76.3	75.0	77.8

1. Average of duplicate analysis.

pears, respectively. It seems that the dehydration conditions applied in the present study succeeded in providing dehydrated apples and pears of lower moisture content than those reported by various investigators from different countries (Mortha Louis et al., 1950; Simon et al., 1955; Lazar et al., 1963; Koshida and Kita,1982; Sayavedra-Soto and Montgomery,1988) who reported higher moisture content (from 13 to 26%) for dehydrated apples. On the other hand, Luh (1971) reported higher moisture content of dehydrated pears fruit (22%). Our results are encouraging in view of the reports of Mrak et al. (1948) that browning in dried cut fruits decreases by decreasing their moisture content and that they darken more rapidly upon storage if the moisture content is high (20-25%). Moreover, Nichols and Reed (1931) stated that drying to approximately 10% moisture improved colour permanence of apples while pears were poorer than apples.

4.1.3.3. Rehydration properties after dehydration (at zero time):

Dried foods,characterized by their lower moisture content, are always soaked in water before consumption and the rate of water absorption depends on several factors such as size of sample, technical aspects before drying, temperature and time of drying, type of food and time of soaking (Saad, 1989), and condition of tests (Ranganna, 1979).

Rehydration ratioes, coefficient of rehydration and moisture content (%) in rehydrated samples were determined for the tested dry fruit slices at various time intervals for a total period of 3 hrs of soaking in water at room temperature (Tables 16 and 17). Both the increase in degrees of temperature and in

period of dehydration during processing influenced the rehydration properties where the higher the extent of these factors the lower the redehydration values with all dehydrated products prepared under the condition of the present study. However, values for rehydration ratioes, coefficient of rehydration and moisture content (%) in rehydrated samples ranged between 1:2.0 to 1:3.0; 0.31 to 0.48 and 55.5 to 71.7%, respectively, after soaking dehydrated apples in water for 1 hr and ranged between 1:3.7 to 1:4.8; 0.57 to 0.78 and 75.9 to 82.3%, respectively, as a result of extending the soaking period to 3 hrs under the same soaking conditions. On the other hand, they ranged between 1:1.9 to 1:2.9; 0.35 to 0.55 and 52.6 to 70%, respectively, after 1 hr of soaking dehydrated pears and ranged between 1:3.6 to 1:4.6; 0.66 to 0.87 and 75.0 to 81.1%, respectively after 3 hrs of soaking.

It should be mentioned that it is difficult to compare our results to others since a method of determining rehydration and conditions during test (such as agitation and temperature) were reported to influence the amount of water absorbed (Neubert et al., 1968). Furthermore,numerous predrying treatments and additives have contributed to the improvement of rehydration characteristics of many dried products (Neumann, 1972) and therefore would influence these properties. For example, predrying treatments with sodium carbonate, sodium bisulfite, and/or 60% sucrose at ambient temperature, separately or in various combinations, produced distinct differences in rehydration characteristics and appearance (Neumann, 1972).

The loss of osmotic properties and differential permeability in the protoplasmic membrane and the increase in crystallisation of polysaccharides gels in the cell wall as well as the

coagulation of protoplasmic proteins occurred as a result of dehydration play . Key role in the changes of texture and rehydration capability that occur after any given food samples that have been dehydrated (Shimazu and Sterling, 1961; Karel, 1974 and De Man, 1976).

The initial rate of rehydration involves mainly the amorphous regions which present the most accessible surface to the rehydration medium. The difference in rehydration that occurs between different dehydrated fruits probably depends upon the hydrolysis of the polysaccharides, such as hemicelluloses and pectinates during dehydration (Saad, 1989).

The hydrolysis of the hemicelluloses, the pectinates, and the amorphous regions of the cellulose molecules is usually catalysed by hydrogen ions. In the hydrolysis of these polysaccharides the acetal bonds between the sugar residues are usually broken and water molecules are added to the polysaccharide molecules at the place of this breakage (Nikitin, 1966). The lower amount of rehydration is subsequently a result of the lesser amount of hydrogen ion present to catalyse the hydrolysis (Horn and Sterling, 1982).

4.1.3.4. Proximate chemical composition of fresh and dehydrated materials:

A) Fresh fruits:

As shown in table 18, moisture formed the highest percentage in the chemical composition of fresh peeled flesh and peels of apples (86.3 and 56.1%, respectively) as well as pears (83.6 and 61.2%, respectively). Crude fiber formed the second major

Table(18): Proximate chemical analysis of processed fresh and dehydrated apples and pears dried at 60°C for 20 hrs.[1]

Material	Moisture %		Crude protein %		Ether extract%		Ash %		Crude fiber %	
	A[2]	P[3]	A	P	A	P	A	P	A	P
Fresh Peeled slices	86.27	83.6	2.813	1.875	2.059	1.677	0.332	0.280	5.017	5.869
Dehydrated Peeled slices	11.69	9.9	1.625	1.037	1.166	0.884	0.351	0.290	4.825	4.935
Peels (fresh)	56.10	61.2	5.937	4.687	3.486	2.781	0.700	0.520	10.730	12.329

1. Average of duplicate analysis, reported on dry weight basis.
2. A: Apple.
3. P: Pear.

constituent in fresh slices and peels of apples (5.02 and 10.73%, respectively) as well as pears (5.9 and 12.33%, respectively). Crude protein represented the third principal constituent (2.8 and 5.94%, respectively) in apples and (1.9 and 4.69%, respectively) and also in pears.

In general, peels of both fruits (Table 18) showed higher crude fiber, crude protein, ether extract and ash contents than their corresponding fruit flesh by about 53.24, 52.62, 40.94, and 52.57%, respectively, in case of apples and 52.40, 59.100, 39.70, and 46.15%, respectively, in case of pears. In contrast, peels exhibited lower moisture content than their corresponding peeled fresh fruit. However, peeled sliced apples and their peels contained higher amounts of moisture, crude protein, ether extract, and ash but lower amount of crude fiber than those of pears.

Results of the proximate chemical composition of apples and pears grown in Egypt were in the range previously reported by many workers (Mallison and Powell, 1934; Mortha Louis et al. 1950; Atwater et al., 1960; Lazar et al., 1963; Hulme and Rhodes, 1971; Belitz and Grosch, 1986) for both fruits grown in different countries. Many investigators who studied the chemical composition of fresh apple and pears, reported higher values for crude fiber content, ether extract, ash content (Mallison and Powell, 1934; Mortha Louis et al., 1950; Atwater et al., 1960; Lazar et al., 1963). On the other hand, some workers (Mortha Louis et al., 1950; Lazar et al., 1963; Belitz and Grosch, 1986) reported higher values for crude fiber, ether extract and ash content in apple and pears compared to their starting fresh materials.

B) Dehydrated fruits:

After dehydration, moisture of peeled apple and pears (Table 18) decreased by about 74.58, 73.70%, respectively. Other workers (Mortha Louis et al., 1950 and Luh, 1971) mentioned lower moisture reduction rates by dehydration of nearly 61% for both fruits. Dehydrated peeled slices exhibited lower crude protein, and ether extract contents than their starting fresh peeled slices by about 42.23 and 43.37%, respectively, in case of apples and 44.69 and 47.29%, respectively, in case of pears. This observation could be probably attributed to the effect of processing conditions and also participition of some of these constituents in the non-enzymatic browning reaction or Maillard reaction (Wedzicha, 1984; Belitz and Grosch, 1986). On the other hand,ash and crude fiber contents of dehydrated fruits showed only slight significant change compared to their starting materials.

4.1.3.5. Selected properties of dehydrated apples and pears:

A) Change in colour:

Colour is an important quality factor for both fresh and dehydrated fruits and vegetables. The rate of darkening or browning is considered always a measure for deterioration in acceptability and also nutritional value of dried product. The measurement of degrees of browning or alcohol-extractable colour (colour index) was always taken as indication of browning reactions either enzymatic or non-enzymatic (Wedzicha, 1984). The estimation of serum colour is another parameter for colour changes where the various soluble constituents present in fruits or vegetables cause decrease in light transmission (Hendel et al., 1953).

It was apparent that fresh sliced apples had lower degrees of browning and higher serum colour values than those found for fresh pears. Freshly sliced apples and pears had variable values for serum colour (97.1 vs. 72.0% ,respectively, for serum colour and 0.074 vs. 0.088 (O.D) for degree of browning, respectively) (Tables 19 and 20).

Under the processing conditions of present study, values for serum colour of all dehydrated products of both fruits decreased gradually while colour index increased with the gradual increase in both degrees of temperature and period of dehydration during processing. For all dehydrated treatments, serum colour values ranged between 75.10 to 69.20% in apples and between 65.3 to 58.6% in pears. These values were lower than the levels present in their starting fresh sliced meterials by about 22.66 to 28.73% in apples and by 9.31 to 18.61% in pears. Values for colour index or degree of browning ranged between 0.08 to 0.09 (O.D) in apples and 0.143 to 0.151 (O.D) in pears. These values were higher by 5.4 to 25.7% in apples and by 62.5 to 71.59% in pears than the levels in their corresponding starting fruits. The highest degree of browning and the lowest serum colour was attained using dehydration temperature of 70°C with drying period of 20 hrs. In contrast, the lowest degree of browning and the highest serum colour value were attained using dehydration temperature of 50°C with drying period of 10 hrs.

A search in literature reports revealed that the effect of dehydration conditions on colour changes in products is critical but sometimes contraversy. Stadtman et al.(1948)stated that the rate of browning is affected by the time and temperature

Table (19): Chemical properties of dehydrated apples processed under different conditions (g/100 g of dry weight).

Analysis[1]	Starting[2] fresh peeled material	Dehydration period							Average	Standard deviation
		10 hrs			15 hrs	20 hrs				
		Temperature of dehydration								
		50°C	70°C	80°C	70°C	50°C	60°C	70°C		
Moisture	86.27	14.98	13.72	12.40	12.23	12.11	11.69	11.45	12.65	± 1.260
Residual sulfur dioxide (ppm)	2160.20	1641.30	1581.60	1498.00	1499.80	1418.30	1401.10	1389.60	1489.90	± 95.450
Serum colour[3]	97.10	75.10	74.20	73.20	71.20	70.10	69.40	69.20	71.77	± 2.390
Degree of browning[4]	0.074	0.078	0.079	0.081	0.083	0.088	0.091	0.093	0.085	± 0.006
Total sugars	73.60	67.30	67.00	66.30	66.00	66.10	65.30	65.00	66.14	± 2.030
Reducing sugars	52.40	49.60	49.00	48.00	47.60	47.70	47.00	46.40	47.90	± 1.220
Soluble pectins	0.69	0.593	0.576	0.503	0.484	0.460	0.440	0.430	0.498	± 0.064
Insoluble pectins	0.79	0.788	0.773	0.708	0.673	0.643	0.629	0.600	0.688	± 0.072

1. Average of duplicate analysis.
2. Dipped in 0.4% $Na_2S_2O_5$ solution for 10 min.
3. % Transmission.
4. Optical density.

Table (20): Chemical properties of dehydrated pears processed under different conditions (g/100 g of dry weight).

Analysis[1]	Starting fresh peeled material[2]	Dehydration period						Average	Standard deviation
		10 hrs			15 hrs	20 hrs			
		Temperature of dehydration							
		50°C	70°C	80°C	70°C	50°C	60°C		
Moisture	83.600	12.908	11.991	10.998	10.701	10.008	9.989	11.100	± 1.150
Residual sulfur dioxide (ppm)	2077.600	1543.800	1412.900	1360.000	1348.000	1299.000	1281.000	1374.100	± 95.380
Serum colour[3]	72.000	65.300	63.500	60.600	60.900	59.100	58.600	61.333	± 2.590
Degree of browning[4]	0.088	0.143	0.144	0.146	0.147	0.149	0.151	0.147	± 0.003
Total sugars	46.900	38.900	38.600	37.300	37.000	37.100	36.600	37.580	± 0.937
Reducing sugars	30.600	26.900	26.700	25.200	25.000	25.100	25.000	25.650	± 0.896
Soluble pectins	0.631	0.539	0.528	0.518	0.508	0.498	0.459	0.508	± 0.028
Insoluble pectins	0.702	0.603	0.600	0.598	0.570	0.570	0.564	0.584	± 0.019

1. Average pf duplicate analysis.
2. Dipped in 0.4% $Na_2S_2O_5$ solution for 15 min.
3. % Transmission.
4. Optical density.

of processing or dehydration. In contrast, the effects of drying time and temperature on the rate of darkening of apricots and peaches appeared to be of no great consequence provided the fruit was not dried to a moisture content less than 25% (Stadtman et al., 1946). However, when Schrader et al. (1943) studied the effect of drying temperature on deterioration of apple he found that browning was apparent only with samples dried at 93°C. This result is in general agreement to our finding.

Upon comparing both dehydrated fruits product, it appeared that dehydrated apples exhibited lower degrees of browning and also higher serum colour values than the corresponding dehydrated pears. This could be attributed probably to the difference in enzymatic activities (Sayavedra-Soto and Montgomery, 1988) and in phenolic compounds (Shallenberger and Jansen, 1977) and also in ascorbic acid content (Sapers and Douglas, 1987; Sapers and Ziolkowski, 1987). Moreover, apples and pears pose certain problem as their tissues contain comparatively large amounts of oxygen (Shallenberger and Jansen, 1977) and thus are apt to rapid changes in colour and drakening. The darkening or changes in colour of apple slices during drying was reported to be related to the ascorbic acid content since enzymic browning will not proceed until all the ascorbic acid has been oxidised (Escher and Neukom, 1971) and also to the enzymatic type of browning which results mainly from the activity of polyphenoloxidase enzymes (Yankov, 1974) due to the presence of their suitable substrates, the polyphenols (Prabha and Patwardhan, 1985).

B) Total and reducing sugars:

Total and reducing sugars are important determinant of fruit quality. Freshly sliced fruits showed variable values for total and reducing sugars content (73.6 and 52.4%, respectively, in apples; 46.9 and 30.6%, respectively, in pears). It is evident that apples had higher total and reducing sugars than pears by 36.3 and 41.6%, respectively (Tables 19 and 20). The values obtained by Von Loesecke (1955) are in general accordance with our data for sugar content of fresh fruits, while Mallison and Powell (1934); Hulme and Rhodes (1971); Lee et al., (1967); Belitz and Grosch, (1986) reported lower values than our obtained data for sugars content in fresh apples and pears grown in different parts of the world (Table 2).

A pronounced decrease in total and reducing sugars was noted in all dehydrated samples with the increase in both degrees of temperature and period of dehydration. Total and reducing sugars ranged between 67.3 to 65.0% (average 66.14%) and between 49.6 to 46.4% (average 47.9%), respectively, in case of dehydrated apples, and between 38.9 to 36.6% (average 37.58%) and between 26.9 to 25.0% (average 25.65%), respectively, in case of dehydrated pears. With all treatments the levels of total and reducing sugars in dehydrated materials were lower than those levels present in their starting fresh sliced fruits by average values ranged between 11.45 to 5.34% and 11.68 to 8.56%, respectively, in case of apples and by 18.30 to 12.09% and 21.96 to 17.06%, respectively, in case of pears (Tables 19 and 20).

The observed variation between the different treatments may be attributed to the Maillard reaction between reducing sugars

and amino compounds (Bhatti et al., 1973; Labuza, 1973 and Wedzicha, 1984) or the hydrolysis or degradation changes. On the other hand, compared to our data, Simon et al.,(1955) reported higher values for sugars content in dehydrated apples and pears grown in different parts of the world, but Lee et al., (1967) as well as Koshida and Kita (1982) reported lower values for sugars content in dehydrated apples.

Similar to the observed trend in fresh state, all dehydrated apple treatments exhibited higher total and reducing sugars content an average of 46.3 and 43.2%, respectively, higher than that present in their corresponding pear treatments.

C) Soluble and insoluble pectins

Soluble and insoluble pectins exhibited slight decrease with the gradual increase in both degrees of temperature and period of dehydration in all dehydrated products of both fruits (Tables 19 and 20). Soluble and insoluble pectins ranged between 0.59 to 0.43 (average 0.50%) and 0.78 to 0.60 (average 0.69), respectively, in case of apples and 0.54 to 0.46(average 0.51%) and 0.60 to 0.56 (average 0.58%), respectively, in case of pears. Upon comparing these results with others, it was found that Hulme and Rhodes (1971) reported higher value for pectin content in fresh apple (3.0%), while Belitz and Grosch (1986) reported similar values for pectin content of fresh apples but lower values for pear fruits (Table 2).

The levels of soluble and insoluble pectins in dehydrated apples were lower than those present in their starting fruit by about 14.49 to 37.68% and 1.27 to 24.05%, respectively, in case of dry apples and 14.58 to 27.26 and 14.10 to 19.66%, respectively,

in case of dry pears. The observed decrease in soluble and insoluble pectins content could be attributed to some chemical reaction such as the hydrolysis of pectic acid to galacturonic acid which reacts with amino acids and causes browning reaction during the long period of dehydration and to the excessive heating in relatively high acid media (Belitz and Grosch, 1986) since apple and pears had a very acidic pH value. The obtained values for pectin content of dehydrated products were in accordance to the reports of Simon et al., (1985) who stated that pectin content of dehydrated apple and pears ranged between 0.6 to 0.4%.

D) Redisual sulfur dioxide content:

Sulfur dioxide has long been considered a safe product for incorporation into processed products especially dehydrated ones (Bolin and Steele, 1987) and is very inexpensive potent inhibitor of undesirable colour changes (Shallenberger and Jansen, 1977). At its current usage rate, SO_2 has been reported to be not harmful to majority of population (Taylor et al. 1986; IFT, 1986). However, there are certain objections to its use as it has certain disadvantages (Mapson, 1965 and Eskin et al. 1971) and there is feeling by some that it may be harmful to health of consumers (Koeing et al., 1983; Sayavedra-Soto and Montgomery, 1988). However, no satisfactory substitute for SO_2 has been found for the preservation of colour and flavour in dried fruits although many possible alternatives have been tested. Sulfur dioxide is added to food to stop non-enzymic browning, to inhibit enzyme catalysed reactions, control micro-organisms and to act as an antioxidant and reducing agent (Wedzicha, 1984).

After pretreatment by soaking in 0.4% $Na_2S_2O_5$ for 10 or 15 min, for apples and pears sliced, respectively, the determination of sulfur dioxide indicated the presence of 2160.2 and 2077.6 ppm, respectively, on dry weight basis. However, the found sulfur dioxide content in pretreated fruits decreased upon dehydration with the gradual increase in both degrees of temperature and the dehydration period during preparation of both fruits. Values for residual So_2 content varied greatly with the variation in dehydration conditions where they ranged between 1641.3 to 1389.6 (averaging 1489) ppm in case of dehydrated apples and between 1543.8 to 1281.0 (averaging 1374.1) ppm in case of pears. The highest residual So_2 level was present in the product processed at the lowest temperature and for the highest period for drying and vise versa with the lowest So_2 level. Meanwhile, the obtained values for residual So_2 are lower than the present in their starting pretreated sulfured sliced materials (previously dipped in 0.4% $Na_2S_2O_5$) by about 24.02 to 35.67% and 25.69 to 58.37% in case of apples and pears, respectively.

In agreement to our results, Sabry (1961) found that sulfured dried fruits lost 30-65% of the absorbed So_2 upon drying; while the degree of browning seemed to vary with the residual So_2 content. However, the used concentration of sodium metabisulfite (0.4%) in the soaking pretreatment together with the application of the dehydration treatments especially those carried under lower temperatures, succeeded in maintaining good colour and lower changes in dehydrated fruits as indicated results of organoleptic tests (Tables 14 and 15) and also in retaining good amount of So_2 which equals

from 76 to 64.3, in case of apples, and from 74.3 to 41.6% in case of pears of the original So_2 supplied during soaking treatment before dehydration.

Moreover, results of organoleptic evaluation tests indicated (Tables 14 and 15) that the obtained scores were not influenced by the presence of excess sulfur so as to affect flavor and taste or the presence of lower residual sulfur so as to effect colour scores. McBean et al. (1965) indicated that sulfur treatment retards deteriorative changes in colour and flavour of fruit during dehydration process. Moreover, Davis et al. (1973) mentioned that sulfur dioxide (So_2) has long been used to retard the rate of browning and maintain the natural colour in dried fruits before and during storage. The range of residual So_2 of the various dehydrated products from both fruits prepared under the conditions of the present study (1281-1641 ppm) is in the middle of the legal limits (1000-3000 ppm) preferred by laws of most countries as indicated (Davis et al., 1973) or the suggested safe limits (1000-2000 ppm) recommended for dry apples and pears (Woodroof and Luh, 1975) and for most dehydrated fruits (Wedzicha, 1984).

Eicit (1938) stated that finished dehydrated apple product should not contain less than 500 ppm or more than 2000 ppm of So_2 Wedzicha (1987) found that the state of So_2 in partially dehydrated foods is complex and depends on pH, ionic strength, a_w and concentration, and on the effects of anions and cations on the solubilities of sulfite and bisulfite salts.

In addition to the aforementioned information, Shallenberger and Jansen (1977) stated that apple segments contain considerable

oxygen in their internal tissue so that internal browning can occur easily unless sulfuring is practised to be effective in apple segments, So_2 must penetrate throughout the whole segment and better penetration is obtained with So_2 in the form of sulfurous acid than in the form of sodium bisulfite. In other fruits, such as apricots and peaches, there is not enough tissue oxygen to cause internal browning. Therefore, complete penetration by So_2 of the whole fruit piece is not necessary, and PPO enzyme inhibition at the surface is sufficient.

4.1.2.5. Characterization of individual sugars of dehydrated apple and pears:

Identification of individual sugars separated from dehydrated apple and pears products was performed using paper chromatography technique. Chromatograms of an authentic mixture of seven sugars and also the individual seven sugars together with chromatography of sugars separated from duplicate samples of each of the hydrolyzates of dehydrated fruits revealed the presence of glucose and xylose in dehydrated apples and only glucose in dehydrated pears (Fig. 3). Qualitative estimation separated sugars based on visual estimation of intensity of spots (Table 21) indicated that glucose was present in nearly equal amounts in dehydrated products of both fruits.

In comparison to our data, Lee et al. (1970) found that free sugars in fruits and vegetables were glucose, sucrose, fructose, and unidentified sugars. Results of the present study did not reveal the presence of sucrose probably because sucrose was not able to be identified as it posses the same Rf of glucose under the conditions of chromatographic separation in the present study.

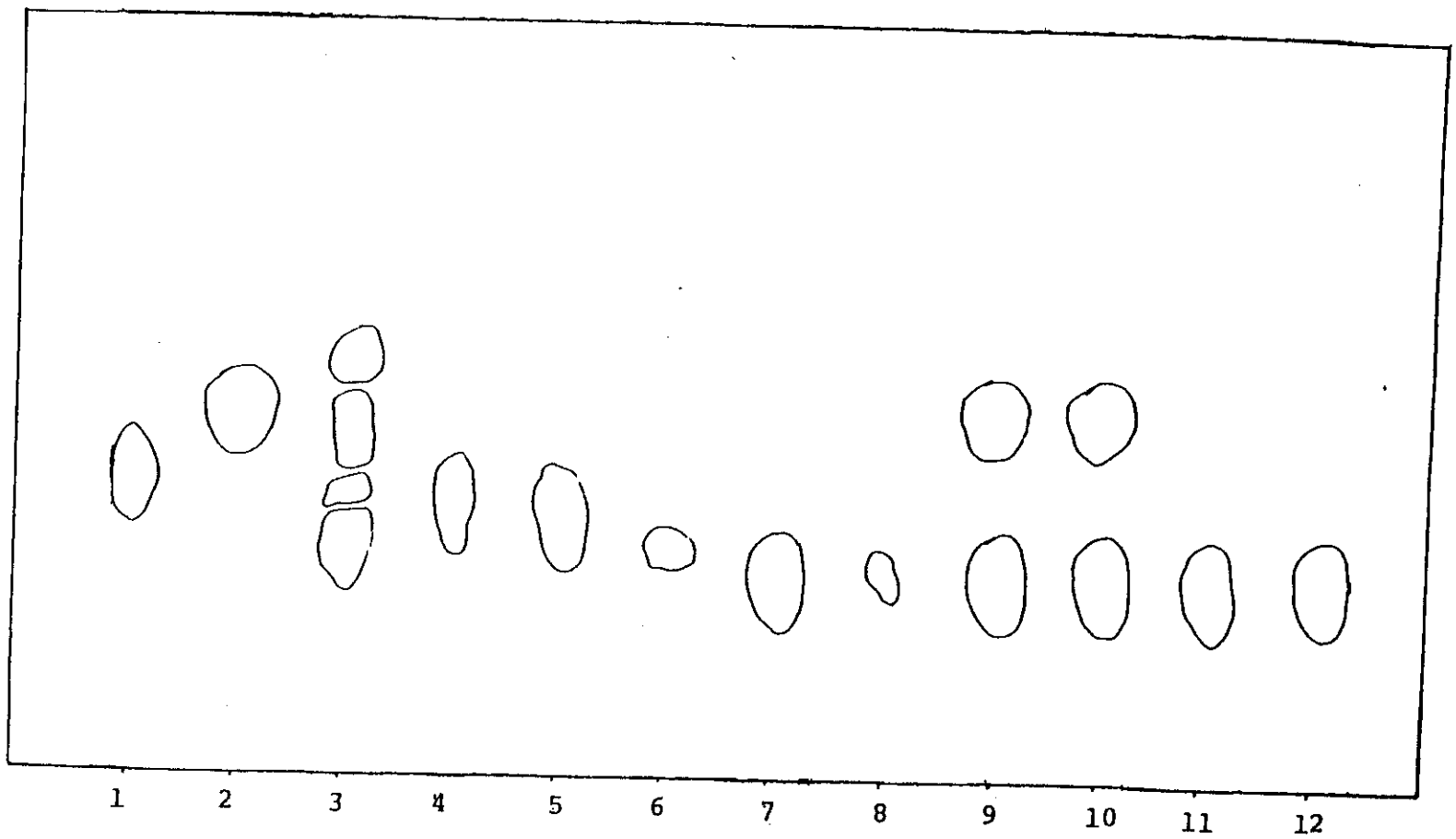


Fig..(3): Chromatograms of individual sugars separated from dehydrated slices of apples and pears 1, Arabinose; 2, xylose; 3, Mixture of individual standard sugars; 4. Mannose; 5. Mannose; 6. Maltose; 7, Glucose; 8, Sucrose; 9, dehydrated apple - sample A; 10, dehydrated apple-sample B; 11, dehydrated pear-sample C ; 12, dehydrated pear-sample D.

Table (21): Qualitative estimation of sugars separated by paper chromatography technique from dehydrated slices of apples and pears.

R_F	Standard	Apples	Pears
0.19	Sucrose	-	-
0.17	Glucose	++	++
0.20	Maltose	-	-
0.22	Mannose	-	-
0.33	Xylose	++	-
0.26	Arabinose	-	-

1. Concentration of individual sugars in standard solution was 1%.
2. ++ Moderate.
   - Not present.

4.1.2.6. Characterization of minerals content of dehydrated apples and pears:

Mineral analysis included the spectrophotometric determination of phosphorus, the flame photometeric determination of Na and K. and the atomic absorbtion spectroscopic determination of Ca, Mg, Mn, Cu, Zn and Fe in dehydrated fruit slices as well as the peels of their starting fresh materials (Table 22).

Apple and pears showed very slight variation in the pattern of distribution of minerals analysed. From the point of availability of minerals in dehydrated apple, they were arranged, in order of decreasing abundance as K, Na, Ca, Fe, Mg, Mn, Cu, P and Zn. The difference between the two fruit lied in that Fe ranked the 3rd and Ca ranked the 4th in case of pears and vice versa in case of apples. Moreover, Zn was not detected in dehydrated pears. The concentration of each of these analysed elements was higher in dehydrated sliced apples than that present in dehydrated pears, with the exception of P and Fe. However, peels of apples had higher amount of elements than pears with the exception of Na, Cu, and Mn.

Peels of both fruits exhibited higher amounts of all the minerals analysed than their corresponding dehydrated peeled flesh when concentration was expressed in mg/100 g of dry materials. Peels of apple and pears were approximately 19 and 37% higher than those present in their corresponding dehydrated flesh. The only exception was for Na which showed lower concentration in peels than flesh of both fruits. This could be attributed to the use of $Na_2S_2O_5$ as dipping solution for the peeled sliced flesh before their dehydration (Tables 9 and 10). The

Table (22): Mineral content of fresh and dehydrated apples and pears (mg/100 g of dry weight)[1]

Element	Apples		Pears	
	Slices	Peels	Slices	Peels
	Dehydrated	Fresh	Dehydrated	Fresh
Macro elements:				
Sodium	29.005	13.553	25.201	14.363
Calcium	20.901	22.670	4.413	9.299
Magnesium	4.235	11.838	4.123	11.874
Potassium	121.000	126.920	66.210	100.432
Phosphorus	0.123	0.388	0.293	0.308
Micro elements:				
Cupper	0.512	0.321	0.372	0.894
Ferrous	5.950	48.677	9.578	39.421
Manganese	2.101	2.587	2.123	2.715
Zinc	0.025	0.065	Zero	0.036
Total	183.852	227.019	112.313	179.342

1. Average of duplicate analysis.

pattern of distribution of minerals in peels was somewhat different than that of their corresponding dehydrated flesh material. In a decreasing order of abundance, the analysed minerals in apple peels were ranked as: K, Fe, Ca Na, Mg, Mn, P, Cu, and Zn, but in pear peels they were ranked as: K, Fe, Na, Mg, Ca, Mn, Cu, P and Zn.

Data of the minerals analysed revealed that peels of apple and pears had higher amounts of all of these minerals than their corresponding flesh correlated with those of ash content (Table 18). Peels of apples and pears had higher amounts of ash than their corresponding flesh material. The mineral estimated at the present study (Table 22) represented about 52.38 and 38.73% of ashes of dehydrated sliced apple and pears, respectively, and 32.43 and 34.49% of ashes of peels of apple and pears, respectively (Table 18).

The observed variations might reflect the difference in mineral uptake of different fruits during growth period which is certainly influenced by location, environmental conditions and different agricultural practices. Among these factors, fertilization, especially nitrogen and calcium or phosphate fertilizers, have been reported to influence greatly the mineral content (Harris and Karmas, 1975). Literature relating to such effect and in relation to effect of soil are voluminous and generally contradictory.

There is lack of literature concerning reliable quantitative determination of mineral matter of dehydrated apple and pears, so as to be compared with our data. However, Zook and Lehmann (1968) mentioned that peels of fresh apple and pears

contain appreciable amount of elements especially Na. They stated that the major elements in decreasing order of abundance were Na, K, Fe, Mn, Cu, P, Mg, and Ca in peeled fresh apples, but Na, K, Cu, Fe, Mn, P, Mg, and Ca in peeled fresh pears.

The obtained results would prove that both fruits contain appreciable amounts of minerals and that both could be considered as a good source for the minerals tested in human food as previously stated by Glasscock et al. (1950), especially when the concentration of the main essential mineral per 100 g of material is compared to the requirements and allowed level permitted for humans. The recommended daily allowance for humans is established for only five minerals (NAS, 1974) while minerals requirements are established for Ca, Mg, Fe, Zn, Cu and I (FAO, 1974). It seems that consumption as small as about 100 g of each dehydrated apples and pears powder or slices would satisfy the daily recommended daily allowance and, in turn, infant requirements for Mg (4-100 mg/day) and Fe (5-10 mg/day) and from 30-40% of the requirements for Cu (1.3-2 mg/day). Moreover, dry peels of both fruits would furnish much higher better levels compared to the reported recommended allowance (FAO, 1974).

4.1.4. Effect of storage conditions on quality of dehydrated apples and pears:

After the chemical characterization of some selected experimental treatments for preparing dehydrated apple and pears which satisfied the requirements for high organoleptic scores, experiments were conducted to study the effect of some factors which influence the shelf life of these dry products throughout their storage. Experiments included studying the effect of duration

of storage period at room temperature and the effect of type of packaging materials utilized throughout the storage on some chemical attributes for these stored dehydrated fruit slices.

The type of container in which the dehydrated products could be stored is an important factor in determining the shelf life of these products, especially when storage is subject to temperature fluctuation or increase. In the present study, two different types of containers from different packaging material, i.e. glass jars and sealed polypropylene bags were used. In package dissctant method was applied where 0.01 g calcium chloride placed in small cloth bag was placed either under cover of glass jar or at top of polypropylene bags before their sealing. Freshly prepared dehydrated apples and pears were packed in the two sets of containers then each set was placed in carton boxes. After closure of carton boxes, they were placed on shelves in large space store house and kept at room temperature. Carton boxes were opened once every three months where some containers from each set were drawn for analysis of their physical chemical and microbiological properties.

4.1.4.1. Moisture content:

With both dehydrated fruits, moisture content reduced gradually by the advancement of storage period at room temperature regardless of the type of packages utilized throughout storage (Tables 23 and 24). Moisture content decreased in accordance to the duration of storage period in function of previous dehydration conditions and kind of fruit rather than the type of packaging materials. The gradual decrease in moisture content was parallel to both the increase in degrees of previous dehydration temperature and in period of dehydration

Table (23): Effect of duration of storage period (3-9 months) on the moisture content of dehydrated apple slices stored in different packaging materials.[1]

Storage period (month)	Type of package	Dehydration period							Average	Std. Dev.
		10 hrs			15 hrs	20 hrs				
		Temperature of dehydration								
		50°C	70°C	80°C	70°C	50°C	60°C	70°C		
0		14.98	13.72	12.40	12.23	12.11	11.69	11.45	12.65	±1.26
3	G[2]	14.39	13.12	11.83	11.69	11.47	11.01	10.65	12.02	±1.30
	P[3]	14.88	13.22	11.99	11.89	11.36	10.98	10.54	12.12	±1.49
6	G	8.84	8.23	7.92	7.60	7.58	6.39	6.01	7.51	±1.00
	P	9.13	9.11	9.04	8.72	8.00	7.19	7.00	8.31	±0.92
9	G	7.41	7.39	6.32	6.22	6.14	5.39	5.15	6.28	±0.88
	P	8.00	7.53	6.69	6.28	6.22	5.99	5.38	6.58	±0.91

1. Average of duplicate analysis.
2. G: Glass jar packages.
3. P: Polypropylene packages.

Table(24) : Effect of duration of storage period (3-9 months) on the moisture content of dehydrated pear slices stored in different packaging materials.[1]

Storage period (month)	Type of package	Dehydration period						Average	Std. Dev.
		10 hrs			15 hrs	20 hrs			
		Temperature of dehydration							
		50°C	70°C	80°C	70°C	50°C	60°C		
0		12.91	11.99	10.99	10.70	10.01	9.99	11.10	±1.15
3	G[2]	12.20	11.39	10.30	10.10	10.00	9.38	10.56	±1.04
	P[3]	12.32	11.48	10.54	10.30	10.23	9.49	10.73	±1.01
6	G	8.33	7.32	7.28	7.00	6.88	6.00	7.14	±0.76
	P	9.24	8.22	8.16	7.99	7.88	7.58	8.18	±0.57
9	G	7.39	6.22	6.21	6.19	5.88	5.65	6.26	±0.60
	P	8.28	7.10	7.00	6.58	6.19	6.00	6.86	±0.82

1. Average of duplicate analysis.
2. G: Glass jar packages.
3. P: Polypropylene packages.

during processing before storage, regardless of the type of packaging materials and/or duration of storage period.

Moisture content of all treatments of stored dehydrated apple slices ranged between 10.54 to 14.88% after 3 months, 6.01 to 9.13% after 6 months and between 5.15 to 8.00% after 9 months of storage (Table 23). In case of stored dehydrated pears moisture content ranged between 9.38 to 12.32% after 3 months and 6.00 to 9.24%, after 6 months, and 5.65 to 8.28%, after 9 months of storage (Table 24).

Stored dehydrated apple slices prepared using the various treatments tested in either glass jars or polypropylene packages showed average rate of decrease in moisture content of only 0.63 and 0.53%, respectively, after 3 months; 5.14 and 4.34%, respectively, after 6 months as well as 6.36 and 6.07%, respectively, after 9 months lower than the level present in their corresponding dehydrated fruit before storage (at zero time). On the other hand, stored dehydrated pear slices stored in either glass jars or polypropylene packages showed average decrease in moisture content of 0.54 and 0.37%, respectively, after 3 months; 3.96 and 2.92%, respectively, after 6 months and 4.84 and 4.24%, respectively, after 9 months of storage.

Although Koshida and Keta (1982) and Sayavedra-Soto and Mont gomery (1988) showed that moisture content in dehydrated apple and pears fruits increased by about 15 to 40% and 13 to 26%, respectively, by increasing the period of storage, results of the present study proved that moisture content of dehydrated apple and pears decreased by extending storage period to 9 months. The observed reduction in moisture content after 6

and 9 months of storage could be attributed to the inclusion of inpackage dissctants(only 0.01 g $CaCl_2$) in containers during storage period. In package-dissctants are widely used as method for reducing moisture and some chemical changes comparing our dehydrated vegetables stored in hermatically sealed containers (Van Loesecke, 1955).

In general, dehydrated fruit slices packed in polypropylene packages for periods up to 9 months exhibited slight high moisture content than their corresponding samples packed in glass jar packages. Such differences were very limited as they did not exceed in case of apple 0.1 to 0.8% but they were 0.2 to 1.04% in case of pears. The slight difference in moisture content between the two packaged dehydrated products could be attributed to the difference in nature of the packaging materials utilized. Polypropylene films has a moderate permiability to moisture, gases and odours, which is not affected by changes in humidity (Morton and Waston, 1988). The closure and the headspace of air in glass jars would also influence moisture content and also some chemical attributes of stored packed dehydrated materials, although inpackage dissctant reduces greatly moisture content as indicated by the present study. Mrake et al. (1948) stated that dried apples kept in glass bell jars at 0% humidity at 25°C remained in good conditions for over 3 years at which time they contained 0.4-0.7% moisture.

On the other hand, regardless of the type of packaging materials, dehydration period and temperature of dehydration, dehydrated apple slices stored for periods up to 9 months exhibited slight higher moisture content than the corresponding dehydrated pear fruit slices. The lower moisture content

obtained in the present study would certainly help in decreasing the rate of browning or colour changes as previously agreed by Mrake et al. (1948).

4.1.4.2. Redhydration properties:

Rehydration properties of both fruits increased gradually parallel to the advancement in storage period for dehydrated products kept at room temperature in either glass jars or polypropylene packages. However, there was a gradual decrease in rehydration properties parallel to the increase in degrees of dehydration temperature and period of dehydration before storage, regardless of difference in type of packaging material and or duration of storage period. (Tables 25 and 26).

Dehydrated apple slices prepared by the seven different treatments and stored in either glass jars or polypropylene packages, respectively, had average values for rehydration ratioes, coefficient of rehydration and moisture (%) in rehydrated samples (after 3 hrs of soaking) of 1:4.3 and 1:4.8; 0.67 and 0.75% as well as 79.5 and 81.7%, respectively, after 3 months while they were 1:4.4 and 1:5.3; 0.65 and 0.79% as well as 79.1 and 82.7%, respectively, after 6 months of storage.

On the other hand, dehydrated pear slices prepared by the six different treatments and stored in either glass jars or polypropylene packages had average values for rehydration ratioes, coefficient of rehydration and moisture (%) in rehydrated samples (after 3 hrs of soaking) of 1:4.2 and 1:4.8; 0.77 and 0.88% as well as 78.7 and 81.4%, respectively, after 3 months; however, they were 1:4.5 and 1:5.3; 0.79 and 0.95% as

... of storage period (3-6 months) on rehydration ratio of dried apple slices stored in different packaging materials.[1]

Storage period (month)	Time min	Dehydration period: 10 hrs, Temperature of dehydration 50°C	10 hrs, 70°C	10 hrs, 80°C	15 hrs, 70°C	20 hrs, 50°C	20 hrs, 60°C	20 hrs, 70°C	Average
0	60	1:3.0	1:2.9	1:2.4	1:2.2	1:2.2	1:2.1	1:2.0	1:2.4
	120	1:4.0	1:3.9	1:3.4	1:3.1	1:3.0	1:2.9	1:2.8	1:3.3
	180	1:4.8	1:4.3	1:4.1	1:3.9	1:3.9	1:3.8	1.3.7	1:4.1
		Glass jar packages							
3	60	1:3.1	1:3.0	1:2.6	1:2.3	1:2.3	1:2.2	1;2.1	1:2.5
	120	1:4.2	1:4.0	1:3.5	1:3.3	1:3.2	1:3.0	1:2.9	1:3.4
	180	1:5.0	1:4.5	1:4.3	1:4.2	1:4.1	1:4.0	1:3.9	1:4.3
6	60	1:3.3	1:3.2	1:2.8	1:2.5	1:2.5	1:2.4	1:2.3	1:2.7
	120	1:4.4	1:4.2	1:3.7	1:3.5	1:3.3	1:3.2	1:3.0	1:3.6
	180	1:5.3	1:4.7	1:4.5	1:4.3	1:4.2	1:4.1	1:4.0	1:4.4
		Polypropylene packages							
3	60	1:3.7	1:3.5	1:3.2	1:2.9	1:2.8	1:2.7	1:2.5	1:3.0
	120	1:4.8	1:4.5	1:4.1	1:3.9	1:3.7	1:3.5	1:3.3	1:4.0
	180	1:5.6	1:5.1	1:4.9	1:4.7	1:4.6	1:4.5	1:4.3	1:4.8
6	60	1:4.2	1:4.0	1:3.7	1:3.4	1:3.3	1:3.2	1:3.0	1:3.5
	120	1:5.3	1:5.0	1:4.6	1:4.4	1:4.2	1:4.0	1:3.8	1:4.5
	180	1:6.1	1:5.6	1:5.4	1:5.2	1:5.1	1:5.0	1:4.8	1:5.3

1. Average of three trials.

Table (26A): Effect of duration of storage period (3-6 months) on rehydration ratio of dried pear slices stored in different packaging materials.[1]

Storage period (month)	Time min	Dehydration period: 10 hrs, Temperature of dehydration: 50°C	10 hrs, 70°C	10 hrs, 80°C	15 hrs, 70°C	20 hrs, 50°C	20 hrs, 60°C	Average
0	60	1:2.9	1:2.4	1:2.2	1:2.1	1:2.1	1:1.9	1:2.3
	120	1:3.8	1:3.3	1:3.0	1:2.9	1:2.9	1:2.8	1:3.1
	180	1:4.6	1:4.2	1:3.9	1:3.8	1:3.8	1:3.6	1:4.0
				Glass jar packages				
3	60	1:3.1	1:2.6	1:2.4	1:2.3	1:2.3	1:2.1	1:2.5
	120	1:4.0	1:3.5	1:3.2	1:3.1	1:3.1	1:3.0	1:3.3
	180	1:4.8	1:4.4	1:4.1	1:4.0	1:4.0	1:3.8	1:4.2
6	60	1:3.4	1:2.9	1:2.7	1:2.6	1:2.6	1:2.4	1:2.8
	120	1:4.3	1:3.8	1:3.5	1:3.4	1:3.3	1:3.2	1:3.6
	180	1:5.1	1:4.7	1:4.5	1:4.2	1:4.2	1:4.0	1:4.5
				Polypropylene packages				
3	60	1:3.6	1:3.2	1:3.0	1:2.9	1:2.9	1:2.7	1:3.1
	120	1:4.6	1:4.1	1:3.8	1:3.7	1:3.7	1:3.6	1:3.9
	180	1:5.4	1:5.0	1:4.7	1:4.6	1:4.5	1:4.4	1:4.8
6	60	1:4.3	1:3.8	1:3.5	1:3.4	1:3.2	1:3.0	1:3.5
	120	1:5.2	1:4.7	1:4.2	1:4.2	1:4.0	1:3.9	1:4.4
	180	1:6.0	1:5.6	1:5.2	1:5.0	1:5.0	1:4.8	1:5.3

1. Average of three trials.

Table (26B): Rehydration properties of dehydrated apple and pear slices during storage for 6 months in different packages kept at room temperature.

Storage period (months)	Apple							Pear						
	Moisture % in average	Rehydration properties						Moisture % in average	Rehydration properties					
		Coefficient of rehydration.			Moisture % in rehydrated sample.				Coefficient of rehydration.			Moisture % in rehydrated sample.		
		1hr	2hrs	3hrs	1hr	2hrs	3hrs		1hr	2hrs	3hrs	1hr	2hrs	3hrs
						Zero time								
	12.65	0.38	0.52	0.65	63.8	73.6	78.8	11.10	0.42	0.57	0.74	61.3	71.3	77.8
						Glass jar packages								
3	12.02	0.39	0.53	0.67	64.8	74.1	79.5	10.56	0.46	0.61	0.77	64.2	72.9	78.7
% change	-0.63	+2.63	+1.92	+3.08	+1.57	+0.68	+0.89	-0.54	+9.52	+7.02	+4.05	+4.73	+2.24	+1.16
6	7.51	0.40	0.53	0.65	65.7	74.3	79.1	7.14	0.49	0.64	0.79	66.8	74.2	79.4
% change	-5.14	+5.26	+1.92	-	+2.98	+0.95	+0.38	-3.96	+16.67	+12.28	+6.76	+8.97	+4.07	+2.06
						Polypropylene packages								
3	12.12	0.46	0.62	0.75	70.7	78.0	81.7	10.73	0.57	0.72	0.88	71.2	77.1	81.4
% change	-0.53	+21.05	+19.23	+15.38	+10.82	+5.98	+3.68	-0.37	+35.71	+26.32	+18.92	+16.15	+8.13	+4.63
6	8.31	0.52	0.67	0.79	73.8	79.6	82.7	8.18	0.63	0.79	0.95	73.8	79.1	82.7
% change	-4.34	+36.84	+28.85	+21.54	+15.67	+8.15	+4.95	-2.92	+50.00	+38.60	+28.38	+20.39	+10.94	+6.30

well as 79.4 and 82.7%, respectively after 6 months of storage.

The rate of increase in average values for rehydration ratioes, coefficient of rehydration and moisture content (%) in rehydrated samples (after 3 hrs of soaking) of apple slices stored in glass jars and polypropylene packages were of 4.9 and 17.1%; 3.08 and 15,38 as well as 0.89 to 3.68%, respectively, after 3 months then increased by 7.3 and 29.3%, 0.0 and 21.54% and 0.38 and 4.95%, respectively, after 6 months of storage, while in case of rehydrated pear slices the rate of increase was of 5 and 20%; 4.05 and 18.92% as well as 1.16 and 4.63%, respectively, after 3 months then increased by 12.5 and 32.5%; 6.76 and 28.38% as well as 2.06 and 6.30%, respectively, after 6 months of storage over the levels present in their corresponding dehydrated fruits before storage (at zero time).

In general, dehydrated fruit slices packed in polypropylene packages for periods from 3 to 6 months exhibited higher rehydration properties and also higher rate of increase than their corresponding fruits packed in glass jar packages. On the other hand, regardless of the type of packaging material, dehydration period and temperature of dehydration, dehydrated apple and pears slices stored for periods up to 6 months did not show great variation in values of rehydration properties. However, dehydration conditions influenced greatly these properties upon storage.

In agreement to our data, dried apricot and grapes(Ibrahim, 1990) as well as dehydrated banana (Abd-El Ghani, 1992) had lower rehydration values after storage for 6 months. In contrast, dehydrated guavas exhibited an increase in values of these

properties after storage for 6 months (Abd-El Ghani, 1992). The variation in rehydration properties observed within the treatments upon their storage is due to the initial variation between these samples before storage or at zero time. Moreover, method of dehydration, predrying treatment and type of packages were reported to influence the rehydration properties of many dried products (Neubert et al., 1968; Neumann, 1977). Loss of differential permeability in the protoplasmic membrane, loss of turgor pressure in the cell, protein denaturation, starch crystallinity, and hydrogen bonding of macromolecules have been suggested as causes of, and at times correlated with various parameters of rehydration (Neumann, 1972) and all of these factors certainly could be influenced by previous dehydration conditions before storage of the dried product.

4.1.4.3. Change in colour:

The principal technical problem in preparation and storage of dehydrated apples and pears products is prevention of colour changes or browning. Dehydrated stored apples and pears showed variable change in colour which was manifested in certain increase in degree of browning (colour index or alcohol - extractable colour (Tables 27 and 28) and slight decrease in serum colour (water-extractable colour(Tables 29, Fig. 4 and 30, Fig. 5) over the levels present corresponding in dry fruits before storage (at zero time) with the elapsement of storage in two different packages at room temperature. The increase in degree of browning and decrease in serum colour was dependent on duration of storage period and was in function of previous dehydration conditions and also kind of fruit rather

Table (27): Effect of duration of storage period (3-9 months) on degree of browning of dehydrated apple slices stored in different packaging materials.[1]

Storage period (month)	Dehydration periods														Average	Standard deviation
	10 hrs						15 hrs						20 hrs			
	Temperature of dehydration															
	50°C		70°C		80°C		70°C		50°C		60°C		70°C			
	Degree of browning	% of increase *	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase		
0	0.078	-	0.079	-	0.081	-	0.083	-	0.088	-	0.091	-	0.093	-	0.085	±0.006
								Glass jar packages								
3	0.088	12.82	0.089	12.66	0.090	11.11	0.092	10.84	0.094	6.82	0.096	5.49	0.098	5.38	0.092	±0.004
6	0.101	29.49	0.103	30.38	0.105	29.63	0.106	27.71	0.108	22.73	0.110	20.88	0.113	21.51	0.107	±0.004
9	0.114	46.15	0.115	45.57	0.118	45.68	0.119	43.37	0.120	36.36	0.122	34.07	0.126	35.48	0.119	±0.004
								Polypropylene packages								
3	0.089	14.10	0.090	13.92	0.091	12.35	0.093	12.05	0.095	7.95	0.098	7.69	0.100	7.53	0.094	±0.004
6	0.103	32.05	0.105	32.91	0.107	32.10	0.108	30.12	0.110	25.00	0.113	24.18	0.115	23.66	0.109	±0.004
9	0.115	47.44	0.116	46.84	0.120	48.15	0.122	46.99	0.124	40.91	0.125	37.36	0.128	37.63	0.121	±0.005

1. Average of duplicate analysis.
2. Measured as optical density.
* Compared to the level present at zero time.

Table (28): Effect of duration of storage period (3-9 months) on degree of browning of dehydrated pears slices stored in different packaging materials.[1]

Storage period (month)	Dehydration periods												Average	Standard deviation
	10 hrs						15 hrs		20 hrs					
	Temperature of dehydration													
	50°C		70°C		80°C		70°C		50°C		60°C			
	Degree of browning	% of * increase	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase	Degree of browning	% of increase		
0	0.143	-	0.144	-	0.146	-	0.147	-	0.149	-	0.151	-	0.147	±0.003
						Glass jar packages								
3	0.148	3.50	0.150	4.17	0.152	4.10	0.156	6.12	0.159	6.71	0.163	7.95	0.155	±0.006
6	0.153	6.99	0.155	7.64	0.158	8.22	0.160	8.84	0.162	8.72	0.168	11.26	0.159	±0.005
9	0.159	11.19	0.162	12.50	0.165	13.01	0.168	14.29	0.171	14.77	0.175	15.89	0.167	±0.006
						Polypropylene packages								
3	0.151	5.59	0.153	6.25	0.154	5.48	0.157	6.80	0.160	7.38	0.164	8.61	0.157	±0.006
6	0.158	10.49	0.160	11.11	0.162	10.96	0.165	12.24	0.167	12.08	0.171	13.25	0.164	±0.005
9	0.160	11.89	0.164	13.89	0.166	13.70	0.170	15.65	0.173	16.11	0.177	17.22	0.168	±0.006

1. Average of duplicate analysis.
2. Measured as optical density.

* Compared to the level present at zero time.

Table (29): Effect of duration of storage period (3-9 months) on the serum color (% transmission) of dehydrated apple slices stored in different packaging materials.[1]

Storage period (month)	Type of package	Dehydration period: 10 hrs, Temperature of dehydration: 50°C, Serum colour	10 hrs, 50°C, % of decrease *	10 hrs, 70°C, Serum colour	10 hrs, 70°C, % of decrease	10 hrs, 80°C, Serum colour	10 hrs, 80°C, % of decrease	15 hrs, 70°C, Serum colour	15 hrs, 70°C, % of decrease	20 hrs, 50°C, Serum colour	20 hrs, 50°C, % of decrease	20 hrs, 60°C, Serum colour	20 hrs, 60°C, % of decrease	20 hrs, 70°C, Serum colour	20 hrs, 70°C, % of decrease	Average	Standard deviation
0		75.1	-	74.2	-	73.2	-	71.2	-	70.1	-	69.4	-	69.2	-	71.8	±2.4
3	G[2]	72.6	3.33	70.3	5.26	70.1	4.23	69.8	1.97	68.9	1.71	67.2	3.17	67.0	3.18	69.4	±1.9
	P[3]	73.2	2.53	71.2	4.04	70.7	3.42	70.3	1.26	69.8	0.43	68.3	1.59	68.0	1.73	70.2	±1.8
6	G	70.1	6.66	69.7	6.06	69.2	5.46	69.2	2.81	68.4	2.43	67.0	3.46	66.7	3.61	68.6	±1.3
	P	71.0	5.46	69.8	5.93	69.8	4.64	69.5	2.39	68.9	1.71	68.0	2.02	67.0	3.18	69.1	±1.3
9	G	69.9	6.92	68.2	8.09	68.0	7.10	68.0	4.49	68.0	3.00	66.8	3.75	65.8	4.91	67.8	±1.3
	P	70.0	6.79	68.5	7.68	68.3	6.69	68.2	4.21	68.2	2.71	67.4	2.88	66.2	4.34	68.1	±1.2

1. Average of duplicate analysis.
2. G: Glass jar packages.
3. P: Polypropylene packages.

* Compared to the level present at zero time.

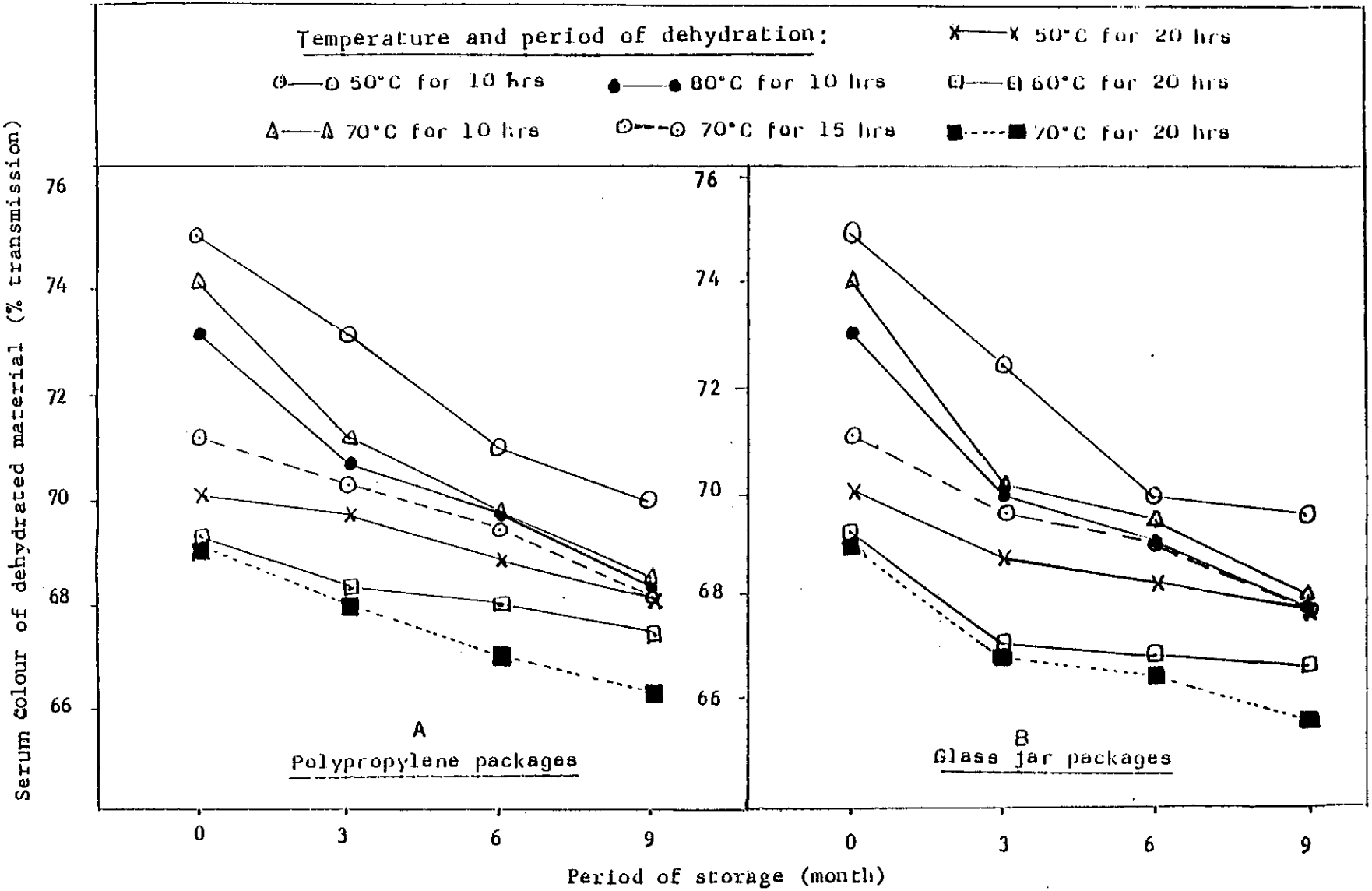


Fig. (4): Comparative presentation for serum colour data (% transmission) obtained for dehydrated apple slices stored in two different packages (A, polypropylene bags; B , glass jars) for periods of 3 to 9 months.

Table (30): Effect of duration of storage period (3-9 months) on the serum color (% transmission) of dehydrated pear slices stored in different packaging materials.[1]

Storage period (month)	Type of package	Dehydration period: 10 hrs, Temperature of dehydration: 50°C — Serum colour	% of decrease *	70°C — Serum colour	% of decrease	80°C — Serum colour	% of decrease	15 hrs, 70°C — Serum colour	% of decrease	20 hrs, 50°C — Serum colour	% of decrease	60°C — Serum colour	% of decrease	Average	Standard deviation
0		65.3	-	63.5	-	60.6	-	60.9	-	59.1	-	58.6	-	61.3	±2.6
3	G[2]	59.2	9.34	56.6	10.87	56.3	7.10	56.4	7.39	56.0	5.25	55.4	5.46	56.7	±1.3
	P[3]	59.4	9.04	56.8	11.55	56.5	6.77	56.7	6.90	56.2	4.91	55.6	5.12	56.9	±1.3
6	G	57.1	12.56	56.0	11.81	55.9	7.76	56.0	8.05	55.6	5.92	54.8	6.48	55.9	±0.7
	P	57.2	12.40	56.3	11.34	56.0	7.59	56.2	7.72	55.8	5.58	55.0	6.14	56.1	±0.7
9	G	56.2	13.94	55.0	13.39	54.9	9.41	55.0	9.69	54.9	7.11	54.2	7.51	55.0	±0.6
	P	56.7	13.17	55.4	12.76	55.0	9.24	55.2	9.36	55.0	6.94	54.6	6.83	55.3	±0.7

1. Average of duplicate analysis.
2. G: Glass jar packages.
3. P: Polypropylene packages.
* Compared to the level present at zero time.

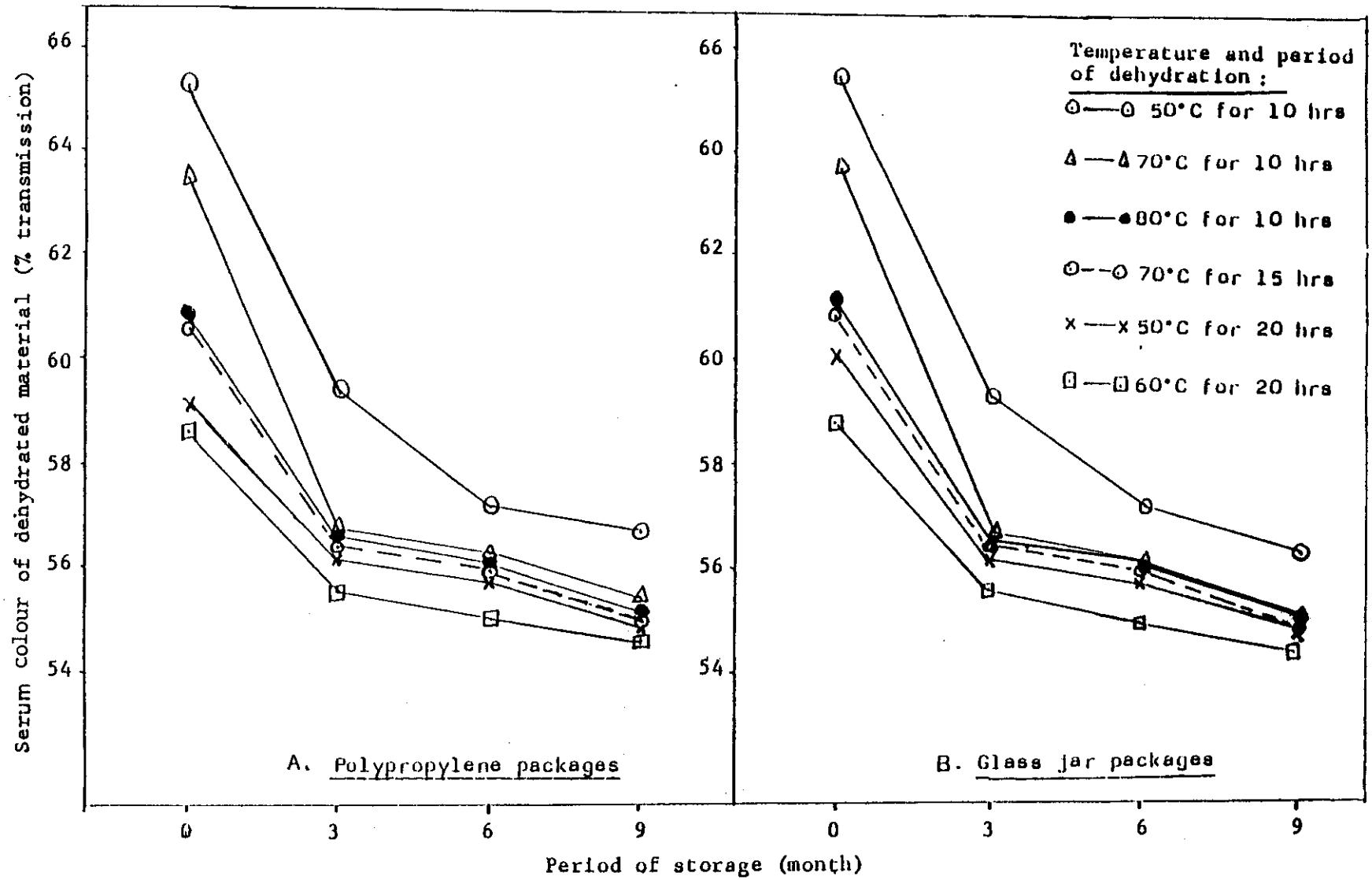


Fig. (5): Comparative presentation for serum colour data (% transmission) obtained for dehydrated pear slices stored in two different packages (A, polypropylene bags; B, glass jars) for periods of 3 to 9 months.

than the type of packaging materials. With the extension of storage period, there was a gradual increase in degree of browning and decrease in serum colour parallel to the increase in degrees of dehydration temperature and also period of dehydration during preparation before storage, regardless of the type of packaging materials.

Degrees of browning (O.D) for all treatments of apple slices stored in two different packages ranged between 0.088 to 0.100, after 3 months 0.101 to 0.115 after 6 months and 0.114 to 0.128 after 9 months of storage, while in case of all treatments for stored pears they ranged between 0.148 to 0.164 after 3 months ; 0.153 to 0.171 after 6 months and 0.159 to 0.177 after 9 months of storage.

The average increase in degree of browning (O.D) in dehydrated apple slices stored in glass jars and polypropylene packages was of 8.2 and 10.6%, respectively, after 3 months as well as 25.9 and 28.2%, respecrively after 6 months while increased by 40 and 42.4%, respectively, after 9 months of storage over (or higher than) the levels recorded for their starting dehydrated products before storage (at zero time).

The average increase in degrees of browning (O.D) in dehydrated pear slices stored in glass jars and polypropylene packages was of 5.4 and 6.8%, respectively, after 3 months as well as 8.2 and 11.6%, respectively, after 6 months and increased by 13.6 and 14.3, respectively, after 9 months of storage over (or higher than) the levels recorded for their starting dehydrated products before storage (at zero time).

In contrast to degrees of browning values, serum colour decreased during storage of dehydrated both fruits for 9 months in the two different packages. Serum colour (%) values showed lower levels compared to those present in their corresponding dehydrated fruits before storage (at zero time). Serum colour (%) values for all dehydrated apple treatments stored in either of both packages ranged between 67.0 to 73.2% after 3 months and 66.7 to 71.0% after 6 months as well as between 65.8 to 70.0% after 9 months, while in case of stored dehydrated pear treatments they ranged between 55.4 to 59.4% after 3 months ; 54.8 to 57.2% after 6 months and 54.2 to 56.7% after 9 months of storage.

The average decrease in serum colour of stored dehydrated apple treatments compared to the original level present before storage was of only 2.75% after 3 months; 4.15% after 6 months and 5.4% after 9 months of storage.

In case of stored pears treatments, the average decrease in serum colour was of 7.35% after 3 months; 8.65% after 6 months and 10.1% after 9 months of storage lower than values recorded for their corresponding dehydrated fruits before storage (at zero time).

The highest browning degrees and lowest serum colour values were attained with those treatments which employed long drying period even at lower temperatures (20 hrs at 50°, 60° and 70°C, in case of apples 50° and 60°C for 20hrs, in case of pears) and those employed also higher drying temperature even for short drying period (70° and 80°C for 10 hrs for both apples and pears). In comment on these findings, it should be mentioned that the browning reaction in fruit has a

relatively high temperature coefficient. Accordingly, it was predicted by Stadtman et al. (1948) that the rate of browning is affected by the time and temperature of processing or dehydration. In contrast, the effects of drying time and temperature on the rate of darkening of apricots and peaches appeared to be of no great consequence provided the fruit was not dried to a moisture content less than 25% (Stadtman et al.,1946). However, when Schrader et al. (1973) studied the effect of drying temperatures on deterioration of apples after dehydration and subsequent storage they found that browning was apparent only with samples dried at 93°C. After 5 months of storage, browning was greatest for the fruit dried at high temperature. Thus, the lowest change in colour during storage was attained by those dehydrated apple and pears at 50°C for 10 hrs.

All dehydrated apples and pears treatments stored from 3 to 9 months in polypropylene packages exhibited a slight high degrees of browning and serum colour values than their corresponding fruits packed in glass jars; however, such differences were very limited as did not exceed 1.7 to 2.1% in case of apples and 0.6 to 3% in case of pears. Moreover, the rate of change in colour was more pronounced in case of stored-polypropylene packaged fruits.

Upon comparing stored dry apples and pears slices, regardless of the type of packaging materials and dehydration conditions during processing, dehydrated apples exhibited lower degrees of browning and also higher values in serum colour than those corresponding of dehydrated pears during tested storage period.

The present data would indicate the suitability of pretreatment and processing conditions and packaging materials used to store dehydrated products at room temperature to maintain colour quality of apple or pear product as indicated serum colour and colour index data. Other investigators found different results. For example, Nichols and Reed (1931) found that only 2-4 months were required for dried fruit to darken to a point described as the "poorest acceptable commercially", whereas the same degree of discoloration was not reached even after 23 months at 0°C (Meyer, 1948).

Heberlein and Clifcorn, (1944) showed that after 2 months storage apple nuggats containing 0.8% moisture at 54.4°C. (130°F) this product had darkened appreciably and significant changes occurred after 6 months at 36.7°C. (98°F), but only a slight change in colour was observed after 12 months at 23.8°-26.7°C. (75°-80°F). Similarly, Sayavedra-Soto and Montgomery (1986) found that storage temperature of golden delicious apples was the most important factor in the degradation of colour in stored dried apple. So, it seems that storing at room temperature for 9 months did not influence greatly the colour changes of the stored dehydrated apple and pears when were prepared and stored under the conditions of the present study providing that their moisture content did not exceed 8.25% and samples were sulfured at the level used at the present study.

4.1.4.4. Residual sulfur dioxide:

The loss in sulfur dioxide (So_2) from dehydrated fruits continues on storage and determines the practical shelf life

with respect to deterioration through non-enzymatic browning. The decrease in So_2 ,variation in storage conditions and moisture content can causes during storage, deterioration in quality of dried fruits (Labuza, 1982). Therefore, the decrease in sulfur dioxide level during storage has been taken as an index of deterioration.

Both dehydrated fruits showed tremendous decrease in residual sulfur dioxide with the elapsement of storage period at room temperature. The rate of such decrease was greatly dependent on duration of storage period rather than previous dehydration conditions before storage and kind of stored dry fruit as well as the type of packaging materials. Residual So_2 in all dehydrated stored apple treatments showed variable So_2 content which ranged between 758.4 to 908.9 ppm after 3 months; between 680.3 to 812 .6 ppm after 6 months and between 572.3 to 702.9 ppm after 9 months;while in case of dehydrated pear slices, So_2 ranged between 696.0 to 899.6 ppm after 3 months, 626.0 to 759.1 ppm after 6 months and 600.0 to 652.6 ppm after 9 months of storage. (Tables 31 , Fig. 6 and 32, Fig. 7).

Compared to the levels present in dehydrated fruit slices before storage (at zero time), the average decrease in So_2 content of all dehydrated stored apple treatments packed in either package ranged between 43.9 to 44.9% after 3 months; between 52.2 to 51.9% after 6 months and between 59.1 to 58.9% after 9 months of storage, while in case of pear stored treatments, the rate of decrease ranged between 43.8 to 42.4% after 3 months; between 50.6 to 49.6% after 6 months and between 55.6 to 54.5% after 9 months of storage life.

Table (31): Effect of duration of storage period (3-9 months) on the residual sulfur dioxide content (ppm) of dehydrated apple slices stored in different packaging materials (on dry weight basis)[1].

Storage period (month)	Type of Package	Dehydration period: 10 hrs, Temperature of dehydration 50°C	10 hrs, 70°C	10 hrs, 80°C	15 hrs, 70°C	20 hrs, 50°C	20 hrs, 60°C	20 hrs, 70°C	Average	Std. dev.
0		1641.3	1581.6	1498.1	1499.8	1418.3	1401.1	1389.6	1489.9	±95.45
3	G[2]	908.9	891.6	876.9	839.8	821.9	815.6	801.2	850.8	±41.60
	P[3]	901.6	880.3	875.6	830.1	800.1	800.2	758.4	835.2	±52.40
6	G	812.6	715.9	704.3	700.9	700.9	696.1	690.6	717.3	±42.70
	P	810.1	704.1	700.2	700.3	700.0	688.1	680.3	711.9	±44.10
9	G	702.9	614.1	602.1	600.3	600.1	591.6	580.1	613.0	±41.00
	P	700.7	606.2	600.9	598.6	600.0	587.1	572.3	609.4	±41.80

1. Average of duplicate analysis.
2. G: Glass jar packages.
3. P: Polypropylene packages.

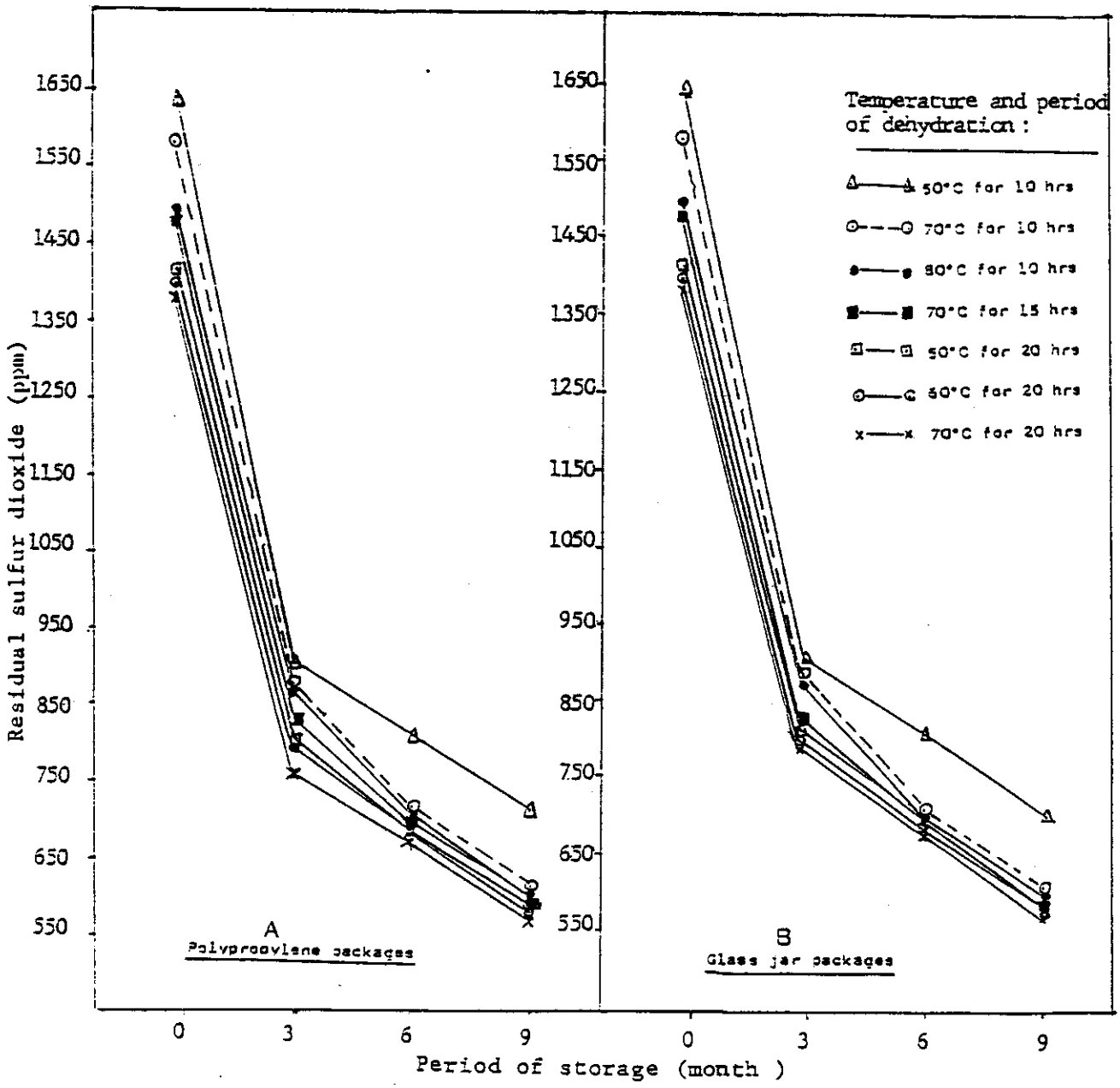


Fig. (6): Comparative presentation for residual sulfur dioxide (ppm) data obtained for dehydrated apple slices stored in two different packages (A, polypropylene bags; B, glass jars) for periods of 3 to 9 months.

Table (32): Effect of duration of storage period (3-9 months) on the residual sulfur dioxide content (ppm) of dehydrated pear slices stored in different packaging materials (on dry weight basis)[1].

Storage period (month)	Type of package	Dehydration period: 10 hrs, Temperature of dehydration 50°C	10 hrs, 70°C	10 hrs, 80°C	15 hrs, 70°C	20 hrs, 50°C	20 hrs, 60°C	Average	Std. dev.
0		1543.8	1412.9	1360.0	1348.0	1299.0	1281.0	1374.1	±95.38
3	G[2]	899.6	806.8	803.1	800.3	739.1	701.0	791.7	±67.90
	P[3]	889.3	800.1	778.6	758.4	709.1	696.0	771.9	±70.00
6	G	759.1	700.9	700.9	702.9	652.6	636.0	692.1	±43.50
	P	744.9	696.3	682.9	679.3	641.9	626.0	678.6	±48.20
9	G	652.6	641.1	633.1	613.1	611.9	603.0	625.8	±19.40
	P	639.1	609.1	607.6	600.9	600.7	600.0	609.6	±15.00

1. Average of duplicate analysis.
2. G: Glass jar packages.
3. P: Polypropylene packages.

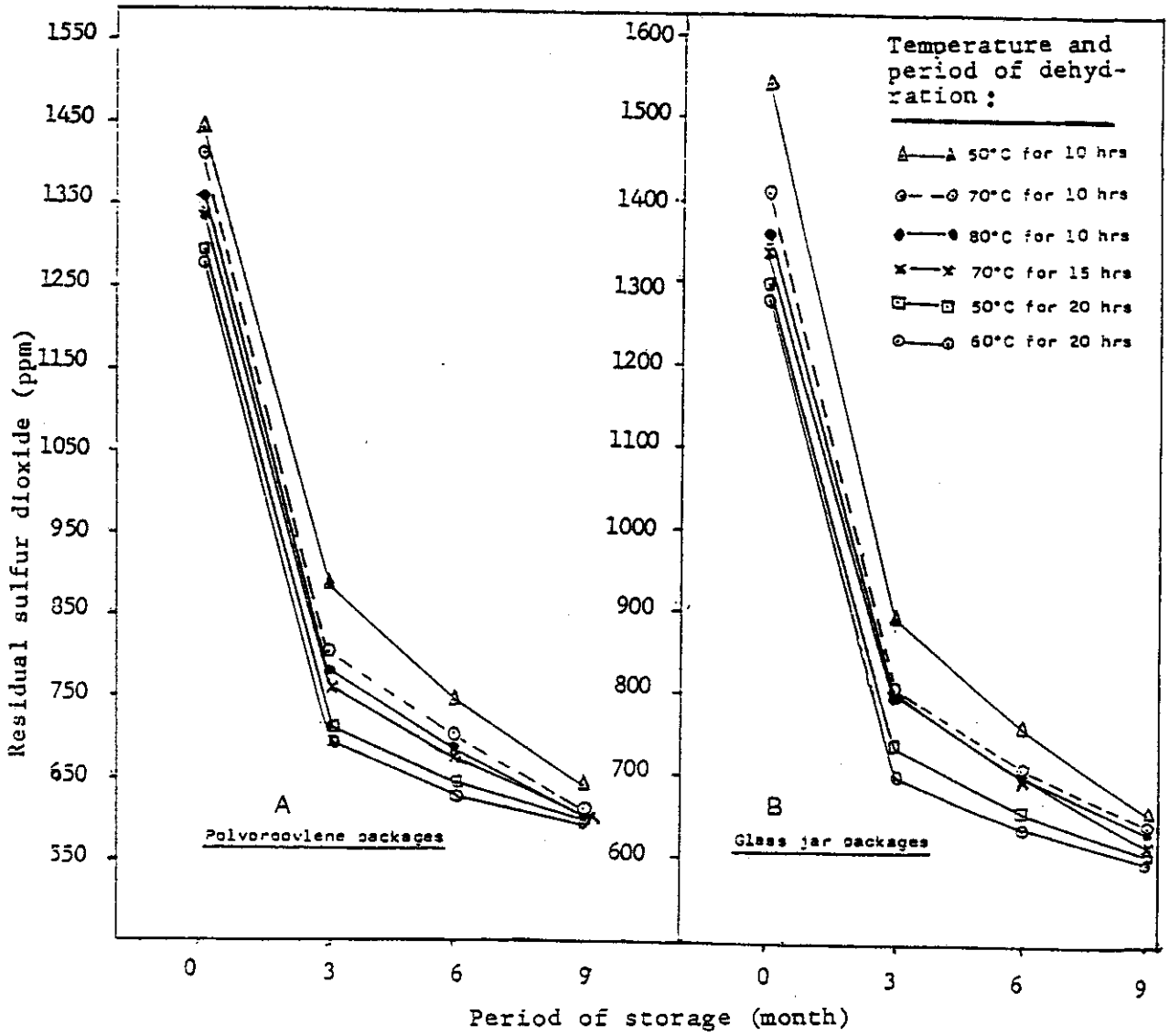


Fig. (7) : Comparative presentation for residual sulfur dioxide (ppm) data obtained for dehydrated pear slices stored in two different packages (A, polypropylene bags; B, glass jars) for periods of 3 to 9 months.

The observed slight variation in So_2 content of stored apple treatments, which seemed to be dependent on increase in dehydration temperature during processing, is attributed to the difference between these treatments in initial So_2 level before storage since the rate of change in residual So_2 did not show significant variation between treatments.

In general, dehydrated fruit slices packed in polypropylene packages exhibited very slight lower sulfur dioxide content than their corresponding fruits packed in glass jar packages. However, such differences were very limited as they did not exceed 0.6 to 1.8% in case of apples but only 2 to 2.6% in case of pears. On the other hand, regardless of the type of packaging materials and dehydration conditions dehydrated apple exhibited a very slight higher sulfur dioxide than the corresponding pears after 6 months of storage while after 9 months of storage, both stored dry fruits showed comparable values.

Sulfur dioxide was added as pretreatment in the present study since it serves several purposes, it reduces on prevents microbial spoilage, preserves ascorbic acid and carotene and inhibits browning during drying and storage (Stafford and Bolin, 1972). Sulfur dioxide is absorbed by fruit tissue when they are dipped in So_2 containing solutions (Davis et al., 1973) and much of the absorbed So_2 is lost during drying and of that which remains, 80-90% is in a combined form (McBean, 1967) while drying stabilizes the amount of So_2 held in the fruit tissue, a further slow loss of the preservative occurs during its storage.

In most cases, about 50% of the sulfite disappeared from dehydrated products before any significant amount of browning developed (Labuza, 1982).

In the present study, all stored apple and pear treatments showed acceptable colour and lower colour changes as indicated in Tables 27 28; 29 and 30. These data indicate that the initial So_2 level before storage as well as storage conditions and type of packages utilized seemed to be convenient in producing dehydrated apples and pears of acceptable colour and lower browning changes although variable rates of loss in SO_2 occurred during storage for one year.

It is well known that the loss of sulfur dioxide from dehydrated fruits or vegetables continues on storage and determines the practical shelf-life with respect to spoilage through non-enzymic browning. However, the rate of So_2 loss increases with increasing So_2 concentrations and therefore the rate of darkening in inversely proportional to So_2 concentration over a range of 1000-8000 ppm (Stadtman et al.1946; and Nury et al. 1960 a, b & c). Eicit (1938) stated that finished dehydrated apple product should not contain less than 500 ppm or more than 2000 ppm of So_2 while Nury et al.(1960a,b,c)found that sulfured dry fruits were no longer acceptable when their So_2 levels had fallen to 700 and 500 ppm, respectively, from initial values of 3000 and 1500 ppm. Tressler and Joslyn (1961) noted that when So_2 was used only to inhibit oxidation reactions about 200 ppm were only adequate. Woodroof and Luh (1975) revealed that residual levels of sulfur dioxide in dehydrated apple and pears required for their successful for preparation and storage were

1000-2000 ppm. Subsequently, the suggested residual So_2 in dehydrated apple and pear products was. reported by Wedzicha(1984) to be 1000-2000 ppm while that for dried apricot and peach was 2000-4000 ppm. In agreement to our data, Sayavedra-Soto and Montgomery (1988) found that aproximately 1500 ppm total So_2 were found necessary at the initial time of storage to prevent change in colour. In the present study, the initial So_2 before storage ranged between 1641.3 to 1389.6 and between 1543.8 to 1281 for all apple and pear treatments tested, respectively. So it is apparent that these found So_2 levels are quite comparable to those recommended by the aforementioned investigators.

The observed variation in residual So_2 level between the tested two packages could be direct reflection of the nature of these two packages especially with regard to permeability characteristics without or in combination with other factors. In fact, some of the first controlled experiments on cut fruits were made by Nichols and Reed (1931) who packed apples, pears and apricots in vacuum-sealed glass jars and in air and stored them at 0°, 21.1° and 37.8°C. The vacuum-packed samples darkened slightly less rapidly than the samples packed in air. In another experiments, they packed these same fruits in tin cans under vacuum, in hydrogen and in air, and in card board cartons. Samples were sent from USA to Manila and to Singapore for storage where they were examined for changes in colour and So_2 after various periods of time. These workers concluded that cartons protected colour of apricots as well as did cans, but that in case of apples and pears So_2 was lost and the colour deteriorated faster in the carton packs than in cans.

Vacuum-packed cans gave the best protection and were better than cans filled with hydrogen and these in turn were better than air-packed cans.

The disappearance of So_2 is sensitive to temperature and moisture content of product. The composition of atmosphere with respect to oxygen in headspace of packaged dehydrated product is important at higher temperature (37°C, Mangan and Doak, 1949) but is significant at lower temperature (24°C; Legault et al., 1942). However, Davis et al. (1973) found that the loss of So_2 from dried fruits during storage due to oxidation by oxygen,which entered the permeable packages,was about twice that caused by oxygen-which was entrapped in the head space of the impereable package. However, it should be stated that, Sayavedra-soto and Montgomery (1988) found that storage temperature in golden delicious apples was the most important factor in the deterioration of colour in stored dried apples.

4.1.4.5. Soluble and insoluble pectin:

Dehydrated fruit of both cultivars showed a variable increase in soluble pectin but decrease in insoluble pectin with the advancement of storage period at room temperature. Such increase and/or decrease was greatly dependent on duration of storage period and type of packages (Table 33; Fig. 8 and 34 ;Fig.9). Both soluble and insoluble pectin contents decreased gradually parallel with the increase in either dehydration temperature or period of dehydration during the processing of stored products.

Soluble and insoluble pectin of all stored dehydrated apple treatments ranged between 0.500 to 0.623% and 0.500 to 0.748%,

Table (33): Effect of duration of storage period (3-9 months) on the soluble and insoluble pectin content of dehydrated apple slices stored in different packaging materials (9/100 g of dry weight)[1].

Storage period(month)	Dehydration period														Average		Standard deviation	
	10 hrs						15 hrs				20 hrs							
	Temperature of dehydration																	
	50°C		70°C		80°C		70°C		50°C		60°C		70°C					
	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin
0	0.593	0.788	0.576	0.773	0.503	0.708	0.484	0.673	0.460	0.643	0.440	0.629	0.430	0.600	0.498	0.688	0.064	0.072
	Glass jar packages																	
3	0.623	0.748	0.615	0.702	0.612	0.652	0.523	0.582	0.515	0.559	0.504	0.518	0.500	0.512	0.556	0.610	0.057	0.092
6	0.692	0.700	0.689	0.652	0.670	0.598	0.599	0.521	0.599	0.499	0.598	0.498	0.590	0.498	0.634	0.567	0.047	0.084
9	0.733	0.633	0.729	0.602	0.703	0.588	0.639	0.499	0.631	0.459	0.602	0.453	0.600	0.430	0.662	0.523	0.058	0.082
	Polypropylene packages																	
3	0.600	0.729	0.599	0.700	0.578	0.623	0.504	0.552	0.503	0.500	0.500	0.500	0.500	0.500	0.541	0.586	0.049	0.098
6	0.689	0.699	0.673	0.643	0.653	0.572	0.542	0.500	0.538	0.462	0.500	0.423	0.500	0.420	0.585	0.531	0.088	0.110
9	0.702	0.604	0.700	0.600	0.700	0.520	0.621	0.470	0.600	0.430	0.576	0.400	0.545	0.400	0.635	0.489	0.066	0.095

1. Average of duplicate analysis.

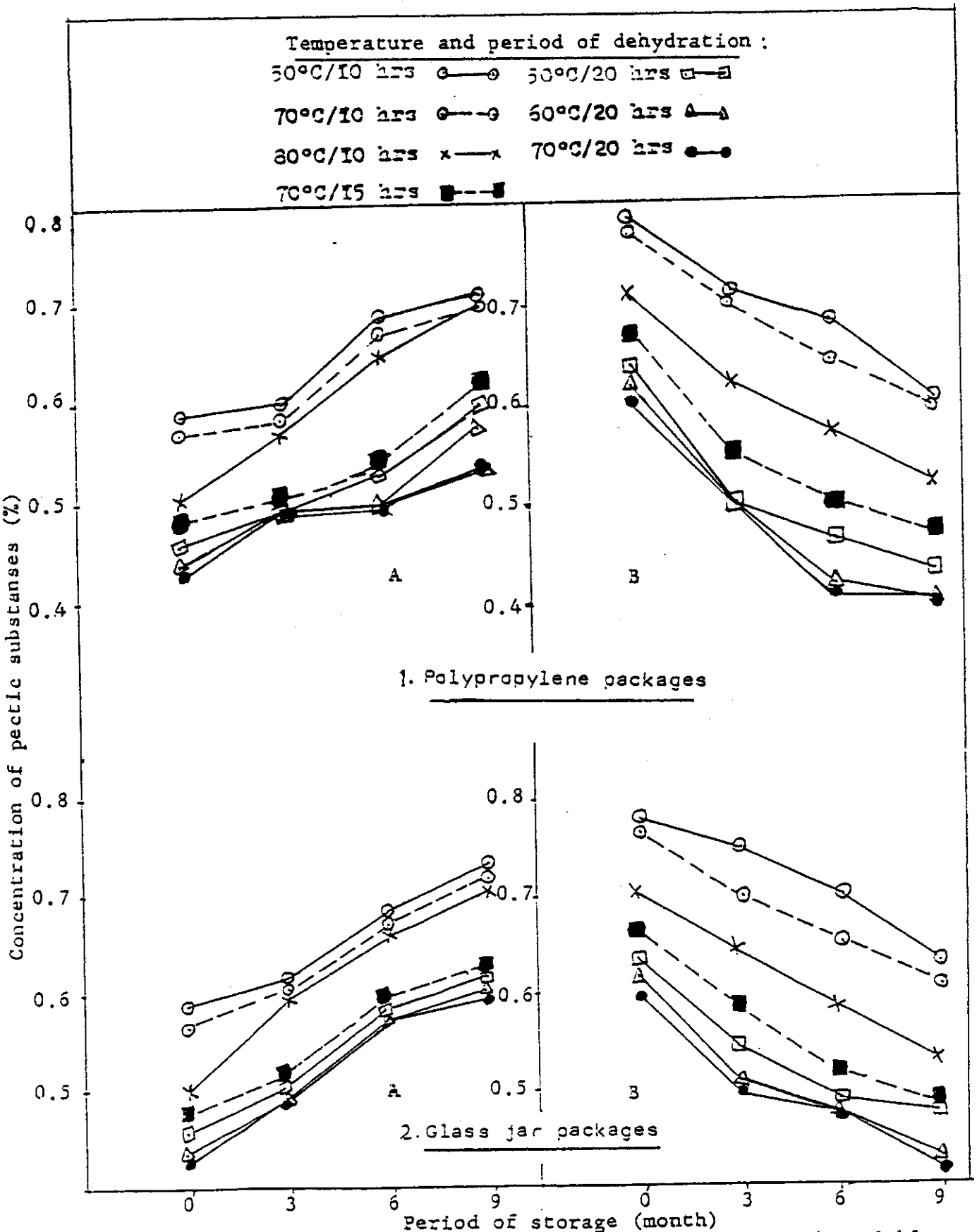


Fig. (8): Comparative presentation for pectic substanses (A; soluble pectin; B, insoluble pectin (%) data obtained for dehydrated apple slices stored in two different packages (1., polypropylene bags; 2., glass jars) for periods of 3 to 9 months.

Table (34): Effect of duration of storage period (3-9 months) on the soluble and insoluble pectin content of dehydrated pear slices stored in different packaging materials (9/100 g of dry weight)[1].

Storage period (month)	Dehydration period												Average		Standard deviation	
	10 hrs						15 hrs		20 hrs							
	Temperature of dehydration															
	50°C		70°C		80°C		70°C		50°C		60°C					
	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin	Soluble pectin	Insoluble pectin
0	0.539	0.603	0.528	0.600	0.518	0.598	0.508	0.570	0.498	0.570	0.459	0.564	0.508	0.584	0.028	0.019
	Glass jar packages															
3	0.639	0.582	0.609	0.582	0.603	0.520	0.600	0.502	0.589	0.500	0.562	0.500	0.600	0.531	0.025	0.033
6	0.698	0.554	0.689	0.500	0.688	0.462	0.678	0.450	0.624	0.432	0.608	0.412	0.664	0.468	0.038	0.051
9	0.743	0.498	0.704	0.480	0.700	0.401	0.698	0.400	0.692	0.398	0.617	0.379	0.692	0.426	0.041	0.050
	Polypropylene packages															
3	0.623	0.579	0.600	0.573	0.600	0.500	0.600	0.500	0.576	0.500	0.554	0.500	0.592	0.525	0.024	0.039
6	0.689	0.549	0.689	0.500	0.679	0.459	0.668	0.449	0.604	0.440	0.596	0.432	0.654	0.472	0.043	0.045
9	0.734	0.488	0.700	0.463	0.689	0.400	0.680	0.400	0.675	0.400	0.600	0.400	0.680	0.425	0.045	0.040

1. Average of duplicate analysis.

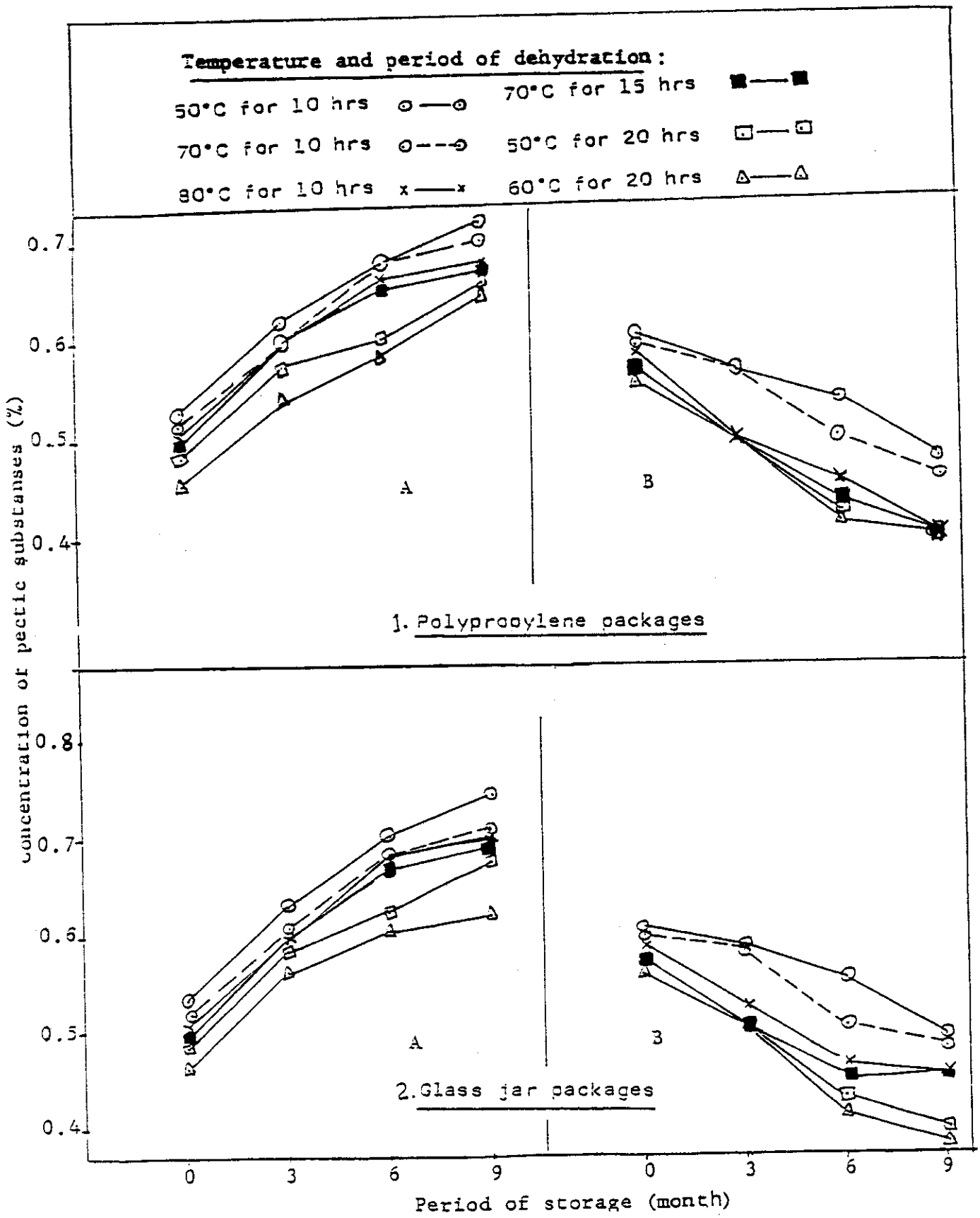


Fig. (9): Comparative presentation for pectic substanses (A; soluble pectin; B, insoluble pectin (%) data obtained for dehydrated pear slices stored in two different packages (1-, polypropylene bags; 2-, glass jars) for periods of 3 to 9 months.

respectively, after 3 months and between 0.420 to 0.692% and 0.420 to 0.700%, respectively, after 6 months as well as between 0.545 to 0.733 and 0.400 to 0.633%, respectively, after 9 months of storage, while with stored dry pear treatments they ranged between 0.554 to 0.639% and 0.500 to 0.582%, respectively, after 3 months and between 0.596 to 0.698% and 0.412 to 0.554%, respectively, after 6 months as well as between 0.600 to 0.743% and 0.379 to 0.498%, respectively, after 9 months of storage.

Compared to the levels present in dehydrated fruit slices before storage (at zero time), all dehydrated apple treatment stored in glass jars and polypropylene packages showed an average increase in soluble pectin of 11.6 and 8.6%, respectively, after 3 months and by 27.3 and 17.5%, respectively, after 6 months as well as 32.9 and 27.5%, respectively, after 9 months of storage. Subsequently, insoluble pectin decreased by 11.3 and 14.8%, respectively, after 3 months and by 17.6 and 22.8%, respectively, after 6 months as well as 24.0 and 28.9%, respectively, after 9 months of storage.

In contrast to apples, no significant differences were observed between the glass jars and polypropylene packaged-stored pear treatment which showed an average increase and decrease in soluble pectin and insoluble pectin, respectively, by 17.3 and 9.6%, after 3 months and by 29.7 and 19.6%, after 6 months as well as 35.1 and 27.2%, after 9 months of storage.

Regardless of the type of packaging materials, dehydration period and temperature of dehydration during processing, stored dehydrated apple slices exhibited higher amounts of insoluble

pectins" and lower amount of soluble pectins than those corresponding dehydrated pear slices, while dehydrated pear slices exhibited slightly higher amounts in "soluble pectin" than in apple slices.

The increase in soluble pectin in apple was reported to be brought about by depolymerization of insoluble propectin and hydrolysis of hemicellulose which are attached to pectic substances by hydrogen bonding because of the effect of heat treatment under the lower pH present naturally in the processed ripe apples (Doesburg, 1961).

4.1.4.6. Total and reducing sugars:

Dehydrated apple and pear fruits showed variable decrease in total and reducing sugars with elapsement of storage period at room temperature (Tables 35 and 36). The extent of such decrease was greatly dependent to duration of storage period in function of previous dehydration conditions and kind of fruit rather than the type of packaging materials utilized throughout the storage period. In other words, dehydrated fruit slices stored in either glass jars or polypropylene packages did not show any significant differences in their sugar content (not exceeding 0.2 to 0.4% in both fruits). There was a gradual decrease in total and reducing sugars parallel to the increase in degrees of dehydration temperature and period of dehydration before storage, regardless of the type of packaging material and/or duration of storage period. Total and reducing sugars of all stored dehydrated apple treatments ranged between 64.2 to 67.1 and 45.3 to 49.1% respectively, after 3 months; between 63.4 to 66.4% and 45.0 to 48.4%, respectively, after 6 months and between 63.0 to 66.1%, and 44.3 to 48.1%, respectively after 9

Table (35): Effect of duration of storage period (3-9 months) on the reducing and total sugar content of dehydrated apple slices stored in different packaging materials (g/100 g of dry weight).[1]

Storage period (month)	Dehydration period: 10 hrs, Temperature of dehydration: 50°C														Average		Standard deviation	
	10 hrs						15 hrs		20 hrs									
	Temperature of dehydration																	
	50°C		70°C		80°C		70°C		50°C		60°C		70°C					
	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars
0	49.6	67.3	49.0	67.0	48.0	66.3	47.6	66.0	47.7	66.1	47.0	65.3	46.4	65.0	47.9	66.1	1.22	2.03
Glass jar packages																		
3	49.0	67.0	48.8	66.3	47.6	65.4	47.0	65.4	47.0	65.3	46.2	65.0	45.3	64.2	47.3	65.4	1.33	0.91
6	48.3	66.3	48.2	66.0	47.2	65.0	46.3	65.0	46.2	65.0	46.0	64.3	45.0	63.4	46.7	65.0	1.21	0.98
9	48.0	66.0	48.0	65.6	47.0	64.2	46.0	64.3	46.0	64.2	45.3	64.0	44.3	63.0	46.4	64.5	1.38	1.01
Polypropylene packages																		
3	49.1	67.1	48.8	66.4	47.7	65.5	47.1	65.3	47.1	65.4	46.3	65.1	45.4	64.3	47.4	65.6	1.31	0.91
6	48.4	66.4	48.3	66.1	47.3	65.1	46.4	65.1	46.0	65.1	46.1	64.4	45.1	63.5	46.8	65.1	1.26	0.98
9	48.1	66.1	48.1	65.7	47.1	64.3	46.1	64.4	45.4	64.2	45.5	64.1	44.4	63.1	46.4	64.6	1.43	1.02

1. Average of duplicate analysis.

Table (36): Effect of duration of storage period (3-9 months) on the reducing and total sugars content of dehydrated pear slices stored in different packaging materials (g/100 g of dry weight)[1].

Storage period (month)	Dehydration period												Average		Standard deviation	
	10 hrs						15 hrs		20 hrs							
	Temperature of dehydration															
	50°C		70°C		80°C		70°C		50°C		60°C					
	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars	Reducing sugars	Total sugars
0	26.9	38.9	26.7	38.6	25.2	37.3	25.0	37.0	25.1	37.1	25.0	36.6	25.7	37.6	0.896	0.937
Glass jar packages																
3	26.0	38.0	26.0	38.0	24.5	36.6	24.6	36.2	24.3	36.1	24.2	36.0	25.0	36.8	0.943	0.939
6	25.5	37.6	25.2	37.2	24.0	36.0	24.0	36.0	24.0	36.0	24.0	36.0	24.5	36.4	0.706	0.868
9	25.3	37.0	25.0	37.0	23.7	35.3	23.3	35.4	23.0	35.2	23.0	35.0	23.9	35.8	1.020	0.926
Polypropylene packages																
3	26.2	38.1	26.0	38.0	24.7	36.7	24.7	36.3	24.4	36.2	24.3	36.1	25.1	36.9	0.833	0.919
6	25.6	37.7	25.6	37.4	24.1	36.1	24.0	36.0	24.0	36.0	24.0	35.5	24.6	36.5	0.683	0.884
9	25.1	37.1	25.0	27.0	23.8	35.4	23.4	35.4	23.2	35.2	23.0	35.1	23.9	35.9	0.918	0.925

1. Average of duplicate analysis.

months of storage, while in case of stored dehydrated pear treatments they ranged between 36.0 to 38.1% and 24.2 to 26.2%, respectively, after 3 months; between 35.5 to 37.7% and 24.0 to 25.6%, respectively after 6 months and between 35.0 to 37.1% and 23.0 to 25.3%, respectively, after 9 months of storage.

Compared to the levels present in dehydrated fruit slices before storage, total and reducing sugars of all apple treatments decreased,on the average,by 0.95 and 1.15%, respectively, after 3 months; by 1.6 and 2.4%, respectively, after 6 months and by 2.4 and 3.1%, respectively, after 9 months of storage. On the other hand, stored pear treatments decreased on the average by 2 and 2.5%, respectively,after 3 months; by about 3.1 and 4.5%, respectively, after 6 months as well as 4.7 and 7.0%, respectively, after 9 months of storage. The highest values for total and reducing sugars were attained with stored apple and pears treatments which employed short drying period even at higher temperature during processing (10 hrs at 50° and 70°C).

Regardless of the type of packaging materials, dehydrated apple rings exhibited a tremendous higher total and reducing sugars contents than the corresponding of dehydrated pears by 43.8 and 47.1%, respectively, after 3 months; 44.0 and 47.5%, respectively, after 6 months and by 44.5 and 48.5%, respectively, after 9 months of storage.

4.1.4.7. Activity of polyphenol oxidase enzyme in fresh and dehydrated apple and pears, as well as after subsequent storage:

The oxidative reactions associated with the undesirable darkening of damaged tissues in fresh fruits and vegetables are catalyzed by the enzyme PPO. PPO activity is particularly high in those fruits and vegetables containing significant levels of phenolic compounds (Kidron et al., 1978) such as apples and pears.

Activity of polyphenol oxidase (PPO) enzyme was measured in fresh and dehydrated apple and pears fruits (Table 37). Initial activity of polyphenol oxidase of fresh apple and pears was 18.89 and 22.58 (u/min/ml), respectively, then reduced greatly after dehydration to 14.56 and 19.30 (u/min/ml), respectively, while after 12 months of storage in glass jar packages it decreased again to 6.8 and 10.4 (u/min/ml), respectively. About 22.9 and 14.5% of the initial PPO activity in apple and pears fruit were lost upon using pre-drying dip treatment solution containing 1% citric acid + 0.5% NaCl during peeling followed by 0.4% $Na_2S_2O_5$ for both apple and pears and dehydration at temperature of 60°C for 20 hrs.

Stored dehydrated fruit slices for 12 months at room temperature showed remarkable decrease in PPO activity from those levels present at zero time (before storage). About 53.3% and 46.1% of PPO activity present in dehydrated apple and pears, respectively, before storage (at zero time) were lost after their storage for 12 months at room temperature. This means that 64 and 53.9% of initial PPO activity present in fresh apple and pears fruit, respectively, were lost by storage of dehydrated apple and pears rings, respectively, for 12 months at room temperature.

Table (37): Polyphenol oxidase enzyme activity in fresh and dehydrated fruits stored for 12 months.

Fruit material	Fresh state	pH[1]	After dehydration at 60°C for 20 hrs		After storage for 12 months		
			Enzyme[2] activity	% residual activity	Enzyme activity	% residual activity	
						A[3]	B[4]
Apples	18.89	3.59	14.56	77.07	6.8	35.99	46.7
Pears	22.58	4.42	19.30	85.47	10.4	46.05	53.8

1. pH of dehydrated material. 2. u/min/ml.

3. A: Residual at enzyme activity from that of fresh state.

4. B: Residual of enzyme activity from that of dehydrated material.

Literature reports are quite contredictory regarding the extent of PPO inactivation upon heating so as to be compared with the obtained results of the present study. For example, Dimick et al. (1951) showed that polyphenol oxidase could be inactivated by heating apple puree for 9 sec. at 81°C. Scott (1975) indicated that PPO enzyme lost 50% of its activity on heating to 80°C for 10 sec while at 90°C less than 1% of the original activity remained after 10 sec.Shallenberger and Jansen (1977) demonstrated that PPO enzyme is very labile to heat at 85°C and above, the higher the temperature, the shorter the time for complete inactivation, and that temperature of 100°C is not necessary for complete inactivation. Approximately 50% of activity was lost after heating PPO enzyme extracted from d'Anjou pears for 11.7, 6.25, 2.24 and 1.1 min at temperatures of 70°, 75°, 80° and 85°C, respectively (Halim and Montgomery (1978). Chung et al. (1983) found that PPO enzyme from apple was very stable with heating at 40°C for 1 hr while heating at 60°C for 30 min resulted about 50% loss of its activity. The activity of PPO increased with the presence of Cu^{2+} and Mn^{2+} and decreased by addition of Na^{+}; Mg^{2+} and Co^{2+}. Subsequently, Jonathan (1984) found that approximately 35 and 15% of initial PPO activity remained after heating PPO enzyme from apple at 60°C and 70°C for 1 hr. Inhibitors i.e. $Na_2S_2O_5$, cystein or vitamin C were found effective against the enzyme as indicated by results of Augustin et al. (1985) on heat denaturation of PPO from various sources, short exposures to temperatures of 70°-90°C are greatly sufficient for partial or total inactivation of the enzyme. Therefore, they stated that for each fruit product, the minimum time temperature requirement for PPO

inactivation must be maintained so as to minimize the undesirable changes accompanying the heating.

The lower inhibition of PPO enzyme in dehydrated apple and pears could be attributed to any of various reasons or a combination of some or all of them such as lower temperature applied during drying (60°C for 20 hrs) or the lower concentration of both citric acid during peeling and $Na_2S_2O_5$ in the pretreatment soaking solution or due to the lower pH during these pretreatments. Sayavedra-Soto and Montgomery (1986) stated that increased concentrations of sulfite and pH levels less than 5 enhanced the inhibition of PPO by sulfite and the sulfite did not inhibit PPO at pH levels equal or greater than 7 unless the concentration was increased above 2.0 mg/ml. As the pH of PPO solution was increased inhibition by sulfite increased until at pH levels below 4. At pH 4, concentrations greater than 0.04 mg/ml completely inhibited 1.000 units of PPO activity almost instantaneously. This suggested that the HCO_3^- molecule was the main component in the sulfite system inhibiting PPO.

The optimum pH of PPO is not very sharp. The range of optimum activity is from 5 to 7. At lower pH values, particularly below a pH of 3, enzyme activity cannot be demonstrated, and subsequent raising of the pH does not restore it. For PPO which was obtained from Bartelett pears, the optimum pH was 6.2 (range 5.8 to 6.4) (Tate et al., 1964) as well as a maximum activity at pH 7.0 was found in apple (Betrosian et al., 1960). However, PPO system in fruits has been shown to be most active

at or near natural pH values. A maximum activity at pH 7.0 was found in apple (Betrosian et al., 1960), pears (Halim and Montgomery, 1978).

The optimum conditions for activity of PPO enzyme extracted from apple were pH 6.0 and 30°C and the enzyme was very stable at pH 4.0 (Chung et al., 1983). Results of the present study indicated that dehydrated apple has lower pH values than thcse of pears.

It should be mentioned that the time required for complete inactivation PPO enzyme by heating depends on amount of enzyme found in fruit and is also dependent on pH (Scott, 1975). Furthermore, the required time and temperature depend greatly on pH. Lowering of pH results in a decrease in enzymatic activity where PPO is inactivated irreversibly at pH value below 3 (Scott, 1975).

In the present study, there was great variation between apple and pears with respect to their enzymatic activities in the fresh and in the dehydrated states as well as after their subsequent storage for one year, although both apple and pears belong to the same genus. It is apparent that pear had higher PPO activity than apples by 119.5% in the fresh state, by 132.6% in the dehydrated state also by 152.9% after storage for one year at room temperature. This means that PPO activity in apples represents about 83.7%, 75.7% and 65.4% of activity present in fresh, dehydrated and stored pear rings, respectively. However, these obtained data would indicate that the rate of inhibition for PPO activity under the constant dehydration and

storage treatments applied in the present study was greater in apples than in pears.

The difference between apple and pear in their PPO enzyme activity could be attributed to their difference in chemical composition and chemical properties such as pH (Table 37) and their content in phenolic compounds, which are the natural substrates for PPO enzyme (Scott, 1975) or the difference in the nature or properties of the enzymes themselves.

Several workers related enzymatic browning with enzyme activity and concentration of substrate (Weuman and Swain, 1953; Walker, 1962: Harel et al., 1970). Apple and pear were reported to contain variable and appreciable concentration of phenolic compounds from 630 to 1660 mg/100 g in raw and from 876 to 1920 in ripe fruit depending on cultivaror variety (Prabha and Patward han, 1985).

Polyphenol oxidase in pears is responsible for the oxidation of ortho - but not meta- or para-dihydroxy phenolic compounds. The main substrates which cause brown pigment formation in pears are catechol, chlorogenic acid, caffeic acid, d-catechol and protocatechinic acid (Luh and Kamber, 1963; Tate et al., 1964). It should be mentioned that chlorogenic acid was reported to be the key substrate for enzymic browning in apples and pears (Weuman and Swain, 1953; Hulme, 1958). Oszmianski and Sozymski (1987) studied the changes in the polyphenolic compounds of apple pulp either during grating or after storage of the pulp at 20°C for 3-240 min. Results indicated that any changes in polyphenolic compounds were rapid immediately after grating and lessened during subsequent storage of the pulp.

In general agreement to our results, Yankov (1974) reported great variation among apple varieties towards enzymic browning since PPO activity varied greatly with variety and also cultivar. PPO activity ranged from one unit/g for Golden Delicious to 8.7 units/g for Red Delicious and total polyphenol concentration from 184 for Golden Delicious to 292 mg chlorogenic acid/100 g for Red Delicious. Furthermore, Prabha and Patwardhan (1985) reported a wide range of variation in total phenolic contents of peels and pulp of apple fruits in function of stage of maturity and therefore PPO activity and the rate of browning varied greatly since phenolic compounds are the main substrates for PPO (Scott, 1975).

In addition, Augustin et al. (1985) indicated that heat stability of PPO enzyme may be related to ripeness of the fruit and in some cases it is also dependent on pH. In addition different molecular forms from the same source may have different thermostabilities (Vamos Vigyazo,1981).

4.1.4.8. Total bacterial count (TBC):

The main purpose for drying foods is to lower their moisture content to a particular level that will exclude the growth of microorganisms. The lower water activity of food, the less probable that microorganisms will grow, generally molds will grow at lower water activities than yeasts (John and Louis, 1980).

Total bacterial count of both fruit slices was carried out on freshly prepared dehydrated fruits before and after storage in two different packages for 6 months at room temperature. Data from Tables 38 and 39 showed that TBC increased in accordance to

Table (38): Total count of bacteria present in dried apple slices stored for(3-9 months) in different packaging materials.

Storage period (month)	Dehydration period: 10 hrs — Temperature of dehydration: 50°C	10 hrs: 70°C	10 hrs: 80°C	15 hrs: 70°C	20 hrs: 50°C	20 hrs: 60°C	20 hrs: 70°C	Average	% increase*
0	2.6×10^1	1.8×10^1	1.4×10^1	1.4×10^1	1.3×10^1	0.6×10^1	-	1.5×10^1	-
Glass jar packages									
3	2.7×10^1	1.9×10^1	1.6×10^1	1.6×10^1	1.4×10^1	0.7×10^1	-	1.6×10^1	6.7
6	3.0×10^1	2.2×10^1	1.9×10^1	1.8×10^1	1.9×10^1	0.9×10^1	-	1.9×10^1	26.7
Polypropylene packages									
3	2.7×10^1	2.1×10^1	1.7×10^1	1.6×10^1	1.5×10^1	0.8×10^1	-	1.7×10^1	13.3
6	3.1×10^1	2.3×10^1	2.0×10^1	1.9×10^1	1.9×10^1	1.0×10^1	-	2.0×10^1	33.3

* Compared to the level present at zero time.

The factor which determines which type of microbial growth occurs is the moisture content of the food, the availability of water. Food processors use this factor to control food contamination by bacteria, while increase in TBC during storage of dehydrated fruits and vegetables (Tolba, 1985).

Part II: Dehydration of green beans:

4.2.1. The establishment of optimum parameters for processing green beans into dehydrated products:

Some predrying treatments were comparatively applied which included the application of blanching treatments in solutions of some common solutes for the purpose of comparing their efficiency in keeping the green colour characteristics of two new cultivars of green beans grown in Egypt (i.e. Morgan and Giza-3) until the completion of steps leading to their dehydration. Selection of optimum blanching and dehydration conditions was effectuated in function of obtained data on sensory evaluation test for experimental blanched and dehydrated beans of both cultivars processed under variable controlled conditions of blanching and dehydration. The retention of pigments as well as ascorbic acid were taken as good measure for adequate heat treatment during processing of green beans. Dehydration of blanched samples from all treatments was achieved using air-circulated oven at certain different designated degrees of temperature and variable periods for drying so as to determine the optimum dehydration conditions for the most successful blanching trials.

4.2.1.1. Selection of optimum blanching conditions for green beans cultivars:

4.2.1.1.1. Selection of optimum blanching solutes:

Blanching treatments included the use of solutions of various solutes at different concentration and also distilled water as blank or control treatment for blanching green beans (from two cultivars) of 3-cm pieces in length (Table 40). The organoleptic properties and the concentration of chlorophyll-A, B, and carotenoids were estimated in all samples after blanching

Table (40): Effect of blanching conditions (blanching solution, period and temperature of blanching) on concentration of pigments present in blanched as well as dehydrated green beans prepared from two different cultivars.[1]

Treatments	Variety of green beans											
	Morgan						Giza-3					
	Type of pigments						Type of pigments					
	Chlorophyll-A		Chlorophyll-B		Carotenoids		Chlorophyll-A		Chlorophyll-B		Carotenoids	
	Blanched	Dried	Blanched	Dried	Blanched	Dried	Blanched	Dried	Blanched	Dried	Blanched	Dried
Type of blanching solution[2]												
$NaHCO_3$ (1%)	30.9	21.8	19.9	15.0	32.8	24.3	32.9	26.0	20.5	15.8	35.2	28.6
$MgSO_4.7H_2O$ (0.5%)	48.9	34.3	27.8	22.8	50.3	36.8	36.2	34.9	22.8	17.9	40.0	38.1
NaCl (1%)	30.2	20.8	15.6	14.0	31.8	22.9	30.8	22.6	16.8	15.3	33.1	24.3
$CaCl_2$ (0.5%)	28.2	19.9	15.3	13.4	30.6	20.9	29.6	21.2	16.7	14.5	30.9	25.6
Water	35.0	26.3	22.4	16.7	37.6	28.3	34.3	27.8	21.8	16.0	36.6	29.9
Time of blanching:[3]												
2 min	46.3	33.2	25.6	21.3	47.9	35.2	34.1	33.8	19.3	16.8	38.3	36.2
3 min	47.1	34.3	26.7	22.2	49.3	36.3	36.6	34.6	20.9	17.9	39.5	37.4
4 min	49.5	35.2	28.6	23.6	51.2	37.1	37.1	35.3	21.1	18.1	40.1	38.3
5 min	46.0	30.1	24.2	20.1	47.2	34.5	32.2	30.9	19.1	16.2	37.6	35.4
6 min	44.2	28.3	22.6	19.3	45.3	33.2	30.6	29.2	18.2	15.8	36.3	34.7
Temperature of blanching:[4]												
50°C	70.9	28.9	23.1	18.9	41.3	32.2	31.8	29.4	18.3	16.3	33.4	32.9
60°C	43.3	29.8	24.3	19.6	45.8	33.4	32.6	30.2	19.0	17.2	34.1	33.5
65°C	44.9	30.4	25.3	20.4	46.3	34.0	34.3	31.6	19.3	17.3	35.8	34.5
70°C	46.8	31.6	26.4	21.6	47.2	35.0	36.1	32.7	19.9	17.6	37.3	35.9
80°C	49.9	34.9	29.0	23.8	50.1	36.9	37.8	35.8	20.0	17.9	39.9	37.6
85°C	46.2	31.1	25.3	21.5	48.0	34.3	33.2	32.1	18.6	15.3	37.6	36.4

1. Dehydrated at 68°C for 6 hrs. 2. Blanched at 85°C for 2 min. 3. Blanched at 85°C. 4. Blanched for 4 min.

using different solutes and at different concentrations at temperature of 85°C for period of 2 min (Katwa et al.,1983) and also after their dehydration in air-circulated oven at 68°C for period of 6 hrs as previously recommended by Zayed (1965) and Saad (1989).

Among the five blanching treatments tested, magnesium sulfate ($MgSO_4$) and water appeared to be the first and the second best treatment from the point of sensory evaluation for characteristic green colour after blanching and dehydration as well as the amount of chlorophyll-A, B, and carotencids pigments present in blanched as well as their corresponding dehydrated beans. Blanching of Morgan beans using $MgSO_4$ and water resulted in beans of higher concentration in chlorophyll-A, B and carotenoids (higher by 64.1 and 17.4; 64.5 and 32.5; 58.7 and 18.6%, respectively) than the average value for pigments content in those subjected to the other tested blanching treatments. Similarly, dehydrated Morgan beans previously blanched in $MgSO_4$ and water exhibited higher concentrations of the three pigments than the average value for the other dehydrated samples previously blanched using completely different treatments (higher by 64.9 and 26.4; 61.7 and 18.4; 62.1 and 24.7%, respectively).

Blanching Giza-3 cultivar using $MgSO_4$ and water resulted also in higher concentrations of chlorophyll-A, B and carotenoids than the average value for pigments in beans blanched with other treatments (higher by 16.4 and 10.3; 26.7 and 21.1; 20.8 and 10.6%, respectively). Consequently, dehydrated Giza-3 beans previously blanched in $MgSO_4$ and water exhibited

also higher concentrations by 49.8 and 19.3; 17.8 and 5.3; 45.4 and 14.1%, respectively.

Before any processing, fresh Morgan beans had initial concentration of chlorophyll-A, B, and carotenoids which were higher by about 27.15, 35.45 and 27.5% than those of Giza-3 cultivar (Table 45). Consequently, Morgan beans blanched in $MgSO_4$ and water) exhibited also similar trend of higher concentration of all three pigments by about 26.0, 18.0, and 20.5 as well as 2.0, 2.7 and 2.7 mg/100 g, respectively, over those present in Giza-3. In spite of the higher concentration of the three pigmentsin Morgan beans than Giza-3, the dehydration of blanched beans revealed different pictures, where dehydrated Morgan beans previously blanched with any of the five treatments tested had lower concentrations in all pigments than those of dehydrated Giza-3, with the exception of chlorophyll-B in dehydrated Morgan beans previously blanched by $MgSO_4$ and water. In other words, dehydrated Morgan beans using $MgSO_4$ and water showed a higher concentration in chlorophyll-B only but not in chlorophyll-A and carotenoids.

Blanching in Magnesium sulfate solution was selected to be tested as efficient pretreatment to green beans due to the well known beneficial effect of sulfur on retention of colour and control of enzymatic reactions (Wedzicha, 1984). Roberts and McWeany (1972) and Downen (1977) prefered blanching of green beans in boiling water containing sulfur as such treatment reduced the microbial load. Literature reports on other Magnesium salts were not encouraging and contradictory. Gupte and Francis (1964) reported that although

the use of magnesium carbonate ($MgCO_3$) in combination with high temperature short time (HTST) at 300°F improved chlorophyll retention in pured spinach, the effect was not stable during storage. On the other hand, Asghar et al. (1978) studied the effect of some predrying unit operations such as priching, blanching, sulphiting and dipping in $MgCl_2$, $MgCO_3$, or $Mg(CH_3COO)_2$ solution on the chlorophyll stability of dehydrated peas and proved that all of these pretreatments favoured conversion of the chlorophyll into phenophytin to different extent, independent on pH value of the dried peas.

It appeared from the obtained results that pretreatments other than $MgSO_4$ were not satisfactory although of the various reports of the effectivness of these pretreatments in maintaining lower changes and also desirable characteristics during processing. For example, calcium chloride was reported by many investigators (Simon et al., 1955; Legault et al., 1951; Burton et al., 1963b; Zerbini and Sozzi, 1980; Bolin and Steele, 1987) as possible inhibitor to browning during processing of fruits and vegetables. Moreover, calcium chloride is usually added to blancher water to form insoluble calcium pectate complexes and thus to maintain firmness in vegetable tissues (Morton and Waston, 1988). In addition, Morton and Waston (1988) mentioned that sodium carbonate or calcium oxide are often added to blancher water to protect chlorophyll and to retain the colour of green vegetables and that enzymic browning of cut potatoes can be prevented by holding the food in dilute (2% w/w) brine prior to blanching.

4.2.1.1.2. Selection of optimum blanching period:

For the establishment of optimum blanching treatment, different periods of time (min) for blanching green beans from both cultivars tested were applied which ranged between 2 to 6 min intervals. Then the sensory evaluation of the characteristic green colour and concentration of chlorophyll-A, B, and carotenoids were estimated after blanching beans at 85°C using 0.5%, $MgSO_4.7H_2O$ solution for each blanching period tested and also after their subsequent dehydration at 68°C for 6 hrs; since blanching in $MgSO_4$ have been proved to produce maximum concentration of all pigments (Table 40).

Among the five blanching intervals applied, samples blanched for 4 min in $MgSO_4$ appeared to be the most successful ones from the standpoint of green colour organoleptic score amounts of chlorophyll A, B, and carotenoids pigments and also colour compared to other treatments blanched for different intervals of time (Table 40).

$MgSO_4$-blanched Morgan beans for intervals of 2 to 6 min exhibited the same green colour but higher amounts of chlorophyll-A, B, and carotenoids than those of Giza-3 cultivar. In contrast, dehydrated Morgan beans exhibited lower amounts of chlorophyll-A, and carotenoids than those present in dehydrated Giza-3 beans, with the exception of chlorophyll-B although did not differ in the characteristic green colour scores. Similar result was obtained previously during the present study (Table 40).

In agreement to our results, Orvin and McCarty (1960) found that the blanching times for number of varieties of green beans

ranged from as low of 4.30 min to a high of 5.95 min at 87.8°C and between 2.52 and 3.23 min at 93.3°C. Seminole variety required 5.94 min at 87.8°C and 2.87 min at 93.3°C, Contender variety required 5.00 min at 90.6°C and 2.83 min at 93.3°C. Walker (1964) showed that the amount of chlorophyll converted to pheophytin was increased approximately linearly with time of blanching up to 3 min, but that with longer blanching times the relative amounts further converted were progressively diminished. Analysis for total chlorophylls and pheophytin content showed that the original content of beans was affected by blanching. Moreover, Halpin and Lee (1987) mentioned that as blanching time increased from 3 to 6 min, the loss of ascorbic acid was significant.

Chlorophyll was found to be more stable in water-blanched than in steam-blanched vegetable samples. When vegetably were preheated in water at 54.4°C rather than in water at 65.6°C, blanching time necessary to degradation cf chlorophyll was relatively lower in the former than the latter (Dietrich and Neumann, 1965). On the other hand, preheating for 5 to 10 min at 54.4°C did not result in chlorophyll conversion while,65.6 or 76.7°C lowered chlorophyll.

4.2.1.1.3. Selection of optimum blanching temperature:

For the completion of optimum conditions for blanching of green beans from both cultivars tested different degrees of blanching temperature were applied using 0.5% $MgSO_4$ in blanching solution at constant blanching period of 4 min. Then,the characteristic green colour as well as concentrations of chlorophyll-A, B, and carotenoids were estimated after

blanching beans after applying every designated blanching temperature and also after their subsequent dehydration at 68°C for 6 hrs.

Among the six blanching temperatures applied, samples blanched at 80°C in $MgSO_4$ appeared to be the most successful ones compared to the other treatments blanched at the other tested temperature from the standpoint of good green colour as well as amounts of chlorophyll-A, B, and carotenoids pigments. However, there was a gradual increase in concentrations of the three pigments parallel to the increase in blanching temperature. Furthermore, $MgSO_4$-blanched Morgan beans at 80°C for 4 min exhibited higher amounts of chlorophyll-A, B, and carotenoids than those of Giza-3 beans although both did not differ in green colour scores. In contrast, dehydrated Morgan beans exhibited lower amounts of chlorophyll-A, and carotenoids than those present of Giza-3 beans. Similar results were previously obtained in the course of the present study (Table 40).

In accordance to our findings, Hassan (1986) found that the rate of chlorophyll changes between the fresh and frozen-blanched green beans was higher when the temperature of blanching raised from 70 to 90°C. However, within a given temperature, the longer the period of heat treatment the higher is the degree of chlorophyll changes to pheophytin. She also revealed that the percentages of changes in chlorophyll to pheophytin in green beans as a result of blanching at 70, 80 and 90°C for 5 min, respectively, were 0.496, 16.58, and 39.49% on dry weight basis.

4.2.1.2. Selection of optimum dehydraton conditions:

4.2.1.2.1. Selection of optimum dehydration temperature:

For the establishment of optimum dehydration conditions for some new Egyptian cultivars of green beans, different degrees of temperature were examined for their ability to dry blanched beans until constant dry weight to the point where maximal desirable green colour scores and higher concentration of plant pigments were attained after dehydration. Therefore, organoleptic evaluation scores for green colour as well as concentrations of chlorophyll-A, B, and carotenoids were estimated in dehydrated beans previously blanched using either 0.5% solution of $MgSO_4$ or water at 80°C for 4 min (Table 41).

Among the four dehydration temperatures tested, samples dehydrated at 65°C appeared to be the most successful ones regardless of the kind of blanching solutions previously applied before drying. At 65°C, dehydrated samples previously blanched in $MgSO_4$ and water ranked the first and the second from the standpoint of successful drying characteristics organoleptic colour scores and also of amounts of pigment present compared to other blanched beans dried at all other tested degrees of dehydration temperature. Although dehydrated beans at 50°C and 60°C exhibited higher retention in the three pigments than those dehydrated at 65°C, these beans did not show complete drying at the period of 6 hrs which seemed to be unsatisfactory drying period. However, there was a gradual decrease in concentration of all pigments parallel to the increase in dehydration temperature compared to the initial level present in fresh starting beans. The 65°C dehydrated Morgan and Giza-3 beans previously blanched in $MgSO_4$

Table (41): Effect of dehydration temperature (50-70°C) of green beans blanched in 0.5% $MgSO_4.7H_2O$ and water at 80°C for 4 min on pigments content (as reported in mg/100 g of dry matter).[1]

Type of pigment	Variety of green beans															
	Morgan								Giza-3							
	Temperature of dehydration								Temperature of dehydration							
	50°C		60°C		65°C		70°C		50°C		60°C		65°C		70°C	
	Blanching conditions								Blanching conditions							
	W[2]	M[3]	W	M	W	M	W	M	W	M	W	M	W	M	W	M
Chlorophyll-A	37.20	39.60	28.09	36.20	26.27	33.90	20.10	24.60	38.10	40.00	30.30	37.10	28.89	35.40	21.20	26.90
Chlorophyll-B	28.10	29.90	19.00	25.30	17.59	23.20	13.20	16.30	19.90	20.10	17.10	19.00	16.00	17.80	12.70	15.00
Carotenoids	38.60	41.00	29.20	37.60	27.20	35.00	21.13	25.90	39.60	41.90	31.30	38.70	29.83	36.50	22.00	27.90
	% of decrease*															
Chlorophyll-A	36.52	32.42	52.06	38.23	55.17	42.15	65.70	58.02	10.75	6.30	29.02	13.09	32.33	17.08	50.34	36.99
Chlorophyll-B	14.85	9.39	42.42	23.33	46.70	29.70	60.00	50.61	6.57	5.63	19.72	10.80	24.88	16.43	40.38	29.58
Carotenoids	38.04	34.19	53.13	39.65	56.34	43.82	66.08	58.43	12.27	7.18	30.66	14.27	33.92	19.14	51.26	38.19

1. Average of duplicate analysis.
2. W = Blanched in water at 80°C for 4 min before dehydration.
3. M = Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min before dehydration.

* Compared to the level of starting fresh materials.

and water exhibited better retention of all pigments compared to beans dehydrated at 70°C.

Compared to the starting fresh beans of both cultivars it was noted that at all dehydration temperatures tested, the retention of the three pigments was considerably higher in dehydrated beans previously blanched in water than their corresponding dried beans blanched in $MgSO_4$. However, with all dehydration temperatures both cultivars had similar green colour appearance but Morgan beans exhibited lower amounts of chlorophyll-A, and carotenoids than those present of Giza-3 beans with the exception of chlorophyll-B. Similar results were obtained before throughout the present study. (See table 40).

4.2.1.2.2. Selection of optimum dehydration period:

Different drying periods were compared for their suitability to dry blanched green beans in either 0.5% $MgSO_4$ or water (at 80°C for 4 min) using air-circulated oven set at dehydration temperature of 65°C until constant dry weight was achieved. Then the characteristic desirable green colour was evaluated and concentrations of chlorophyll-A, B, and carotenoids were estimated in dehydrated-blanched beans (Table 42).

Among the three dehydration period tested, samples dehydrated for 6 hrs appeared to be the most suitable ones, regardless of the type of previous blanching treatment. At drying period of 6 hrs, dehydrated beans previously blanched in $MgSO_4$ and water ranked the first and the second from the point of successful drying characteristics green colour scores and also maximum retained amounts of pigments. Although

Table (42): Effect of duration of dehydration period (3-9 hrs) of green beans blanched in 0.5% $MgSO_4.7H_2O$ and water at 80°C for 4 min on pigments content (as reported in mg/100 g of dry matter).[1]

Type of pigments	Variety of green beans											
	Morgan						Giza-3					
	Period of dehydration						Period of dehydration					
	3 hrs		6 hrs		9 hrs		3 hrs		6 hrs		9 hrs	
	Blanching conditions						Blanching conditions					
	W[2]	M[3]	W	M	W	M	W	M	W	M	W	M
Chlorophyll-A	32.90	37.52	27.37	35.60	18.31	20.60	35.90	38.60	29.79	36.40	21.50	29.70
Chlorophyll-B	22.99	28.90	18.15	24.55	13.20	17.30	19.00	20.10	16.80	18.70	12.20	16.70
Carotenoids	34.60	39.35	28.20	37.09	19.30	20.90	36.30	40.30	30.38	37.50	21.80	30.20
						% of decrease*						
Chlorophyl-A	43.86	35.97	53.29	39.25	68.75	64.85	15.91	9.58	30.22	14.73	49.64	30.43
Chlorophyll-B	30.33	12.42	45.00	25.61	60.00	47.58	10.80	5.63	21.13	12.21	42.72	21.60
Carotenoids	44.46	36.84	54.74	40.47	69.02	66.45	19.58	10.72	32.70	16.93	51.71	33.10

1. Average of duplicate analysis.
2. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C.
3. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C.

* Compared to the level of starting fresh materials.

beans dehydrated for 3 hrs exhibited higher pigment concentration than those dehydrated for 6 hrs, their beans did not show complete drying at 65°C used. However, there was a gradual decrease in concentration of all pigments parallel to the increase in period of dehydration compared to the initial level present in fresh starting beans, blanched Morgan and Giza-3 beans (in $MgSO_4$ and water), dehydrated for 6 hrs exhibited better retention in all pigments compared to corresponding dehydrated for 9 hrs.

Compared to the starting fresh beans of both cultivars, it was noted that with all periods for dehydration tested, the retention of each of the three pigments was considerably higher in dehydrated beans previously blanched in water than their corresponding dried beans previously blanched in $MgSO_4$. However, with all periods for dehydration, Morgan beans exhibited lower amounts of chlorophyll-A, and carotenoids than those present of Giza-3 beans with the exception of chlorophyll-B. Similar results were obtained before throughout the present study (See Tables 40 and 41).

According to Weir (1944) a temperature of 60°C under wet conditions destroys carotene in green beans while a temperature of 80°C under dry conditions tends to preserve it. However, carotenoids are well retained during dehydration if the vegetable has been blanched and sulfured. In fact the drying Schedule for green bean was reported by Von Loesecke (1955) as follows: 60°C for 4½ hrs; 65.6°C for 30 min; 76.7°C for 30 min and 90.6°C for 30 min; the material then bin-dried at 48.9°C to 5 percent moisture content. He stated that it

is necessary to avoid all iron contamination which will give the product a dull appearance when reconstituted and that the dried material should contain from 400 to 600 ppm of sulfur dioxide.

In agreement to our results, Foda et al. (1968) reported that chlorophyll retention after blanching of green beans decreased as the blanching time and temperature increased. Also greater retention of chlorophyll and pheophytin had occurred after dehydration resulting from longer blanching time and higher temperature. On the other hand, Cruess and Mackinney (1943) found that a shorter drying time at 65.6°C to 71.1°C was less destructive to vitamin C than a longer period at 48.9°C.

Processing of the new dehydrated green cultivar into dehydrated product according to the conditions of the present study resulted in good green colour and appreciable concentration of plastid pigments compared to literature reports on other cultivars grown in Egypt. Zayed (1965) found that Mont-Calme, Contendar, Seminole and ideal, the Egyptian cultivars of green beans dehydrated at 68°C for 6 hrs, respectively, contained 53.6, 46.7, 48.3 and 41.3 mg % total chlorophyll and 2.5, 2.8, 2.7 and 2.61 mg % carotene, respectively. These values for the four old varieties, respectively, were lower than the average value for the total chlorophyll and carotenoids present in both the two new cultivars blanched by the both treatments as found in the present study upon

dehydration at 70°C for 6 hrs by 29.7, 19.3, 21.9 and 8.7% respectively for total chlorophyll and by 89.7, 88.5, 88.9 and 89.3%, respectively, for carotenoids. In addition, Saad (1989) found that green bean dehydrated at 60°, 70° and 80°C for 10, 8 and 7.5 hrs, respectively, contained 2.48, 2.94 and 2.75 mg %, respectively, chlorophyll-A and 0.33, 0.43 and 0.41 mg % , respectively, chlorophyll-B. These values at the three temperature used, respectively, are lower than the average value for the same pigments present in both the two new cultivars blanched by both treatments as found in the present study upon dehydration at 65°C for 6 hrs by 90.5 and 97.7%, respectively.

Concluding remarks:

Data cllected from the experiments performed for the establishment of the optimum condition for processing two new green bean varieties, grown in Egypt, into dehydrated products revealed that under the conditions of the present study, the optimum blanching parameters appeared to be the following: blanching solution of $MgSO_4$ at blanching temperature of 80°C for period of 4 min. In addition, blanching in water, under the same conditions, was chosen as a blank to $MgSO_4$ especially after noting that water followed $MgSO_4$ in keeping maximal characteristic green colour together with higher pigment concentration (Table 40) during the experiment for determination of the best blanching solution.

Further, the optimum dehydration parameters under the conditions of the present study were taken as: air-circulated oven at dehydration temperature of 65°C for 6 hrs to dry blanched beans in either water or 0.5% $MgSO_4$ solution.

4.2.2. Effect of the selected dehydration conditions on characteristics of processed green beans:

4.2.2.1. Drying ratioes:

Drying ratioes were found to differ according to percentage of moisture content before and after processing had drying ratioes of 1:6.96 and 1:7.03 (average 1:6.99) for water and $MgSO_4$-blanched Morgan beans, respectively, while in case of Giza-3 beans they were 1:6.09 and 1:6.15 (average 1:6.12), respectively. With both blanching treatments, dehydrated Morgan beans exhibited slight higher drying ratioes than the corresponding Giza-3 beans by about 12.6%. However, blanching conditions did not influence the drying ratio for both beans cultivar (Table 43).

It is well known that the drying ratio differs considerably according to the variety, time of harvest, grade of raw material and loss in preparation (Von Loesecke, 1955) and is greatly affected by dry matter and moisture contents. For example, Cruess and Mackinney (1943) found different drying ratioes for several varieties of green beans grown in USA: Stringless green pod, 6.8:1; Stringless, 9.2:1, Plentiful, 6.7:1, Relujee U.S. No. 5, 8.0:1; Blue lake, 12.8:1; Stringless Blue Lake, 10.2:1; White Kentucky Wonder, 8.3:1; Brown Kentucky Wonder, 10.0:1; McCastin, 10.2:1; and S.A. No. 1, 5.6:1. Some of these reported ratioes are comparable to our results especially with Stringless green pod, Plentiful and S.A. No. 1. In contrast, the drying ratioes for many green beans such as Stringless; Refujee U.S. No. 5; Blue Lake; Stringless Blue Lake; White Kentucky Wonder; Brown Kentucky Wonder and McCastin are higher by 28.4; 17.6; 48.5; 35.4; 20.6; 34.1 and 20.6%, respectively than the average value found for the two Egyptian cultivars tested.

Table (43): Dehydration and rehydration ratioes of dehydrated green beans pieces prepared from two Egyptian cultivars previously blanched in water and $MgSO_4$ before dehydration.

Analysis[1]	Time (min)	Green beans cultivar					
		Morgan			Giza-3		
		Blanching conditions					
		W[2]	M[3]	Average	W	M	Average
- Moisture of dehydrated sample (%)	-	7.00	6.20	6.60	7.00	6.50	6.75
- Drying ratio	-	1:6.96	1:7.03	1:6.99	1:6.09	1:6.15	1:6.12
- Rehydration ratio	1 hr	1:2.5	1:2.6	1:2.6	1:2.0	1:3.0	1:2.5
	2 hrs	1:3.2	1:3.3	1:3.3	1:3.0	1:3.5	1:3.3
	3 hrs	1:4.5	1:4.7	1:4.6	1:4.0	1:4.6	1:4.3
	6 hrs	1:5.3	1:5.5	1:5.4	1:5.0	1:5.8	1:5.4
- Coefficient of rehydration	1 hr	0.72	0.74	0.73	0.65	0.97	0.81
	2 hrs	0.92	0.94	0.93	0.98	1.14	1.06
	3 hrs	1.29	1.33	1.31	1.31	1.49	1.40
	6 hrs	1.52	1.56	1.54	1.63	1.88	1.76
- Moisture content in rehydrated sample (%)	1 hr	81.4	82.0	82.0	76.8	84.4	81.4
	2 hrs	85.5	85.8	85.8	84.5	86.6	85.9
	3 hrs	89.7	90.0	89.8	88.4	89.8	89.2
	6 hrs	91.2	91.5	91.4	90.7	91.9	91.4

1. Average of three trials.
2. W = Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M = Blanched in 0.5% $mgSO_4 \cdot 7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

Zayed (1965) reported that the drying ratioes for the old green beans grown in Egypt such as Mont-calme, Siminole, Ideal and Contender were 10.7:1; 10.5:1; 8.3:1 and 9.8:1, respectively, when dried at 68°-70°C for 6-10 hrs. These ratioes are higher than those average ratio obtained in the present study for the two new green beans cultivar by 38.4; 36.2; 20.6 and 32.8%, respectively.

4.2.2.2. Rehydration properties:

The rehydration ratio, coefficient of rehydration and moisture content (%), in rehydrated samples were determined for the tested samples at various time intervals for a total period of 6 hrs of soaking in water at room temperature and the obtained results are shown in Table (43). The rehydration ratio coefficient of rehydration and moisture content(%) in rehydrated samples showed variation in their values in function of various treatment before dehydration where they ranged with Morgan beans between 1:2.5 to 1:2.6; 0.72 to 0.74 and 81.4 to 82.0%, respectively, after soaking in water for 1 hr, and ranged between 1:5.3 to 1:5.5; 1.52 to 1.56 and 91.2 to 91.5%, respectively, after extending soaking period to 6 hrs under the same soaking conditions. On the other hand, with rehydrated Giza 3 beans they ranged between 1:2.0 to 1:3.0; 0.65 to 0.97 and 76.8 to 84.4%, respectively, after soaking in water for 1 hr, and ranged between 1:5.0 to 1:5.8; 1.63 to 1.88 and 90.7 to 91.9%, respectively, after 6 hrs of soaking.

With both cultivars, dehydrated beans exhibited slight higher rehydration properties for beans previously blanched in

$MgSO_4$ than those previously blanched in water. Furthermore, there was variation in rehydration properties for both bean cultivars tested.

In general, the reported rehydration ratioes are much better or higher than those reported for some older Egyptian cultivars of green beans (Zayed ,1965 and Saad ,1989). In agreement to our results Zayed (1965) reported variation in rehydration ratioes of six commercial dehydrated green beans prepared from two Egyptian cultivars processed at two different factories of Nasr Company for dehydrated products in Egypt in function of starting cultivar and quality of dehydrated product. Dehydrated Mont-Calme (Grade 1) processed at Souhag and Alexandria factories had 1:4.14 and 1:4.1, respectively, while grade II of the same variety had 1:3.33. On the other hand, dehydrated seminol (Grade 1) processed at Souhag and Alexandria factories showed 1:4.27 and 1:3.8, respectively, while grade II had 1:4.17. Furthermore, Saad (1989) stated that rehydration ratioes and coefficient of rehydration of baladi green beans dehydrated at 60°C had 1:2.3 and 0.43%, respectively after soaking in water for 1 hr as well as 1:3.04 and 0.58%, respectively, after soaking in water for 2 hrs at room temperature. The difference between our results and those of Zayed (1965) and Saad (1989) could be attributed to the fact that the new green bean cultivars (i.e. Morgan, Giza-3) had complete different chemical composition than that for the older cultivars, especially in crude fibers. High content of fibers is well known to result in poor rehydration properties as observed in case of celery (Neubert et al., 1968).

The observed differences in rehydration properties between the various treatments of the present study also between our data and those reported in literature could be attributed to the fact that there are many factors which influence the dehydration products and therefore their subsequent rehydration since rehydration is not the opposite of dehydration (Morton and Waston, 1988). Furthermore, the loss of different permeability in the protoplasmic membrane, loss of turger pressure in the cell, protein denaturation, starch crystallinity, and hydrogen bonding of macromolecules have been suggested as causes of, and at times correlated with various parameters of rehydration (Neumann, 1972). For example, the effect of blanching on rehydration properties of vegetables is contradictory. Gold (1962) reported some increase in rehydration with celery dise blanched before drying, while Neubert et al. (1966) noted lower rehydration values. Neumann (1972) stated that blanching of celery increased rehydration by only 5% and that type of solute or chemical substance added to blancher water influence rehydration properties. The pH and ionic salts was reported to influence rehydration properties since they affect cell wall permeability to water (Neumann, 1972). Furthermore, it is difficult to compare our results to others because method of determining rehydration and conditions during test (such as agitation and temperature) were reported to the amount of water absorbed (Neubert et al. 1968).

4.2.2.3. Moisture content of fresh, blanched and dehydrated green beans:

As shown in (Table 44), moisture content formed the first major constituent and occupied the highest percentage of chemical composition of both fresh green bean varieties (86.7 and 84.8% for Morgan and Giza-3 cultivars, respectively). Mortha Louis et al. (1950) and Lazar et al. (1963) reported slight higher moisture content by about 3.1 and 4.7%, respectively than the average value for moisture content of both fresh beans obtained in the present study for the two Egyptian cultivars. Moreover, Zayed (1965) reported that fresh Mont-Calme, Contender, Seminole and Ideal Egyptian cultivars of green bean contained respectively, 91.26, 90.45, 91.14 and 88.65% moisture content These values are higher than the average value for moisture content found in fresh green beans from both the new cultivars by about 5.46, 4.65, 5.34 and 2.85%, respectively.

Blanched green beans in either water or $MgSO_4$ exhibited slight higher moisture content by about 1.2 and 1.9%, respectively, for Morgan cultivar and 1.7 and 2.9%, respectively, for Giza-3 cultivar over the level present in their starting fresh vegetables.

Dehydrated green beans cultivar previously blanched in either water or $MgSO_4$, showed moisture content of 7.0 and 6.2%, respectively, for Morgan cultivar and 7.0 and 6.5%, respectively, for Giza-3 cultivar. It is apparent that although Morgan beans exhibited slight higher amounts of moisture content than the corresponding Giza-3 beans in the fresh and blanched states,

Table (44): Proximate chemical analysis of fresh and dehydrated green beans obtained from two different varieties (on dry weight basis)[1].

Material analysed	Blanching condition									
	W[2]	M[3]	W	M	W	M	W	M	W	M
	Total solids %		Crude protein %		Ether extract %		Ash %		Crude fiber %	
Morgan variety										
Starting fresh material	13.30		0.728		0.727		0.595		0.339	
Blanched material	12.20	11.40	0.566	0.529	0.014	0.088	0.450	0.535	0.120	0.230
Dehydrated material[4]	93.00	93.80	0.071	0.050	0.009	0.012	0.446	0.530	0.043	0.140
Giza-3 variety										
Starting fresh material	15.20		0.463		0.316		0.597		0.091	
Blanched material	13.50	12.30	0.290	0.277	0.018	0.073	0.492	0.512	0.078	0.079
Dehydrated material	93.00	93.50	0.080	0.077	0.011	0.018	0.440	0.500	0.023	0.033

1. Average of duplicate analysis.
2. W: Blanched in water at 80°C for 4 min
3. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min.
4. Dried at 65°C for 6 hours.

both cultivars showed comparable moisture values after dehydration. After dehydration, the rate of decrease in starting moisture content of Morgan beans under the applied dehydration conditions was in order of 79.7 and 80.5% for water and $MgSO_4$-blanched treatment, respectively, while for Giza-3 beans was 77.8 and 78.3%, respectively.

Many investigators including Weston and Moris (1954); Dextar et al. (1955); Swanson et al. (1977) and Chang et al. (1979b) reported higher moisture content by 2.1-6.8%; 2.2-4.3%; 4.32% and 19.3%, respectively, than the average value for moisture content obtained in the present study for both dehydrated green beans processed from the two Egyptian cultivars.

The moisture contents of dehydrated green bean products prepared from two new cultivars grown in Egypt as shown in the present study are comparable with those reported by Zayed (1965) for dehydrated products processed from the old-grown green bean varieties (between 6.3 to 7.21%).

4.2.2.4. Proximate chemical composition of fresh starting blanched and dehydrated green beans:

After moisture content, crude protein formed the second major chemical constituent in fresh Morgan cultivar (0.728%), but the third major in fresh Giza-3 cultivar (0.463%). Ether extract represented the third major constituent in fresh Morgan cultivar (0.727%), but the fourth in fresh Giza-3 cultivar (0.316%); crude fiber formed a very small proportion in Morgan and Giza-3 cultivars (0.339 and 0.091%, respectively. In general, fresh Morgan cultivar exhibited higher amounts of all main chemical constituents than those found in Giza-3 cultivar, especially crude fiber. (Table 44).

Lazar et al. (1963) reported similar values to those obtained for fresh beans in the present study for ether extract and ash contents but higher valuesfor moisture, crude protein and crude fiber contents. Zayed (1965) reported that fresh pods of the old-cultivated; Mont-Calme, Contender, Seminole and Ideal Egyptian cultivars of green beans contained respectively, 16.35, 16.09, 18.99 and 18.13% crude fiber as well as 8.077, 7.790, 8.036 and 8.669% ash. These values are higher than the average value found in the present study for both the fresh green bean new cultivars by about 98.7, 98.9 and 98.8%, respectively, crude fiber as well as 92.6, 92.3, 92.6 and 93.1%, respectively, ash content.

Many investigators (Chang et al., 1979b; Reddy et al.,1985; Sansulski and McCurdy, 1987) studied the chemical composition of fresh green beans in different countries. However, they reported higher values for crude protein, ether extract and

ash content. Blanched Morgan cultivar in water and $MgSO_4$ showed lower amounts of crude protein by about 22.3 and 27.3%, respectively, ether extract by 98.1 and 87.9%, respectively, ash by 24.4 and 10.1%, respectively, crude fiber by 64.6 and 32.2%, respectively than their starting fresh Morgan beans. On the other hand Giza-3 cultivar blanched in either water or $MgSO_4$ showed also the same trend of lower crude protein by about 37.4 and 40.2%, respectively, ether extract by 94.3 and 76.9%, respectively, ash 17.6 and 14.2%, respectively, crude fiber 14.3 and 13.2%, respectively than their starting fresh beans.

In both cultivars, water-blanched beans contained lower moisture, ether extract, ash and crude fiber contents but higher content in crude protein than those present in $MgSO_4$-blanched beans. On the other hand, Morgan cultivar blanched in $MgSO_4$ exhibited higher amounts of all chemical constituents than the corresponding Giza-3 beans. In contrast, water-blanched Morgan beans showed a higher moisture, crude protein and crude fiber contents but lower amounts of ether extract and ash content than those of Giza-3 cultivar.

Dehydrated Morgan beans previously blanched in either water or $MgSO_4$ exhibited lower amounts of crude protein by about 90.2 and 93.1%, respectively; ether extract by 98.8 and 98.3% respectively; ash by 25.0 and 10.9%, respectively; crude fiber by 87.3 and 58.7%, respectively, than their starting fresh Morgan beans. On the other hand, dehydrated Giza-3 beans after blanching either water or $MgSO_4$ showed also the same trend of lower or crude protein by about 82.7 and 83.4%,

respectively, ether extract by 96.5 and 94.3%, respectively, ash by 26.3 and 16.2%, respectively, crude fiber 74.7 and 63.7%, respectively, than their starting fresh Giza-3 beans

Both dehydrated Morgan and Giza-3 cultivars previously blanched in water only had higher content in crude protein, but lower content in ether extract, ash and crude fiber, than these present in dehydrated beans previously blanched in $MgSO_4$ from both cultivars. On the other hand, dehydrated Morgan exhibited lower amounts of crude protein and ether extract and higher ash and crude fiber than those of Giza-3 cultivar regardless of type of blanching treatment applied. However, dehydrated beans from both cultivars (either previosly blanched in water or $MgSO_4$) exhibited nearly the comparable moisture contents.

Comparing the chemical composition of dehydrated beans with literature reports from different countries revealed that higher values for moisture, crude protein, ash, and crude fiber content but lower value for ether extract than those obtained in the present study were reported by Mortha Louis et al., (1950) while other investigators (Weston and Moris, 1954; Dextar et al. 1955; Swanson et al., 1977; Chang et al., 1979b; Rockland et al., 1979; Reddy et al., 1985; Belitz and Grosch, 1986; Sanstlski and McCurdy, 1987) reported higher value for all chemical constituents than those obtained in the present study for dehydrated green beans processed from both the new-cultivated Egyptian green bean varieties.

Comparing the chemical composition of both the dehydrated products prepared from both the new cultivated green bean varieties with the old varieties grown in Egypt prior to 1980 revealed great variation. For example, Zayed (1965) reported that dehydrated Mont-Calme, contender, Siminole and Ideal Egyptian varieties of green beans contained, respectively, 7.00, 6.00, 7.21 and 6.35% moisture content. These values are comparable with the average value for moisture content found in dehydrated products of the two new cultivars which did not exceed (+0.32, -0.68, +0.53, and -0.33%, respectively). Furthermore, moisture and crude fiber content of six commercial dehydrated green beans prepared from two Egyptian cultivars processed at two different factories of Nasr Company for dehydrated products, Egypt, were reported by Zayed(1965). Dehydrated Mont-Calme (grade I) processed at Souhag and Alexandria factories had 8.53, 7.75 moisture and 15.53, 15.91 crude fiber content (dry basis), respectively, while grade II of the same variety had 6.81% moisture and 18.63% crude fiber content. On the other hand, dehydrated Seminol (Grade I) processed at Souhag and Alexandria factories showed 8.49%, 7.75% moisture and 16.83, 15.91% crude fiber, respectively, while grade II had 11.06% moisture at 21.01% crude fiber content.

4.2.2.5. Selected chemical properties of dehydrated green bean varieties:

4.2.2.5.1. Acidity:

Values for acidity (as citric acid)for fresh immature pods of Morgan beans (0.084 vs. 0.073%). The values reported by Saleh (1991) for acidity (1.81% as citric acid) of fresh Giza-3 variety grown in Egypt is higher than that found in the present study for the same cultivar (0.073%).

However, total acidity increased by blanching and also by dehydration of green beans (Table 45). Such increase was more dependent on previous blanching treatment rather than the effect of green beans variety or cultivar since fresh starting Morgan had higher acidity values than Giza-3 counterpart (0.084 vs. 0.073). However, the increase in acidity was greatly higher upon blanching in $MgSO_4$ than blanching in water. Such increase could be attributed to the addition of $MgSO_4$ (pH 3-5) to blancher water. In addition, the rate of increase in acidity after either blanching or dehydration was considerably higher in $MgSO_4$-blanched samples than in water-blanched samples. In case of Morgan cultivar, the rate of increase as a result of blanching in water and $MgSO_4$ solution was about 31.0 and 138%, respectively, while in case of Giza-3 cultivar such increase was 50.7 and 187.7%, respectively.

Mori et al. (1966) noted a relationship between the rise in total acidity and chlorophyll degradation during heating process and storage of green beans.

Table (45): Chemical properties of dehydrated green beans processed under different conditions (reported on dry weight basis).

Analysis[1]	Variety of green beans									
	Morgan					Giza-3				
	Starting fresh material	Blanching conditions				Starting fresh material	Blanching conditions			
		W[2]		M[3]			W		M	
		B[4]	D[5]	B	D		B	D	B	D
Moisture %	86.70	87.90	7.00	88.60	6.20	84.80	86.50	7.00	87.70	6.50
Acidity (%)	0.084	0.110	0.104	0.200	0.168	0.073	0.110	0.100	0.210	0.192
Ascorbic acid (mg/100 g)	13.86	8.09	5.83	8.56	5.86	10.87	4.35	1.72	5.01	1.92
Reducing sugars (%)	8.27	11.41	9.95	12.49	10.75	9.65	12.20	11.96	13.85	12.47
Total sugars (%)	8.82	13.17	12.72	14.20	13.79	10.96	14.27	13.90	15.24	14.10
Chlorophyll-A	58.60	35.41	27.37	50.09	35.60	42.69	32.40	29.79	38.30	36.40
Chlorophyll-B	33.00	22.26	18.15	29.57	24.55	21.30	17.98	16.80	20.60	18.70
Carotenoids	62.30	38.94	28.20	52.18	37.09	45.14	34.11	30.38	40.86	37.50
Serum color (% transmission)	83.40	62.70	56.70	55.40	43.00	88.00	74.70	56.00	60.50	49.80
Degree of browning (Optical density)	0.089	0.103	0.115	0.110	0.142	0.092	0.104	0.116	0.113	0.135

1. Average of duplicate analysis.
2. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
4. B = Blanched.
5. D = Dehydrated.

It should be mentioned that it is already reported that both the extent of pH change and the rate of change due to increments in NH_4HCO_3 differed with vegetable (Watt and Merrill, 1963). Aside of the effect of blanching solutes on acidity value for blanched green beans, Eheart and Odland (1973a) indicated that blanching of green beans at 93°C for 4-4.5 min resulted in the increase in pH of both cooked beans and cooking water with various treatments while acidity varied in versely with pH.

With respect to the effect of water blanching on the pH and acidity;in contrast to our findings, Saleh (1991) showed that acidity of both water-blanched peas and green beans were lower than that of fresh samples; values that were 1.23 and 1.81% dry matter for fresh samples, decreased to 0.79 and 1.48% dry matter for water-blanched one. The pH values, slightly changed from 5.96 to 6.17 in breen beans. Similar findings were mentioned by Odland and Eheart (1975) who indicated a decrement trend for titratable acidity from 3.49 to 1.47 mg/100 g wet basis, and a slight change of pH from 6.64 to 6.56.

Upon dehydrating blanched beans from both cultivars, certain decrease in acidity values was attained compared to the levels of blanched samples. In case of Morgan cultivar, acidity after dehydration decreased by 5.5 and 16.0% lower than those present in samples blanched with water and $MgSO_4$, respectively, which means that the total increase in acidity of dehydrated products compared to their starting fresh materials was in the order of 23.8 and 100%, respectively.

In case of dehydrated Giza-3 cultivar, acidity lowered by 8.1 and 8.6 %, respectively, thus the total increase in acidity in dehydrated samples compared to their starting fresh materials was in the rate of 37.0 and 163.0%, for water and $MgSO_4$-blanched dehydrated samples, respectively. In contrast to our findings, Saleh (1991) reported that no significant change in acidity occurred during freezing of processed Giza-3 beans.

4.2.2.5.2. Ascorbic acid content:

Ascorbic acid is able to attach itself to oxygen and is one of the most important antioxidant for fruits and vegetables that have a tendency to do colour and lose their natural flavour (Fennema, 1976). Morton and Waston (1988) mentioned that losses in vitamins (ascorbic acid) are used generally as indicator of food quality and therefore the severity of blanching treatment. However, Muftugil and Yigit (1983) showed that blanching reduced ascorbic acid content in some vegetables (green peppers, beans, onions and carrots). Fresh Morgan beans had higher ascorbic acid content (by about 21.6%) than those found for fresh Giza-3 beans (13.78 vs. 10.87 mg/100 g, respectively) (Table 45).

The old cultivated varieties of green beans grown in Egypt, Mont-Calme, Contender, Seminole and Ideal, were reported by Zayed (1965) to contain, respectively, on dry weight basis 241.4, 215.1, 207.8 and 188.7 mg % ascorbic acid. These values are higher than the average value found in the present study for ascorbic acid content of fresh pods of both the new cultivars by about 94.9, 94.2, 94.0 and 93.4%, respectively. However, different investigators reported different values for

ascorbic acid content for fresh green beans newly grown in Egypt, Hassan (1986), Saad (1989) and Saleh (1991) reported that fresh green beans from different cultivated varieties in Egypt contained 10.08, 79.92 and 74.81 mg %, respectively, on the dry weight of fresh pods. The average value for ascorbic acid content found in the present study for both tested new cultivars is higher than that found by Hassan (1986) by 18.5% and meanwhile lower than those reported by Saad (1989) and Saleh (1991) by 84.4% and 85.5%, respectively.

Results in Table 45, revealed that ascorbic acid content reduced after blanching in either water or $MgSO_4$ by about 41.6 and 38.2%, respectively, in case of Morgan cultivar and by 59.9 and 53.9%, respectively, in case of Giza-3 beans.

Type of blanching treatment influenced ascorbic acid content and also the rate of retention. However, the rate of retention after blanching was higher in water-blanched samples than in $MgSO_4$-blanched samples. $MgSO_4$-blanched beans contained higher ascorbic acid over that in water blanched by 13.2%in case of Giza-3 beans and 5.5 in case of Morgan beans In contrast, the total rate of decrease (% retention) by dehydration was of comparable values for water and $MgSO_4$ blanched beans. Morgan beans exhibited higher amounts of ascorbic acid contents than those of Giza-3 beans in both blanched (by 43.9% in average) and dehydrated states (by 68.9% in average) probably due to higher initial content in Morgan beans in ascorbic acid.

However, the observed decrease after dehydration was attributed to the effect of blanching and also drying conditions on the degradation of ascorbic acid content (Labuza, 1973).

The loss of ascorbic acid in 8 varieties of vegetables during preparation and dehydration was found to range from 29 to 90% (Anonymous, 1942) while Morgan et al.(1949) found that loss of vitamin C due to blanching and dehydration was 16-83%. Most of ascorbic acid lost during blanching of vegetables is reported to be primarily by leaching (Luh et al., 1967 and Fennema, 1977). Halpin and Lee (1987) found that Vitamin C losses are expected to occur during blanching of vegetables due to thermal degradation and due to the action of ascorbic acid oxidase.

The observed decrease in ascorbic acid content after blanching by two treatments was in the range previously reported by many investigators. Labuza (1973) mentioned that ascorbic acid losses widely varied from as 10% before blanching to almost complete destruction. Hassan (1986) reported that the percentage of decrease in ascorbic acid content by blanching was of 33.33% for water-blanched (at 80°C for 5 min) green beans. However, higher rate of loss was observed upon blanching the tested two cultivars, especially with Giza-3 beans which showed much higher rate of loss.

After dehydration of blanched green beans (in water or $MgSO_4$) a further decrease in ascorbic acid contents was observed. Ascorbic acid content decreased by 27.9 and 31.5%, lower than the levels present in their starting blanched beans in either water or $MgSO_4$, respectively. This means that the total decrease in ascorbic acid content of dehydrated samples compared to their starting fresh materials was 57.9 and 57.7%,

for water and $MgSO_4$ blanched dehydrated samples, respectively. In case of dehydrated Giza-3 cultivar, ascorbic acid content lowered by 60.5 and 61.7 than those of beans blanched in water and $MgSO_4$, respectively, which means that the total decrease in ascorbic acid content of dehydrated product was 84.2 and 82.3% for water and $MgSO_4$-blanched dehydrated samples, respectively.

Zayed (1965) reported that dehydrated Mont-calme, Contender, Seminole and Ideal, the old Egyptian cultivars of green beans contained, respectively, on dry weight , 28.3, 42.2, 27.4 and 37.6 mg % ascorbic acid content. These values are higher than the average value for ascorbic acid found in the present study for dehydrated products prepared from both the new cultivars by about 86.6, 91.0, 86.2 and 89.9%, respectively. Furthermore, Saad (1989) reported that green beans dehydrated at 60°, 70° and 80°C for 10, 8 and 7.5 hrs, respectively had on dry weight 21.26, 23.10 and 31.72 mg % ascorbic acid content. These values are higher than the average value for ascorbic acid content of both dehydrated beans found in the present study by abcut 82.2, 83.6 and 88.1%, respectively.

4.2.2.5.3.Change in colour:

Browning of dehydrated products has been always considered a serious problem to the food industry especially in dehydrated vegetables and fruits. Typical optical density values are given in (Table 45) for fresh water, and $MgSO_4$-blanched as well as the dehydrated materials of green bean from two different cultivars. Results of the present study (Table 45) indicated that regardless of the green beans cultivar, there was a significant change in colour as a result of blanching and also dehydration, regardless of the kind of previous blanching treatments appliedbefore drying and also green bean cultivars. Comparable values for degree of browning were found for all blanched and dehydrated samples. However,although of the comparable values for colour index between both starting fresh beans, there was significant change in degree of browning as a result of blanching and also dehydration in function of cultivars and blanching treatments.

In other words, the degree of browning increased after blanching Morgan beans in water (15.7% higher) and in $MgSO_4$ (23.6% higher). However, Giza-3 beans showed an increase in degree of browning only by (13.0%) after blanching in water and by (22.8%) after blanching in $MgSO_4$. Dehydrated beans of both cultivars showed higher degree of browning than that for their corresponding starting fresh beans by 29.2% in case of dry Morgan beans previously blanched in water but much higher browning of 59.6% in case of $MgSO_4$ blanched-dehydrated beans. In dehydrated Giza-3 bean, the degree of browning was

higher by 26.1% in water blanched-dehydrated beans and by 46.7% in $MgSO_4$-blanched-dehydrated beans than the levels present in their starting fresh beans.

In contrast, values for serum colour (%) decreased by blanching beans in either water or $MgSO_4$ as well as by the dehydration of beans blanched by the two tested treatments. Such decrease in case of Morgan bean was in the order of 24.8 and 33.6% after blanching in water or $MgSO_4$, respectively, and in the order of 32.0 and 48.4% after dehydration of water-blanched and $MgSO_4$-blanched beans, respectively, compared to their corresponding starting fresh materials, while, in case of Giza-3 cultivar, the rate of decrease in serum colour was in the order of 15.1 and 31.3% by blanching in water or $MgSO_4$, respectively, and in the order of 36.4 and 43.4% by dehydration of water-blanched and $MgSO_4$-blanched beans, respectively, compared to their corresponding starting fresh materials, with both bean cultivars, values for rate of change in the increase in degree of browning and also decrease in serum colour after either blanching or dehydration was highly pronounced in $MgSO_4$-blanched than in water-blanched samples, compared to their starting fresh materials.

Giza-3 cultivar exhibited higher amounts of serum colour than those of Morgan beans during the blanching and dehydration process with the exception of dehydrated water-blanched samples.

It should be stated that during dehydration of green vegetables, the principal changes in colour were darkening

and graying. This change in colour was due to the conversion of chlorophyll to its degradation products pheophytin. (Blair, and Ayres, 1943 and Saleh, 1991).

4.2.2.5.4. Pigments content:

The plastid pigments, chlorophyll and carotenoids are greatly involved in colour and colour retention of dried products (McBean et al., 1971). Chlorophylls, carotenoids, anthoxanthins are the chief pigments in most vegetables (Meyer, 1978).

Fresh Morgan beans exhibited higher amounts of chlorophyll-A, B and carotenoids, respectively, than those in the corresponding Giza-3 fresh beans (58.6, 33.0 and 62.30 vs. 42.69, 21.30 and 45.1 mg/100 g, respectively). These values are quite different from literature values. Zayed (1965) reported that old cultivated varieties of green beans, Mont-calme, Contender, Seminole and Ideal grown in Egypt contained respectively, on dry weight basis, 151.3, 129.3, 129.4 and 103.3 mg % total chlorophyll and 3.7, 3.0, 3.1 and 3.4 mg % carotenoids, respectively. These values are higher than the average value for total chlorophyll found in the present study for both new cultivars by about 48.6, 39.8, 39.9 and 24.7%, respectively, but lower than the found average value for carotenoids by about 93.1, 94.4 , 94.2 and 93.7%, respectively. In addition, Saad (1989) reported that fresh green beans of an Egyptian variety contained 68.7 and 66.79 mg % chlorophyll-A and B, respectively. These values are also higher than the found average value for chlorophyll-A and B in both fresh cultivars by about 52.7 and

70.8%, respectively. In complete contrast to Saad (1989), Saleh (1991) reported that fresh Giza-3 beans contained, on dry weight basis, 29.73, 13.28 and 13.17 mg %, chlorophyll-A, B and carotenoids. These values are lower than the values for the same cultivar found in the present study by about 10.18, 24.5 and 61.2%, respectively.

As shown in Table (45) there was a variable decrease in pigments content of green beans of both cultivars as a result of the blanching process under the conditions applied in the present study. In case of Morgan cultivar, chlorophyll, A, B, and carotenoids reached about 35.41, 22.26 and 38.94 mg/100 g, respectively, in water-blanched samples, and 50.09, 29.57 and 52.18 mg/100 g respectively, in $MgSO_4$-blanched samples. Meanwhile, in case of Giza-3 beans they reached 32.40, 17.98, and 34.11 mg/100 g, respectively, in water-blanched samples, and 38.30, 20.60, and 40.86 mg/100 g, respectively, in $MgSO_4$-blanched samples. These results would indicate that in case of Morgan cultivar there was a loss in the amount of the three pigments by 39.57, 32.55 and 37.50%, respectively, in water-blanched samples, and by 14.52, 10.39, and 16.24%, respectively, in $MgSO_4$-blanched samples, while in case of Giza-3, they decreased by 24.10, 15.59, and 24.43%, respectively, in water-blanched samples, and by 10.28, 3.29, and 9.48%, respectively in $MgSO_4$-blanched samples lower than their corresponding starting fresh materials. So it appears that the decrease in concentrations of the three pigments was tremendously greater upon blanching in water than in $MgSO_4$, with both green bean cultivars and that Morgan cultivar retained higher amounts of the three pigments than Giza-3 cultivar.

The decrease in pigments content after blanching could be attributed to the conversion of chlorophylls to pheophytin (Potter, 1968, and (Kolzlowask., 1979). However, the rate of decrease in chlorophyll content was higher upon blanching beans in water than in $MgSO_4$ solution. Foda et al. (1967) stated that percent retention of chlorophyll-A, B and carotenoids in green beans blanched in water was of 34.1, 35.3 and 41.6%, respectively. In addition, Hassan (1986) revealed that the percentages of changes in chlorophyll to pheophytin in green beans as a result of blanching at 70, 80 and 90°C for 5 min, respectively, were 0.496, 16.58 and 39.49%, on dry weight basis. The higher the blanching temperature the higher the changes in chlorophyll during freezing green beans.

After dehydration of Morgan blanched beans, the three pigments (chlorophyll A, B, and carotenoids) reached about 27.37, 18.15 and 28.20 mg/100 g, respectively, in water-blanched samples, and 35.60, 24.55, and 37.09, respectively, in $MgSO_4$-blanched samples while in case of Giza-3 cultivar they reached 29.79, 16.80 and 30.38 mg/100 g, respectively, in water-blanched samples, and 36.40, 18.70, and 37.50 mg/100 g, respectively, in $MgSO_4$-blanched samples. Beside the decrease occurred upon blanching, a further variable decrease in the concentrations of the three pigments analysed occurred also after dehydration of blanched beans of the two cultivars. In case of dehydrated Morgan beans, the decrease in chlorophyll-A, B and carotenoids after dehydration was estimated to be in the order of 22.7%, 18.5%, and 27.6% mg/100 g respectively, lower than that present in water-blanched samples, respectively and 28.9%, 17.0% and

28.9%, mg/100 g respectively, lower than that present in $MgSO_4$-blanched samples. This means that the total decrease in chlorophyll-A, B, and carotenoids in dehydrated samples compared to their starting fresh materials was 53.29, 45.0, and 54.74 mg/100 g, respectively, for water-blanched samples, and 39.25, 25.61, and 40.47 mg/100 g, respectively, for $MgSO_4$-blanched samples. On the other hand, in case of dehydrated Giza-3 cultivar, the rate of decrease in chlorophyll-A, B, and carotenoids was 8.1%, 6.6%, and 10.9 mg/100 g, respectively, lower than that present in water-blanched samples, and 5.0%, 9.2% and 8.2% mg/100 g, respectively, lower than that present in $MgSO_4$-blanched samples. This means that the total decrease in chlorophyll-A, B, and carotenoids in dehydrated products than the level present in their starting fresh materials was 30.22, 21.13, and 32.70 mg/100 g respectively, for water-blanched samples and 14.73, 12.21 and 16.93 mg/100 g, respectively, for $MgSo_4$-blanched samples.

With both beans cultivars, the rate of decrease in the content of the three pigments after dehydration was considerably higher in case of water-blanched than in $MgSO_4$-blanched samples, compared to their starting fresh materials. On the other hand, dehydrated Morgan beans exhibited lower amounts of chlorophyll-A, and carotenoids than those of corresponding dehydrated Giza-3 beans, with the exception of chlorophyll-B, with both conditions of blanching.

Such observed decrease after dehydration is in agreement with the reports of Ehart and Gott (1964) who mentioned that dehydration process is responsible for the conversion of 26%

of the chlorophyll to pheophytin in green vegetables, and they also found that blanching prior to dehydration increased the conversion of chlorophyll to pheophytin in the dehydrated materials. Furthermore, Tressler (1942) indicated that there was a large loss in carotenoids during dehydration of vegetables which were not blanched.

In addition, Zayed (1965) reported that dehydrated green bean of the old varieties Mont-Calme, Contender, Seminole and Ideal grown in Egypt contained respectively, on dry weight basis, 53.6, 46.7, 48.3 and 41.3 mg % total chlorophyll and 2.5, 2.8, 2.7 and 2.61 mg % carotenoids, respectively. These values are higher only in case of Mont-calme by 3.0% but lower with others by 10.2, 7.1 and 20.6%, respectively, than the average value for total chlorophyll in dehydrated products prepared in the present study from both of the new cultivated varieties of green beans and also lower than the average value for carotenoids in both the new cultivars by about 92.5, 91.6, 91.9 and 92.2%, respectively.

4.2.2.5.5. Total and reducing sugars:

Fresh Giza-3 and Morgan bean cultivars had variable total and reducing sugars content (10.96 and 9.65% vs, 8.82 and 8.27%, respectively). Thus., Giza-3 beans had higher total and reducing sugars, than Morgan beans by 19.5 and 14.3, respectively. Literature values are quite different from the obtained values. For example, Zayed (1965) reported that untreated fresh green beans from old cultivars grown in Egypt contained (on dry basis) 37.42, 35.04, 31.82 and 28.28%, respectively, total sugars as well as 23.73, 24.98, 23.13 and 24.05%, respectively, reducing sugars.

These values are higher than the average value for both tested green beans cultivars in the present study by about 73.6, 71.0, 68.9 and 65.0%, respectively, for total sugars as well as 62.2, 64.1, 61.3 and 62.7%, respectively, for reducing sugars.

Hassan (1986) reported that untreated fresh green beans contained (on dry basis) 32.6% total sugars and 18.71%, reducing sugars. These values are higher than the average value for both tested green bean cultivars in the present study by about 69.7% for total sugars and 52.1% reducing sugars. However, Saad (1989) reported that fresh green beans of an Egyptian grown cultivar contained (on dry basis) 12.82% reducing sugars. This value is also higher than the average value for both tested cultivars by about 30.1%. On the other hand, Saleh (1991) reported that fresh Giza-3 beans contained 11.24% total sugars and 10.71% reducing sugars of the dry weight. Again these values are higher than the average value found for both tested green bean cultivars by about 12.0% and 16.3%, respectively.

Total and reducing sugars showed a pronounced increase after blanching in either water or $MgSO_4$ (Table 45). In case of Morgan cultivar, the rate of increase in total and reducing sugars was estimated to be in the order of 49.3 and 38.0%, respectively, for water-blanched samples as well as 60.9 and 51.0%, respectively, for $MgSO_4$-blanched samples, over the levels present initially in fresh beans, while in case of Giza-3 cultivar such rate of increase was of 30.2 and 26.4%, respectively, with water-blanched samples and of 39.0 and 43.5%, respectively, with $MgSO_4$-blanched samples over the initial level in fresh beans.

The values found by Hassan (1986) for blanched green beans at 70°, 80° and 90°C for 5 min are higher than the average value for blanched beans from both new cultivars found in the present study by about 55.5, 54.6 and 51.9%, respectively, total sugars and by 32.5, 33.4 and 33.5%, respectively, reducing sugars. She also reported that blanched green beans at 70°, 80° and 90°C for 5 min contained 31.93, 31.26 and 29.5%, respectively total sugars and 18.7, 18.95 and 18.99%, respectively, reducing sugars. In contrast with our results, Hassan (1986) stated that these values decreased by 0.72, 2.4 and 8.3%, respectively, for total sugars as well as increased by 0.05, 1.3 and 1.5, respectively, for reducing sugars with blanching process.

After dehydration at 65°C for 6 hrs, certain decrease in total and reducing sugars content was observed compared to the levels present in their corresponding blanched beans of both cultivars tested although of the fact that their dehydrated beans had higher total and reducing sugars than their corresponding starting fresh beans. In case of Morgan cultivar, the decrease in total and reducing sugars was of 3.4 and 12.8%, respectively, lower than that present in water-blanched samples as well as, 2.9 and 13.9%, respectively, lower than that present in $MgSO_4$-blanched samples. This means that the total increase in total and reducing sugars in dehydrated samples over the level present in their starting fresh materials was 44.2 and 20.3%, respectively for water-blanched samples as well as 56.3 and 30.0%, respectively, for $MgSO_4$-blanched samples. However, dehydrated Giza-3 beans decreased by 2.3 and 2.0%,

respectively, lower than that present in water-blanched samples as well as 7.5 and 10.0%, respectively, lower than that present in $MgSO_4$-blanched samples. This means that the total increase in total and reducing sugars for dehydrated samples over the present in their starting fresh material, was 26.8 and 23.9%, respectively, for water-blanched samples as well as 28.6 and 29.2%, respectively, for $MgSO_4$-blanched samples.

The extent of increase in total and reducing sugars after either blanching or dehydration was highly notable in $MgSO_4$-blanched samples than in water-blanched samples. Meanwhile, Giza-3 beans exhibited higher amcunts of total and reducing sugars than those of Morgan cultivar upon blanching and drying using either water or $MgSO_4$.

Data on the fate of sugars upon dehydration of green beans are contradictory. Saad (1989) reported that dehydrated beans at 60°, 70° and 80°C for 10, 8 and 7.5 hrs, respectively, contained 20.76, 17.04 and 15.50%, respectively, reducing sugars. In agreement with our results, Saad (1989) stated that these values increased by about 38.2, 24.8 and 17.3%, respectively, with dehydration process. However, the values found by Saad (1989) for dehydrated green beans at 60°, 70° and 80°C for 10, 8 and 7.5 hrs, respectively, are higher than the average value found of both dry products of the new cultivars in the present study by about 56.8, 47.4 and 42.2%, respectively.

On the other hand, Zayed (1965) reported that Mont-calme, Contender, Seminole and Ideal Egyptian varieties of dehydrated green beans contained on dry weight basis, respectively, 24.94, 24.68, 20.47 and 21.60%, total sugars; 22.15, 20.74, 17.67 and

20.13%, reducing sugars. In contrast to our results, Zayed (1965) stated that these values decreased by 33.4, 29.6, 35.7 and 23.6%, respectively for total sugars as well as 6.7, 17.0, 23.6 and 16.30%, respectively for reducing sugars with dehydration process. The values found by Zayed (1965) for dehydrated green beans prepared from old cultivars grown in Egypt are higher than the average value found of both dry products of the two new cultivars tested by about 56.7, 51.6, 52.9 and 44.1%, respectively, for total sugars as well as 52.7, 51.7, 49.5 and 49.3%, respectively, for reducing sugars.

4.2.2.5.6. Characterization of individual sugars of dehydrated green beans variety:

Identification of individual sugars separated from dehydrated beans prepared from immature Morgan and Giza-3 cultivar performed using paper chromatography technique. Chromatograms of an authentic mixture of seven sugars and also their constituent seven individual sugars together with sugars separated from duplicate samples of each of the dehydrated green bean products are presented in Fig. 10. Arabinose was not able to be identified because it was the same Rf of xylose under the condition of chromatographic separation in the present study. Paper chromatographic separation of free sugars revealed the presence of mannose and xylose in dehydrated bean processed from the two cultivars tested. Qualitative estimation separated sugars (Table 46) indicated that mannose and xylose were present in nearly equal amounts in dehydrated products of both vegetables.

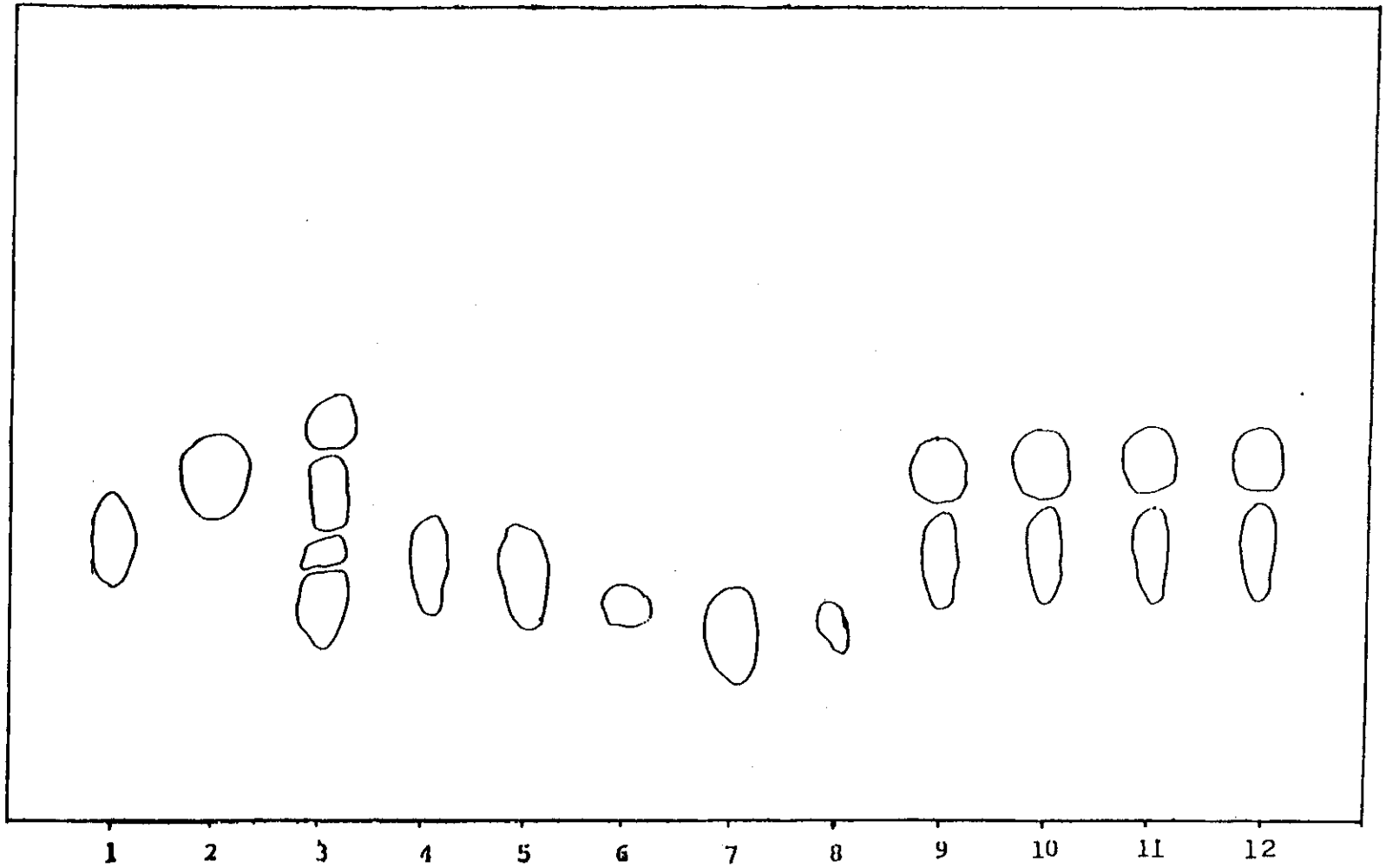


Fig. (19): Chromatograms of individual sugars separated from dehydrated green beans obtained from two different cultivars 1, Arabinose ; 2, Xylose; 3, Mixture of individual standard sugars; 4, Mannose; 5, Mannose ; 6, Maltose; 7, Glucose ; 8, Sucrose; 9, Dehydrated Giza-3 cultivar (smaple A); 10, Dehydrated Giza-3 cultivar (sample B); 11, Dehydrated Morgan cultivar (sample C);12, Dehydrated Morgan cultivar (sample D).

Table (46): Qualitative estimation of sugars separated by paper chromatography technique from dehydrated green beans of two different cultivars.

R_F	Standared[1]	Morgan	Giza-3
0.19	Sucrose	-[2]	-
0.17	Glucose	-	-
0.20	Maltose	-	-
0.22	Mannose	++[2]	++
0.33	Xylose	++	++
0.26	Arabinose	-	-

1. Concentration of individual sugars in standard solution was 1%.
2. ++ Moderate.
   - Not present.

In partial agreement of our results, Lee et al. (1970) found that free sugars present in vegetables were xylose, mannose, raffinose, stachyose and unidentified sugars. Moreover, Chang et al.(1979a) found that free sugars in winged beans were mannose, xylose, galactose, glucose, raffinose, and stachyose in winged beans. However, results obtained in the present study did not reveal the presence of glucose, galactose, raffinose or stachyose probably because dehydrated products were prepared from green beans in the immature stage, while most literature reports listed these sugars in mature green beans or in their seeds.

4.2.2.5.7. Characterization of mineral content of dehydrated green beans variety:

Mineral analysis included the spectrophotometric determination of phosphorus, the flame photometric determination of Na and K and the atomic absorbtion spectroscopic determination of Ca, Mg, Mn, Cu, Zn and Fe in fresh and blanched green beans varieties (Table 47). Both green beans varieties had appreciable mineral matter content but they showed different distribution pattern for the minerals analysed. From the point of availability of minerals, they were arranged, in order of decreasing abundance as; K, Cu, Mg, Na, Fe, Cu, Mn, Zn, and P in case of fresh Morgan variety, and as K, Ca, Na, Mg, Fe, Mn, Cu, Zn, and P in case of fresh Giza-3 variety.

The concentration of each of the analysed elements in fresh and blanched samples of Morgan cultivar was higher than those present in both fresh and blanched samples of Giza-3 cultivar, with the exception of Fe. When concentration was expressed in

Table (47): Mineral content of fresh and blanched, green beans (mg/ 100 g of dry weight) previously blanched under different conditions.[1]

Elements	Variety of green beans					
	Morgan			Giza-3		
	Starting fresh material	Blanching conditions		Starting fresh material	Blanching conditions	
		W[2]	M[3]		W	M
Macro elements:						
Na	27.140	25.110	30.070	23.540	22.110	25.120
Ca	49.830	49.200	53.290	35.060	34.900	39.10
Mg	38.920	37.200	52.090	17.510	17.320	31.210
K	140.700	140.000	142.100	131.700	130.800	134.900
P	0.115	0.114	0.159	0.115	0.105	0.152
Micro elements:						
Cu	2.300	2.080	3.070	0.450	0.402	0.489
Fe	16.860	16.600	18.200	15.261	14.920	19.000
Mn	0.800	0.721	0.971	0.620	0.600	0.810
Zn	0.718	0.702	0.953	0.401	0.361	0.444
Total	277.383	271.727	300.903	224.657	221.518	251.135

1. Average of duplicate analysis.
2. W: Blanched in water at 80°C for 4 min.
3. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min.

mg/100 g of dry materials, blanching of both Morgan and Giza-3 cultivars in water resulted in decreaseing the total amount of analysed minerals by only 2.04 and 1.40%, respectively, lower than those present in their corresponding starting fresh materials. In contrast, blanching of Morgan and Giza-3 beans in $MgSO_4$ solution caused the accumulation and the increase amount of minerals analysed by 8.48 and 11.79%, respectively, higher than those present in their corresponding starting fresh materials. On the other hand, blanching Morgan and Giza-3 beans in $MgSO_4$ resulted in higher concentration by approximately 10.74 and 13.37%, respectively, than those present in their corresponding water blanched-counterparts (Table 47). This observation could be attributed to the higher ash contents of $MgSO_4$-blanched vegetables from both cultivars than the corresponding water blanched beans (Table 44). However, the minerals estimated at the present study (Table 47) represented about 46.6 and 37.6% of ashes (Table 44) of their starting fresh Morgan and Giza-3 cultivars, respectively. On the other hand, total minerals content reached 60.4 and 45.0% of ashes (Table 44) of water blanched, Morgan and Giza-3 cultivars, respectively, and by 56.2 and 49.0% (Table 44) in $MgSO_4$-blanched samples, respectively.

Results of mineral content of fresh, blanched new cultivated green beans grown in Egypt are in the range previously reported for green beans by Morton and Waston (1988) with regard to most individual minerals analysed as well as the range reported by Mortha Louis et al. (1950) and Lazar et al. (1963) for calcium content.

4.2.2.5.8. Enzyme activities:

The oxidases, peroxidase and polyphenyl oxidase have been implicated in many metabolic changes and reactions occurring in fruits and vegetables after dehydration and also subsequent stcrage.

Activities of polyphenol oxidase (PPO) and peroxidase (POD) enzymes and also their % residual activities were measured in fresh, blanched (water or $MgSO_4$) and dehydrated green beans of both cultivars (Table 53) and after this subsequent storage at room temperature (Tables 54 and 55). Enzyme activity decreased after blanching by both treatments and also dehydration. However, fresh green beans cultivar showed variable enzymatic activities and also after blanching or dehydration.

A) Enzymatic activities in function of green bean cultivars:

There was great variation in enzymatic activities present in the two green bean cultivars tested, where Morgan cultivar had high activities of PPO and also PDD in the fresh, blanched as well as the dehydrated states under the conditions of the present study.

Fresh Morgan beans exhibited higher PPO and POD activities than Giza-3 beans by 319.8% and 329.6%, respectively. This means that enzyme activities in Giza-3 beans represented only one third (31.0% and 30.3%, respectively) of the activities of the two enzymes present in Morgan.

Among many vegetables tested, green bean and cabbage were found to have high POD activity (Muftugil, 1985). Furthermore, it

has been demonstrated by Saleh (1991) that PPO of fresh green beans was of 6.02 to 6.72 (unit/min/g) as well as POD 221.5 to 599.3 unit/min/g.

Blanched Morgan beans in either water or $MgSo_4$ showed higher enzymic activities by 223.1 and 244.8%, respectively, for PPO and by 132.7 and 247.9%, respectively, for POD than those for corresponding Giza-3 beans. This means that enzyme activities in blanched Giza-3 beans represented 44.8 and 40.9% and by 75.3 and 40.3%, respectively, of the activities of the two enzymes present in Morgan.

Dehydrated Morgan beans prepared from unblanched, water-blanched and $MgSo_4$-blanched exhibited an increase in PPO activity by 425.1, 184.3 and 179.7%; respectively and also an increase in POD activity by 325.5, 113.9 and 269.0%, respectively higher than those corresponding Giza-3 beans. This means that enzyme activities of dehydrated Giza-3 beans represented only 23.5, 54.3 and 55.6%, respectively, for PPO and 30.7, 87.8 and 37.2%, respectively, for POD of the activities present in Morgan.

B) Enzymatic activities in function of processing conditions:

1) Blanching:

The extent of inhibiting of enzyme activity by blanching process (which employed heating at 80°C for 4 min) and also by dehydration (which employed 65°C for 6 hrs) was much influenced by kind of processed green cultivars, kind of blanching solution, the type of inhibitant enzyme.

Blanching in either water or $MgSO_4$ at 80°C for 4 min reduced PPO enzyme activities by about 57.6 and 70.2%, respectively, of that present in fresh Morgan and by 39.2 and 61.0%, respectively, for that present in fresh Giza-3 beans. On the other hand POD activity reduced by 79.4 and 82.4%, respectively, in Morgan and by 48.7 and 76.6%, respectively for that present in fresh Giza-3 beans.

So it appears that activity of POD enzyme was more effected or more sensitive to blanching temperature applied in the present study than that of PPO. Since POD activity was more greatly reduced by blanching than PPO, the % residual activity in relation to activity in fresh beans was also lower for POD than for PPO.

Although similar temperature (80°C) and time (4 min) of blanching were used, the addition of $MgSO_4$ to blancher water appeared to influence greatly activities and rate of inhibition of both PPO and POD enzymes. $MgSO_4$ was more effective in inhibiting both enzymes, since water-blanched beans of Morgan and Giza-3 cultivars showed higher enzymatic activity by 29.6% and 35.9%) respectively than $MgSO_4$-blanched beans, and also exihibited higher % residual activity (42.38% vs. 29.84% and 60.76% vs. 38.96%, respectively for PPO as well as 20.64% vs. 17.60 and 51.26% vs. 23.41%, respectively for POD). Values for % residual activity in water-blanched beans is higher than that found in $MgSO_4$-blanched samples of Morgan and Giza-3 beans by 29.6% and 35.9%, respectively for PPO and by 14.7% and 54.3%, respectively, for POD.

2) Dehydration:

The enzymatic activities in dehydrated beans processed from unblanched, blanched beans were investigated. Dehydrated unblanched beans showed higher PPO enzyme activity than water-blanched and $MgSo_4$-blanched beans by 69.1 and 82.5%, respectively, for Morgan and by 28.8 and 58.7%, respectively, for Giza-3 beans and also higher POD by 82.4 and 88.0%, respectively, for Morgan beans and by 49.6 and 85.5%, respectively, for Giza-3 beans. Peroxidase activity has been detected in foods containing as low as 12.5% water (Acker, 1962).

Although constant temperature (65°C) and time (6 hrs) of dehydration were used, the previously water-blanched or $MgSO_4$-blanched dry beans varied greatly in their residual enzymatic activities of both PPO and POD enzymes. Water-blanched dehydrated beans of both Morgan and Giza-3 beans showed higher enzyme activities than $MgSO_4$-blanched dehydrated beans (8.92 vs. 5.05% and 4.84 vs. 2.81%, respectively, for PPO enzyme as well as 3.94 vs. 2.68% and 3.46 vs. 0.996%, respectively, for POD enzyme). This means that residual activities in dehydrated water-blanched beans were higher than those found in dry $MgSO_4$-blanched beans of Morgan and Giza-3 cv. by 43.4% and 41.9%, respectively, for PPO enzyme as well as 32.0% and 71.2%, respectively, for POD enzyme.

In comparison to the enzymic activities of starting blanched Morgan and Giza-3 beans, dehydration decreased PPO activity by 38.9 and 26.1%, respectively, in water-blanched beans as well as 50.9 and 33.1%, respectively, in $MgSO_4$-blanched beans, while POD activity decreased by 59.2 and 52.4%, respectively as well as 67.4 and 70.0%, respectively.

This means that in comparison to original enzymic activities present in both fresh beans before blanching, dehydration decreased PPO activity by 74.1 and 55.1%, respectively, for water-blanched beans as well as 85.3 and 73.9%, respectively, for $MgSO_4$-blanched beans, while POD activity decreased by 91.6 and 75.6%, respectively, as well as 94.3 and 93.0%, respectively.

It could be concluded that similar to blanched samples, dehydrated $MgSO_4$-blanched had lower activities than the water-blanched ones with Morgan having higher activities than Giza-3. Moreover, POD activities were more effected by dehydration conditions than PPO since % residual activity for POD enzyme activity is lower than those for PPO.

In agreement to our finding, Yankov (1963) stated that POD was less heat stable in vegetables than in fruits while PPO showed the opposite trend. Peroxidase is the most heat-resistant enzyme in vegetables and its activity is usually considered as index of blanching or indicator for enzyme inactivation after heat treatment (Wang and Luh, 1983) However, POD activity has been shown to survive temperature of 120°C for several minutes, while activities of other enzymes were negligible after blanching for 80°C (Cox and Mitchell, 1972). Moreover, Peroxidase is considered to have an empirical relationship to off-flavors and off-colours in raw and unblanched vegetables (Whitaker, 1972). The relationship between peroxidase activity and off flavor production in peas has been well established (Wagenkneeht and Lee, 1958; Pinsent, 1962). This has also been demonstrated for green beans and turnips (Zoueil and Esselen, 1959).

The found value for POD inactivation using under the processing conditions applied in the present study is much better than that reported earlier by Zayed (1965) who stated also that peroxidase of old green bean cultivars was heat resistant. He reported also that the thermal destruction rates (rate of change) of peroxidase (POD) of the old-cultivated green bean variety Seminole at different degrees of blanching temperature (82.2, 87.8°, 93.3° and 100°C, respectively) were 95.25, 81.3, 77.61 and 72.63%, respectively, after blanching for 3 min as well as 43.48, 34.35, 16.66 and 6.03%, respectively after blanching for 4 min, while it was of 38.78, 12.34 0.00 and C.000%, respectively, after blanching for 6 min but it reached 18.88 and 0.00% at 82.2° and 87.8°C, respectively. after 10 min of blanching. Finally, POD reduced by 8.68% after 12 min of blanching at 82.2°C. A complete destruction of the POD activity occurred after 6 min of blanching at 93.3°C and the same effect occurred after steam blanching (100°C) and also after 10 min of blanching at 87.8°C.

In the present study, percent of change or destruction rates of peroxidase enzyme by blanching green beans of both tested new cultivars at 80°C for 4 min (71.8%) is higher than that found by Zayed (1965) for the old-cultivated Seminole variety blanched at 82.2° and 87.8°C for 4 min, respectively (43.48 and 34.35%).

Muftugil (1985) found that time for peroxidase enzyme inactivation depended on the temperature of the blanching water, size of vegetables and the nature of the enzyme present. However, most literature reports did not agree on common condition for complete

or incomplete inactivation of enzymatic activities in green bean or any other vegetable.

Joslyn and Marsh (1938) recommended a range between 1 and 5 min in boiling water or in steam as the necessary period for blanching the green beans. On the other hand, Bottcher (1962) found that heat inactivation of POD was most efficient over the ranges 50-60°C and 70.95°C in case of vegetables with small size using hot-water blanching for just 1 minute. This resulted is more than 80 percent decrease in peroxidase activity. Baruffalidi et al (1983) found that 99.2% of POD activity in green beans was destroyed after 16 min of blanching at 88°C, 99.4% after 4 min at 92°C, 97.7% after 2 min at 96°C and 98.3% after 4 min of blanching at 97.8°C. El-Shemy (1986) indicated that the residual activity of peroxidase in frozen green beans previously blanched at 70°C was higher than that noticed after heating at 80°C and 90°C. On the other hand, upon using 80°C for blanching the frozen samples higher enzyme inhibition was realized upon heating for 7 min. Same findings were noticed when 90°C was used for 5 min instead of 3 min.

The higher additional inhibitory effect of blanching in $MgSO_4$ than in water could be attributed to the additional inhibitory effect of sulfite present in $MgSO_4$ and partly due to lower pH (3.33) of $MgSO_4$ during blanching rather than the effect of heat treatment condition on PPO since it was equal in both $MgSO_4$ and water blanching or the effect of Mg ions.

It has long been known that sulphite inhibits PPO catalysed browning, but the mechanism of this effect of sulphite is non-traversy. Evidence of the mechanisms of inhibition of PPO

activity by sulfite, such as formation of quinone sulfite complexes and the inactivation of PPO has been reported (Embs and Markakis, 1965; Cole, 1967; Haisman, 1974; Assa et al., 1978). Moreover, upon studying specificity and inhibition of PPO enzyme, Galeazzi and Sgarbieri (1981) treated cut fruits with $MgSO_4$ and $Na_2S_2O_5$ and stated that a possibility exisits that bisulfite ion could bind to the oxidised substrate at the enzyme-substrate complex and thus contributing to the inhibitory process of PPO enzyme. On the other hand, Mg ion was found not to influence PPO enzyme activity extracted from (Chung et al., 1983).

In addition Vamos-Vigyazo et al. (1979) found that POD activity is highest in the pH range of 5.1 to 6.25 and it increase with temperature according to an exponential plot up to 35°C. However, Vamos vigyazo (1981) stated that the optimum pH of peroxidase from green beans was 5.0.

One of the problems with respect to incomplete inactivation of POD is the presence of 1-10% of more heat-stable isoenzymes of POD in most vegetables (Winter, 1969; Delincee and Schaefer, 1975). Therefore, Erwin (1969) stated the heat-resistant peroxidase detectable in the range of 1-10 percent of the original activity in most vegetables would require a very long heating time for its complete destruction. Wang and Luh (1983) found that at 70°C about 12% of the total POD activity existed in the heat-resistant form for soluble peroxidase and 31% for the ionically bound enzyme. When the heat treatment temperature increased to 90°C, the heat resistant form reduced to 3% and 4%, respectively.

4.2.3. Effect of storage conditions on physical and chemical characteristics of dehydrated green beans:

In an attempt to evaluate the shelf-life of dehydrated green beans during storage, experiments were conducted to study the effect of duration of storage and type of packaging materials and previous blanching treatments on some physical and chemical attributes of dehydrated products upon their subsequent storage for six months. Fresh green beans of two new cultivars grown in Egypt i.e. Morgan and Giza-3 were blanched in either water or 0.5% $MgSO_4$ at 80°C for 4 min before their dehydration in air-circulated oven at 65°C for 6 hrs. Freshly dehydrated beans from every treatment of each cultivar were packed in two sets of glass jars and also of polypropylene bags.

The sets of each type of containers were either sealed or closed carefully, then placed in carton boxes. Closed carton boxes were placed in shelves of large-space store house and kept at room temperature for 6 months where opened once every three months to drow some containers for physical, chemical and microbiological analysis.

4.2.3.1. Moisture content:

With both green beans cultivars, moisture increased gradually by the advancement of storage period at room temperature. However, the increase in moisture content was in accordance to the duration of storage at room temperature and in function of type of packaging utilized throughout storage, rather than the kind of blanching treatments or kind of green beans cultivar (Table 48 A)

Dehydrated beans prepared from both blanching treatments and stored in two different packages of prepared from Morgan and Giza-3 cultivars had moisture content in the range between 7.24 to 9.0% (average 8.15%) and 7.36 to 8.97% (average 8.11%), respectively, after 3 months , while they ranged between 8.32 to 9.0% (average 8.75%) and 7.98 to 9.37% (average 8.57%), respectively, after 6 months of storage.

After 3 months of storage, dehydrated Morgan and Giza-3 beans previously blanched by both treatments, showed an average increase in moisture content of 1.07 and 0.86%, respectively, upon storage in glass jars and of 2.03 and 1.86%, respectively, in polypropylene packages over the levels present in their starting fresh dehydrated samples at zero time of storage. However, after 6 months of storage, the average increase in moisture was 2.06 and 1.24%, respectively in glass jars as well as 2.24 and 2.41%, respectively, in polypropylene packages.

With both cultivars, dehydrated beans stored in polypropylene packages for periods up to 6 months exhibited a slight higher moisture content than their corresponding beans packed in glass jar packages. However, the increase in moisture content was higher in dehydrated beans

Table (48A) :Effect of storage period (3-6 months) on moisture content and rehydration ratioes of dried green beans of two Egyptian cultivars stored in two different packaging materials.[1]

Duration of storage period (month)	Blanching treatment	Green bean cultivars									
		Morgan						Giza-3			
		Moisture %	% of increase *	Rehydration period				Moisture %	% of increase	Rehydration period			
				1 hr	2 hrs	3 hrs	6 hrs			1 hr	2 hrs	3 hrs	6 hrs
0	W[2]	7.00	-	1:2.5	1:3.2	1:4.5	1:5.3	7.00	-	1:2.0	1:3.0	1:4.0	1:5.0
	M[3]	6.20	-	1:2.6	1:3.3	1:4.7	1:5.5	6.50	-	1:3.0	1:3.5	1:4.6	1:5.8
		Glass jar packages											
3	W	7.24	0.24	1:4.0	1:5.0	1:6.0	1:6.5	7.36	0.36	1:3.5	1:3.2	1:4.3	1:5.5
	M	8.10	1.90	1:4.2	1:5.2	1:6.3	1:7.9	7.85	1.35	1:3.5	1:4.2	1:5.2	1:6.1
6	W	8.32	1.32	1:4.3	1:6.3	1:7.0	1:7.5	7.99	0.99	1:3.5	1:4.0	1:5.0	1:5.8
	M	9.00	2.80	1:4.5	1:6.4	1:7.3	1:8.0	7.98	1.48	1:3.8	1:4.8	1:5.6	1:7.3
		Polypropylene packages											
3	W	8.25	1.25	1:4.2	1:4.8	1:6.2	1:6.8	8.24	1.24	1:3.1	1:3.5	1:4.6	1:6.0
	M	9.00	2.80	1:4.3	1:5.3	1:6.5	1:8.1	8.97	2.47	1:3.6	1:4.8	1:5.9	1:6.6
6	W	8.67	1.67	1:5.0	1:7.0	1:7.3	1:8.0	8.94	1.94	1:3.5	1:4.0	1:5.8	1:6.6
	M	9.00	2.80	1:5.5	1:7.5	1:7.9	1:8.5	9.37	2.87	1:3.9	1:4.9	1:6.0	1:7.6

1. Average of duplicate analysis.
2. W = Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M = Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

* Compared to the level present at zero time.

previously blanched in $MgSO_4$ than those previously blanched in water, regardless of the type of packages utilized.

On the other hand, regardless of the type of packaging materials and kind of blanching treatment applied before drying, dehydrated Morgan beans exhibited slight higher moisture content than the corresponding dehydrated Giza-3 beans upon storage for 6 months.

The obtained results for moisture content are in agreement with those reported by Nelson et al. (1956) and Foda et al. (1967), who found that moisture content of dried green beans and lima beans also increased during storage for periods up to 4 months when packed in paper cartons, polyethylene bags, metal containers, or tin cans.

In agreement with our results, Zayed (1965) reported that moisture content of Mont-Calme, contender, Seminole and Ideal Egyptian varieties of green beans, respectively, increased by 6.10 to 7.51; 7.00 to 8.13; 5.44 to 6.62 and 7.39 to 8.00% after two months as well as, 7.51 to 7.7; 8.13 to 8.65; 6.62 to 7.34 and 8.00 to 8.55% after six months of storage in carton package. However, dehydrated beans from different cultivars packed in tin cans showed an increase in moisture content by about 6.10 to 6.40; 7.00 to 7.21; 5.44 to 6.60 and 7.39 to 7.50%, respectively, after two months while it reached about 6.52; 7.70; 6.75 and 7.50%, respectively, after six months of storage.

4.2.3.2. Rehydration properties:

With both beans cultivar , rehydration properties of dehydrated green beans stored at room temperature in either glass jars or polypropylene packages improved gradually parallel to the advancement of storage period in function of type of package material utilized throughout storage as well as the kind of blanching treatment and also varieties or kind of green beans. (Table 48 B)

Dehydrated beans prepared from both cultivars by the two blanching treatments and stored in two different packages had average values for rehydration ratioes, coefficient of rehydration and moisture content (%) in rehydrated samples (after 6 hrs in cold water) in the range between 1:5.5 to 1:8.1; 1.81 to 2.37 and 91.6 to 94.4%, respectively, after 3 months while they ranged between 1:5.8 to 1:8.5; 1.92 to 2.48 and 97.1 to 94.6%, respectively, after 6 months of storage.

The increase in rehydration ratioes, coefficient of rehydration and moisture content in Morgan samples previously blanched in either water or $MgSO_4$ and stored in glass jars were over those found for started dry beans before storage (at zero time) of 22.6 and 38.6; 22.4 and 46.2% and 1.9 and 3.0%, respectively, after 3 months as well as 41.5 and 40.4%; 43.4 and 50.0%; 3.0 and 3.1%, respectively, after 6 months, while for those stored in polypropylene packages, they increased by 28.3 and 42.1%; 29.6 and 51.9%; 2.3 and 3.2%, respectively after 3 months and 50.9 and 49.1%; 53.3 and 58.9%; 3.4 and 3.4%, respectively, after 6 months of storage.

Table (48B): Rehydration properties of dehydrated green beans prepared from two cultivars during storage for 6 months in different packages kept at room temperature.

Storage period (month)	Blanching treatments	Morgan								Giza-3							
		Moisture (%) in dry product.	Rehydration properties: Coefficient of rehydration.				Moisture % in rehydration sample.				Moisture (%) in dry product.	Redhydration properties: Coefficient of rehydration.				Moisture % in rehydrated sample.			
			1hr	2hrs	3hrs	6hrs	1hr	2hrs	3hrs	6hrs		1hr	2hrs	3hrs	6hrs	1hr	2hrs	3hrs	6hrs
										Zero Time								
0	Water	7.00	0.72	0.92	1.29	1.52	81.4	85.5	89.7	91.2	7.00	0.65	0.98	1.31	1.63	76.8	84.5	88.4	90.7
	$MgSo_4$	6.20	0.74	0.94	1.33	1.56	82.0	85.8	90.0	91.5	6.50	0.97	1.14	1.49	1.88	84.4	86.6	89.8	91.9
										Glass jar packages								
	Water	7.24	1.15	1.43	1.72	1.86	88.4	90.7	92.2	92.9	7.36	0.82	1.05	1.41	1.81	81.5	85.5	89.2	91.6
3	% change	+0.24	+59.7	+55.4	+33.3	+22.4	8.6	6.1	3.6	+1.9	+0.36	26.2	7.1	7.6	11.0	6.3	1.2	0.9	0.9
	$MgSo_4$	8.10	1.21	1.50	1.82	2.28	89.0	91.2	92.7	94.2	7.85	1.15	1.38	1.71	2.01	86.8	89.0	91.1	92.4
	% change	+1.9	+63.5	+59.6	+36.8	+46.2	8.5	6.3	3.0	+3.0	+1.35	18.6	21.1	14.8	6.9	2.8	2.8	1.4	0.5
	Water	8.32	1.25	1.85	2.03	2.18	89.3	92.7	93.5	93.9	7.99	1.16	1.32	1.65	1.92	86.8	88.5	90.8	92.1
6	% change	+1.32	+73.6	+98.9	+57.4	43.4	9.7	8.4	4.2	+3.0	+0.99	78.5	34.7	25.9	17.8	13.0	4.7	2.7	1.5
	$MgSo_4$	9.00	1.32	1.87	2.13	2.34	89.9	92.9	93.8	94.3	7.98	1.26	1.59	1.85	2.41	87.9	90.4	91.8	93.7
	% change	+2.8	+78.4	+98.9	+60.2	50.0	9.6	8.3	4.2	+3.1	+1.48	29.9	39.5	24.2	28.2	4.1	4.4	2.2	1.9
										Polypropylene packages								
	Water	8.25	1.22	1.39	1.80	1.97	89.1	90.4	92.6	93.3	8.24	1.03	1.16	1.52	1.99	85.2	86.9	90.0	92.4
3	% change	+1.25	+69.4	+51.1	+39.5	29.6	9.5	5.7	3.2	+2.3	+1.24	58.5	18.4	16.0	22.1	10.9	2.8	1.8	1.9
	$MgSo_4$	9.00	1.26	1.55	1.90	2.37	89.4	91.4	93.0	94.4	8.97	1.20	1.60	1.97	2.20	87.4	90.5	92.3	93.1
	% change	+2.8	+70.3	+64.9	+42.9	51.9	+9.0	6.5	3.3	+3.2	+2.47	23.7	40.4	32.2	17.0	3.6	4.5	2.8	1.3
	Water	8.67	1.46	2.04	2.12	2.33	90.9	93.5	93.7	94.3	8.94	1.17	1.34	1.94	2.20	87.0	88.6	92.2	93.1
6	% change	+1.67	+102.8	+121.7	+64.3	53.3	11.7	9.4	4.5	+3.4	+1.94	80.0	36.7	48.1	35.0	13.3	4.9	4.3	2.6
	$MgSo_4$	9.00	1.61	2.19	2.31	2.48	91.7	93.9	94.2	94.6	9.37	1.31	1.64	2.01	2.55	88.4	90.8	92.5	94.0
	% change	+2.8	+117.6	+132.9	+73.7	58.9	+11.8	+9.4	+4.7	+3.4	+2.87	35.1	43.9	34.9	35.6	4.7	4.8	3.0	2.3

On the other hand dehydrated Giza-3 beans previously blanched in either water or $MgSO_4$ and stored in glass jars showed also an increase in their rehydration properties of only 10.0 and 5.2%; 11.0 and 6.9%; 0.9 and 0.5%, respectively after 3 months and they reached 16.0 and 25.9%, 17.8 and 28.2%; 1.5 and 1.9%, respectively, after 6 months of storage, while for those stored in polypropylene packages they increased by 20.0 and 13.8%; 22.1 and 17.0%; 1.9 and 1.3%, respectively, after 3 months but 32.0 and 31.0%; 35.0 and 35.6; 2.6 and 2.3%, respectively, after 6 months of storage.

With both cultivars, dehydrated beans stored in polypropylene packages for periods up to 6 months exhibited a slight higher rehydration properties and also higher rate of increase in these properties than their corresponding dry beans packed in glass jar packages.

The highest rate of increase was attained upon soaking after 1 hr of test while the rate decreased gradually with increasing soaking time to 6 hrs.

Regardless of the type of packages utilized, the increase in rehydration properties after 6 months of storing dehydrated beans from both cultivars over that of their corresponding dry beans before storage (at sero time) was higher for those previously blanched in $MgSO_4$ than those previously blanched in water.

On the other hand, regardless of the type of packaging materials and kind of blanching treatment applied before drying, dehydrated Morgan beans stored for periods up to 6

months exhibited a slight higher rehydrated properties than their corresponding dehydrated Giza-3 beans.

In general, the reported rehydrated ratioes are much better or higher than those reported for some older Egyptian cultivars of green beans by Zayed (1965). In agreement to our results Zayed (1965) reported variation in rehydration ratioes between different green bean cultivars. However, in contrast to our findings he found that these values reduced gradually by storage up to 6 months.

Zayed (1965) reported lower and variable rehydration ratioes after 6 hrs of soaking for some green bean cultivars grown in Egypt, i.e. Mont-calme, contender, Seminole and Ideal where they were reduced from 1:4.0 to 1:3.2 from 1:4.8 to 1:4.5 from 1:3.8 to 1:3.3 and from 1:4.3 to 1:4.1, respectively, after 2 months and further reduced until reached about 1:3.1; 1:4.0; 1:3.0 and 1:4.0, respectively, after 6 months of storage in carton package. Dehydrated beans from different cultivars packed in tin cans showed also decrease in rehydration ratioes from 1:4.0 to 1:3.8; 1:4.8 to 1:4.7; 1:3.8 to 1:3.6 and 1:4.3 to 1:4.4, respectively, after 2 months then continued to reduce to 1:3.5; 1:4.3; 1:3.4 and 1:4.2, respectively after 6 months of storage.

The difference between our resuls and those of Zayed (1965) could be attributed to the fact that the new green bean cultivars (i.e. Morgan and Giza-3) have complete different chemical composition than that for the older cultivars, especially in crude fiber. High fiber content is well known

to result in poor rehydration properties as observed in case of celery (Neubert et al. 1968). Moreover, numerous predrying treatments and additives and better packaging also have contributed to rehydration characteristics of many dried products (Neumann, 1972). Method of rehydration influence the mount of water absorbed (Neubert, et al. 1966 & 1968).

4.2.3.3. Total acidity:

Dehydrated beans of both cultivars showed variable and gradual decrease in acidity with the elapsement of storage period. The rate of such decrease was greatly dependent on duration of storage period in function of type of blanching treatments before dehydration rather than the kind of green beans cultivars or the type of packaging materials. In other words, all dry beans treatments stored in either glass jars or polypropylene packages did not show significant differences among themselves in their acidity values which were decreased by months extending storage time. In addition, regardless of the type of packaging material and kind of blanching treatment applied before drying, stored dehydrated Morgan and Giza-3 beans had a nearly comparable values for acidity and also for the rate of change by storage. (Table 49).

Acidity of all stored dehydrated beans from all treatments of blanching and packaging ranged between 0.072% and 0.0645% after 3 and 6 months of storage, respectively, compared to the levels present before storage (at zero time), dehydrated stored beans (in either packages) processed from water and $MgSO_4$ blanched beans of both cultivars showed a tremendous decrease

Table (49): Effect of storage period (3-6 months) on acidity and ascorbic acids of dehydrated green beans of two Egyptian cultivars stored in two different packaging materials (on dry weight basis)[1].

Duration of storage period (month)	Blanching treatment	Green bean cultivars							
		Morgan				Giza-3			
		Acidity %	% decrease *	Ascorbic acid mg/100 g	% decrease	Acidity %	% decrease	Ascorbic acid mg/100 g	% decrease
0	W[2]	0.104	-	5.83	-	0.100	-	1.72	-
	M[3]	0.168	-	5.86	-	0.192	-	1.92	-
		Glass jar packages							
3	W	0.026	75.0	4.41	24.4	0.025	75.0	1.41	18.0
	M	0.113	32.7	4.42	24.6	0.117	39.1	1.40	27.0
6	W	0.020	80.8	3.29	43.6	0.020	80.0	1.32	23.2
	M	0.109	35.1	3.28	44.1	0.110	42.7	1.30	32.2
		Polypropylene packages							
3	W	0.026	75.0	4.43	24.0	0.029	71.0	1.41	18.0
	M	0.113	32.7	4.44	24.2	0.119	38.0	1.40	27.0
6	W	0.016	84.6	3.29	43.6	0.020	80.0	1.32	23.2
	M	0.110	34.5	3.30	43.7	0.110	42.7	1.30	32.2

1. Average of duplicate analysis.
2. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

* Compared to the level present at zero time.

in acidity averaging 73.0 and 35.7% respectively after 3 months as well as 81.4 and 38.8, respectively, after 6 months of storage. It's evident that, the rate of total decrease in acidity occurred by storage was considerably higher for water-blanched stored dehydrated beans than their corresponding $MgSO_4$-blanched counterpart.

Total acidity of dehydrated vegetables were reported to decrease after blanching and also after subsequent storage due to reaction between organic acids and sugars forming mono esters, such reaction was explained by Ingles and Renolds (1959).

4.2.3.4. Ascorbic acid content:

Dehydrated beans of both cultivars showed a variable gradual decrease in ascorbic acid content with the increase in storage period. However, the rate of such decrease was greatly dependent on storage period elapsed in function of the kind of processed green beans cultivar rather than the difference in type of packages utilized throughout the storage period. In other words, dry beans of each of the two cultivars stored in either glass jars or polypropylene packages did not show significant differences in their ascorbic acid values. Previous blanching treatment before dehydration only influenced the ascorbic acid content of stored Giza-3 beans but not that of Morgan beans.

All stored Morgan and Giza-3 beans treatments in either package tested had average ascorbic acid content of 4.41 and 1.41 mg/100 g, respectively, after 3 months as well as 3.29

and 1.31 mg/100 g, respectively, after 6 months of storage. Compared to the levels present initially before storage, the average decrease in both treatments of stored Morgan beans in ascorbic acid content was about 24.3% and 43.75% after 3 and 6 months of storage, respectively. Meanwhile, dehydrated Giza-3 beans prepared from water and $MgSO_4$ blanching treatments, and stored in either package showed a decrease in ascorbic acid content of about 18.0 and 27.0%, respectively, after 3 months and by 23.2 and 32.2%, respectively, after 6 months of storage.

There was no significant differences in ascorbic acid content by storage in the Morgan bean group between water-blanched and $MgSO_4$-blanched stored dry beans, probably because beans of both blanched treatments had comparable value initially at zero time before storage. In contrast, there was a certain variation within Giza-3 group according to the kind of previous blanching treatment applied before dehydration since the rate of total decrease in ascorbic acid content was slightly higher for $MgSO_4$-blanched than in water-blanched stored beans. The main reason for such difference during storage is attributed to presence of such difference initially at zero time of storage.

On the other hand, regardless of the type of packaging material and kind of blanching treatment before drying, stored Morgan beans exhibited a higher ascorbic acid content than the corresponding dehydrated Giza-3 beans by about (in average) 68.3% after 3 months and 59.9% after 6 months of storage probably because of the higher initial level of Morgan beans in ascorbic acid in the fresh state (by 21.6%, Table 45) and after blanching (by 43.9%, Table 45) and after drying just before storage (by 68.9%, Table 45).

Various investigators reported certain variable degrees of loss or destruction in ascorbic acid content during storage of fresh, freeze dried as well dehydrated vegetables including green beans. Vitamin C content of all fresh vegetable was reported by Watada et al. (1987) to decrease nonlinearly during storage. Green beans, unpackaged and kept at 20°C samples lost vitamin C most rapidly among the treatments, with 63% loss by the sixth day, while the packaged 20°C sample lost 54% by the sixth day, whereas both packaged and unpackaged samples at 10°C lost only 25% of the total content (Watada et al., 1987). With regard to freeze-stored green beans Philippon and Rovat-Mayer (1971) stated that ascorbic acid content decreased by 17% during freezing (at -20°C) and by 55% during 1 year of storage (at -20°C) of unblanched green beans. Muftugil and Yigit (1983) reported that there was a significant loss of ascorbic acid (70%) in unblanched green beans after 9 months of freeze-storage. Recently, Saleh (1991) found that ascorbic acid of frozen green beans was reduced by 74.81 to 24.96 without thawing (unblanched sample) and by 74.81 to 19.95 mg/100 g dry matter thawed at room temperature after 6 months of storage at -18°C.

With regard to dehydrated green beans, Morgan et al.(1949) mentioned that stored dehydrated vegetables retained from about 12-50% of their vitamin C after 6 months. Storage in Co_2 improved the retention of ascorbic acid. Comparing these data to our results (% retention was 70.5% losses was in the range between 18.0 to 32% in case of Giza-3 beans and 24.0 to 44.1% in case of Morgan beans) it appears that the rate of retention found in the present study under the same conditions is much better than those obtained by Morgan et al. (1949)

In agreement to our general findings Zayed (1965) indicated that ascorbic acid content in the old varieties of green beans grown in Egypt (Mont-Calme, Contender, Seminole, and Ideal), in general, was greatly influenced by dehydration than by freeze-drying and that the type of containers used during storage also influenced its stability.

Zayed (1965) reported that ascorbic acid content of Mont-Calme, Contender, Seminole and Ideal Egyptian varieties of green beans, respectively, was reduced during storage for 6 months by about 16.17 to 5.00; 36.93 to 13.11; 18.68 to 8.77 and 24.10 to 11.00 mg/100 g, respectively, when packed in carton during storage while it reduced by 16.17 to 7.10; 36.93 to 18.84; 18.68 to 8.81 and 24.10 to 16.00 mg/100 g, respectively when packed in tin cans.

The results obtained by Zayed (1965) revealed that ascorbic acid showed greater losses in stored dehydrated green beans packed in carton boxes. The percent retention of ascorbic acid after 6 months storage of dehydrated beans ranged from 30.92 to 53.61%, 32.96 to 56.18% and from 43.90 to 60.11% and while in case of freeze-dried beans the retention ranged from 54.16 to 62.17%, 53.61 to 67.23% and 64.45 to 78.36% when packed in carton boxes, polyethylene bags and tin cans, respectively. He also stated that the instability of ascorbic acid during storage was due to its chemical properties as being heat sensitive and easily oxidized.

Comparing these data to our results, it appears that the rate of retention found in the present study after storing the dry new

green cultivars,under the same conditions,is much better than those obtained by Zayed (1965) for the old-cultivated green beans varieties.

4.2.3.5. Change in colour:

The most obvious sign for deterioration of dehydrated products upon storage is the loss of their original colour of material after drying.

With the advancement of storage period of dehydrated beans stored in two different packages at room temperature, there was variable change in colour which was manifested in certain increase in degree of browning (alcohol extractable colour or colour index) and slight decrease in serum colour(water extractable), than those levels present in dehydrated beans at zero time. The change in colour was greatly dependent on period of storage in function of type of package material utilized throughout storage as well as the kind of previous blanching treatment and kind of stored dehydrated green beans cultivar (Table 50).

The degree of browning (O.D.)with all dehydrated stored treatments of Morgan and Giza-3 cultivars ranged between 0.151 to 0.171 (average 0.160) and 0.134 to 0.163 (average C.149), respectively, after 3 months, while ranged between 0.173 to 0.193 (average 0.183) and 0.176 to 0.198 (average 0.188), respectively, after 6 months of storage. The rate of increase in degree of browning (O.D) for water and $MgSO_2$ blanched-dehydrated Morgan beans stored in glass jars was in the order of 31.3 and 12.0%, respectively, after 3 months as well as 50.4 and 28.2%, respectively, after 6 months while with those

Table (50): Effect of storage period (3-6 months) on degree of browning and serum color of dehydrated green beans from two Egyptian cultivars stored in two different packaging materials.[1]

Duration of storage period (month)	Blanching treatment	Green bean cultivars							
		Morgan				Giza-3			
		Degree of browning[2]	% of increase*	Serum colour[3]	% of decrease	Degree of browning	% of increase	Serum colour	% of decrease
0	W[4]	0.115	-	56.7	-	0.116	-	56.0	-
	M[5]	0.142	-	43.0	-	0.135	-	49.8	-
		Glass jar packages							
3	W	0.151	31.3	41.0	27.7	0.134	15.5	47.8	14.6
	M	0.159	12.0	40.2	6.5	0.146	8.1	46.9	5.8
6	W	0.173	50.4	35.7	37.0	0.176	51.7	37.6	32.9
	M	0.182	28.2	31.3	27.2	0.188	39.3	36.9	25.9
		Polypropylene packages							
3	W	0.160	39.1	39.6	30.2	0.152	31.0	45.8	18.2
	M	0.171	20.4	37.8	12.1	0.163	20.7	43.8	12.0
6	W	0.184	60.0	30.9	45.5	0.190	63.8	34.3	38.8
	M	0.193	35.9	30.1	30.0	0.198	46.7	32.9	33.9

1. Average of duplicate analysis.
2. Measured as optical density.
3. Measured as % transmission.
4. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
5. M: Blanched in 0.5% $MgSO_4.H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

* Compared to the level present at zero time.

stored in polypropylene packages degree of browning (in O.D) increased by 39.1 and 20.4%, respectively, after 3 months and 60.0 and 35.9%, respectively, after 6 months of storage higher than the level present in corresponding samples at zero time. On the other hand, the rate of increase in degree of browning for water and $MgSO_4$ blanched dehydrated Giza-3 beans stored in glass jars was in the order of 15.5 and 8.1%, respectively, after 3 months as well as 51.7 and 39.3%, respectively, after 6 months while with those stored in polypropylene packages it was of 31.0 and 20.7%, respectively, after 3 months as well as 63.8 and 46.7%, respectively, after 6 months of storage.

In contrast to degree of browning data, serum colour (%) decreased by storage and thus showed lower levels compared to those of their corresponding dehydrated beans before storage (at zero time). Serum colour values (%) for all dehydrated stored treatments of Morgan and Giza-3 cultivars ranged between 37.8 to 41.0, (average 39.7) and 43.8 to 47.8 (average 46.1), respectively, after 3 months while they ranged between 30.1 to 35.7 (average 32.0) and 32.9 to 37.6(average 35.4), respectively, after 6 months of storage. The rate of decrease in serum colour values (%) for water and $MgSO_4$-blanched-dehydrated Morgan beans stored in glass jars was in the order of 27.7 and 6.5%, respectively, after 3 months as well as 37.0 and 27.2%, respectively, after 6 months, while with those stored in polypropylene packages, the decrease was of 30.2 and 12.1%, respectively, after 3 months and by 45.5 and 30.0%, respectively, after 6 months of storage compared

to the level present in corresponding samples at zero time. On the other hand, the rate of decrease in serum colour values (%) for water and $MgSO_4$-blanched-dehydrated Giza-3 beans stored in glass jars was in the order of 14.6 and 5.8, respectively, after 3 months as well as 32.9 and 25.9%, respectively, after 6 months, while with those stored in polypropylene packages the decrease was of 18.2 and 12.0%, respectively, after 3 months as well as 38.8 and 33.9%, respectively, after 6 months of storage.

Dehydrated beans of both cultivars stored for 3 or 6 months in polypropylene packages exhibited a slight higher degrees of browning and also a slight lower of serum colour values (%) than the corresponding dry beans stored in glass jar packages. Compared to the levels present in dehydrated beans before storage (at zero time), dehydrated beans processed from both cultivars of the water blanched group then stored in either package exhibited slightly lower degrees of browning and also a slight higher serum colour values than their $MgSO_4$-blanched counterpart. On the other hand, regardless of the type of packaging materials and also type of blanching treatment before drying, dehydrated Giza-3 beans stored for 3 months exhibited lower degree of browning and also a higher values for serum colour than thcse corresponding dry Morgan beans. Such observation was previously noticed after dehydration of both cultivars at zerc time (Table 45). However, after 6 months of storage, Giza-3 beans had higher values for both colour index and serum colour than those found for the corresponding Morgan beans.

The observation of the noted increase in degree of browning or decrease in serum colour by storage beans may be attributed to the chemical interaction occurred during this storage period (Soliman, 1969). Apparently, the effect of treating with $MgSO_4.7H_2O$ could play a good role in retarding such reactions which maintain the colour, El-Sherbiny and Rizk (1981), revealed that serum colour was decreased during storage beans for 6 months at room temperature due to non-enzymatic browning reaction and formation of hydroxy methyl furfural.

4.2.3.6. Pigments content:

With the advancement of storage period of dehydrated beans stored in two different packages at room temperature there was lower concentrations of the three pigments analysed compared to the levels present in their corresponding original dehydrated beans at zero time. Pigments content decreased in proportion to the increase in duration of storage in function of kind of stored cultivar of beans, the kind of blanching treatments and type of package utilized during storage. (Table 51 ; Figs 11 and 12).

Dehydrated beans prepared from either methods of blanching and stored in either packages tested had variable concentrations of chlorophyll-A, chlorophyll-B and carotenoids which ranged between 20.9 to 32.4, 15.9 to 22.8 and 22.6 to 35.6 mg/100 g (average 26.7, 19.4 and 28.9 mg/100 g), respectively, for Morgan group while ranged between 23.5 to 35.6, 14.8 to 17.9 and 24.1 to 36.5 (average 29.5, 16.4 and 30.1 mg/100 g), respectively, for Giza-3 group after 3 months

Egyptian cultivars stored in two different packaging materials (mg/100 g of dry weight)[1].

Duration of storage period (month)	Blanching treatments	Green bean cultivars											
		Morgan						Giza-3					
		Chloro-phyll-A	% of decrease *	Chloro-phyll-B	% of decrease	Carotenoids	% of decrease	Chloro-phyll-A	% of decrease	Chloro-phyll-B	% of decrease	Carotenoids	% of decrease
0	W[2]	27.37	-	18.15	-	28.20	-	29.79	-	16.80	-	30.38	-
	M[3]	35.60	-	24.55	-	37.09	-	36.40	-	18.70	-	37.50	-
		Glass jar packages											
3	W	22.39	18.20	16.36	9.90	23.50	16.70	25.48	14.50	15.90	5.40	25.60	15.70
	M	32.40	8.99	22.80	7.13	35.60	4.02	35.60	2.20	17.90	4.30	36.50	2.70
6	W	19.92	27.20	15.04	17.10	19.98	29.10	22.49	24.50	13.87	17.40	22.90	24.60
	M	28.20	20.80	20.50	16.50	32.40	12.60	31.86	12.50	16.00	14.40	33.60	10.40
		Polypropylene packages											
3	W	20.90	23.60	15.90	12.40	22.60	19.90	23.50	21.10	14.80	11.90	24.06	20.80
	M	31.09	12.70	22.48	8.40	33.90	8.60	33.50	8.00	16.80	10.20	34.20	8.80
6	W	18.70	31.70	13.80	24.00	18.83	33.20	20.01	32.80	12.96	22.90	21.01	30.80
	M	26.90	24.40	19.70	19.80	30.50	17.80	29.60	18.70	15.00	19.80	32.90	12.30

1. Average of duplicate analysis.
2. W = Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M = Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

* Compared to the level present at zero time.

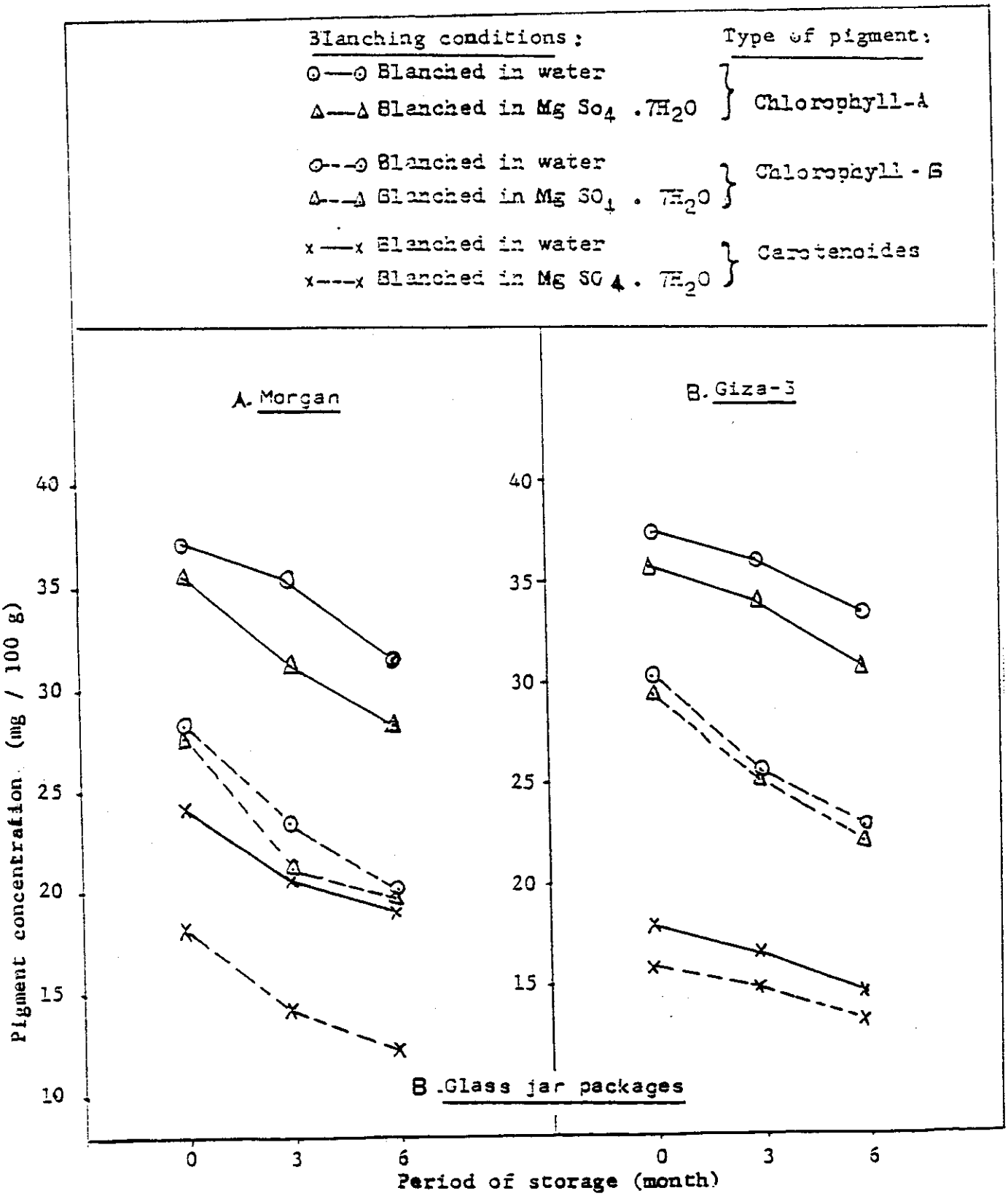


Fig.(11): Comparative presentation for pigments content (1, chlorophyll-A; 2, chlorophyll-B; 3, carotenoids) of dehydrated green beans obtained from two different cultivars (A., Morgan; B.,Giza-3) stored in two different packages (A, polypropylene bags; B, glass jars) for periods of 3 to 6 months.

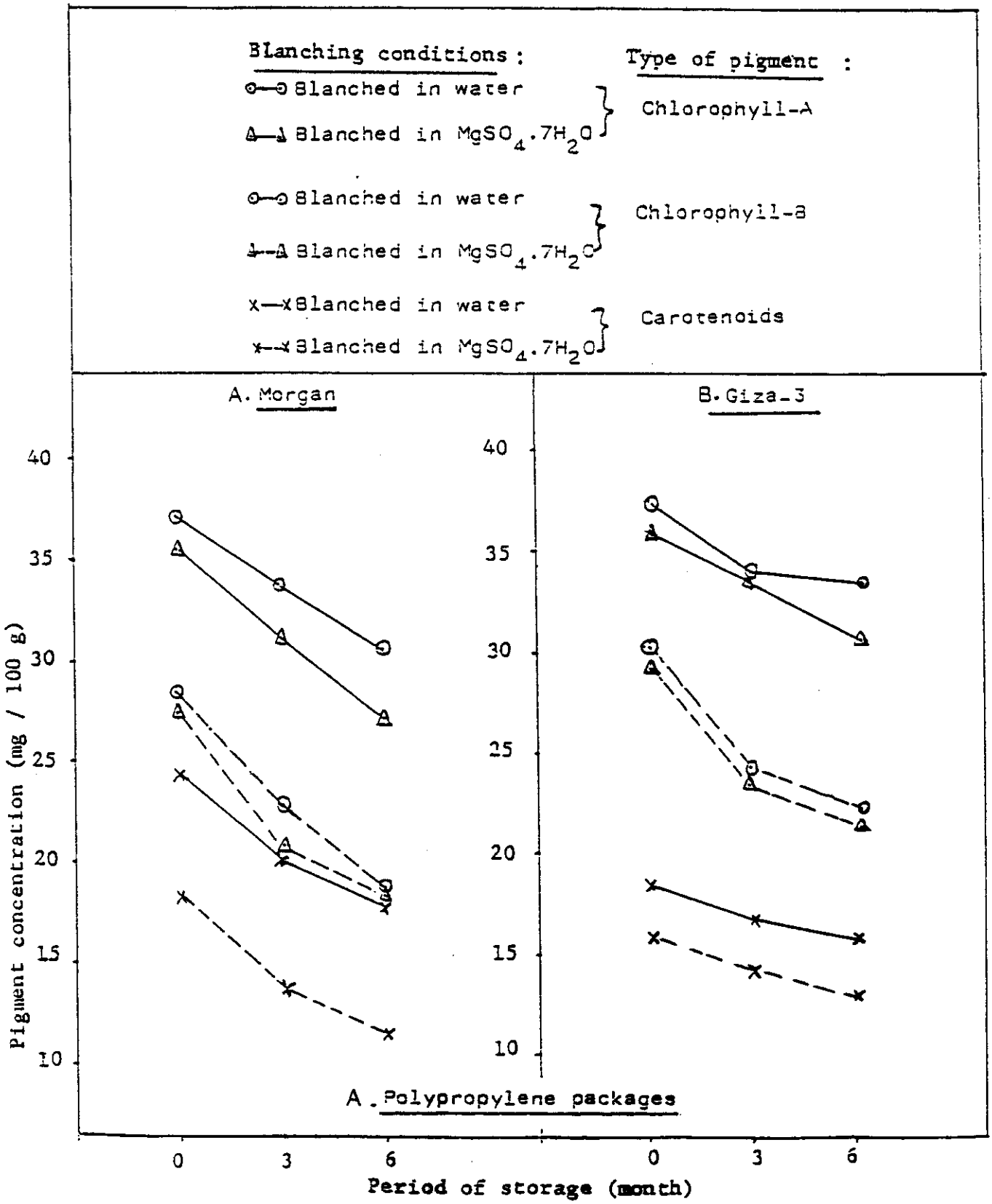


Fig.(12): Comparative presentation for pigments content (1, chlorophyll-A; 2, chlorophyll-B; 3, Carotenoids) of dehydrated green beans obtained from two different cultivars (A., Morgan; B., Giza-3) stored in two different packages (A, polypropylene bags; B, glass jars) for periods of 3 to 6 months.

while they ranged between 18.7 to 28.2, 13.8 to 20.5 and 18.8 to 32.4 (average 33.4, 17.3 and 25.4 mg/100 g), respectively, for Morgan beans as well as 20 to 31.9, 13 to 16 and 21 to 33.6 (average 26, 14.5 and 27.6 mg/100 g), respectively, for Giza-3 group after 6 months of storage.

In case of dehydrated Morgan beans stored in glass jars of the water or $MgSO_4$-blanched groups, the concentration of chlorophyll-A, B and carotenoids decreased by 18.2, 9.9 and 16.7%, respectively, vs. 8.99, 7.13 and 4.02%, respectively, after 3 months while decreased by 27.2, 17.1 and 29.1%, vs. 20.8,16.5 and 12.6%,respectively, after 6 months of storage On the other hand, concentration of the three pigments, respectively, of the corresponding water and $MgSO_4$-blanched groups stored in polypropylene bags, decreased by 33.6, 12.4 and 19.9%, respectively, vs. 12.7, 8.4 and 8.6%, respectively, after 3 months while decreased by 31.7, 24.0 and 32.2%, respectively, vs. 24.4, 19.8 and 17.8, respectively, after 6 months of storage.

On the other hand, dehydrated Giza-3 stored in glass jars of the water-blanched and $MgSO_4$-blanched groups,the concentration of chlorophyll-A, B and carotenoids decreased by 14.5, 5.4 and 15.7%, respectively, vs. 2.2, 4.3 and 2.7%, respectively, after 3 months while decreased by 24.5, 17.4 and 24.6%, respectively, vs. 12.5, 14.4 and 10.4%, respectively, after 6 months of storage, while concentration of the three pigments, respectively, of the corresponding water and $MgSO_4$-blanched stored Giza-3 beans in polypropylene bags decreased by 21.1, 11.9 and 20.8%, respectively, vs. 8.0,

10.2 and 8.8%, respectively, after 3 months while decreased by 32.8, 22.9 and 30.8%, respectively, vs. 18.7, 19.8 and 12.3%, respectively, after 6 months of storage.

Regardless of the kind of green beans cultivar and also type of packaging material utilized throughout the storage period up to 6 months, the rate of total decrease in plastid pigments content occurred by storage was higher for water-blanched stored dehydrated beans than their c orresponding $MgSO_4$-blanched counterpart. Such observation was previously noticed directly after blanching and dehydration of both cultivars at zero time (Table 45). Furthermore. with both cultivars, dehydrated beans stored in glass jars for periods up to 6 months exhibited higher plastid pigments content than their corresponding dry beans stored in polypropylene packages. In addition, regardless of the type of blanching and also packaging materials, stored dehydrated Morgan beans exhibited lower amounts of pigments (chlorophyll-A and carotenoids) than those of the corresponding dehydrated Giza-3 beans, with the exception of chlorophyll-B. The observed decrease in contents of the three pigments throughout storage for period of 3 to 6 months is in agreement with the reports of Feaster (1960) and Richardson et al. (1961) that chlorophyll-A, B, decreased after blanching and dehydration and they attributed such decrease to the increase in total acidity, while the decrease in total carotenoids contents was attributed to the oxidation of these pigments during storage.

The found variation in pigment concentration of stored green beans in function of type of previous blanching pre-treatment and also type of package during storage are in close

agreement with data reported by various investigators for either stored dehydrated or frozen stored green beans. Dutton (1943) found that the rate of destruction of carotene was largely independent of moisture content and greatly dependent upon storage atmosphere. The percentage losses of carotene and percentage conversion of chlorophyll during storage of dehydrated spinach of different moisture contents stored in various atmospheres increased with the increase in storage period. The loss and conversion ranged between 3-74% and 5-100%, respectively, depending on moisture level in product and atmosphere of storage, respectively. In Egypt, Zayed (1965) found that the destruction of the chlorophyll pigments due to its conversion to pheophytin during storage impairs the green colour of the dehydrated and freeze-dried beans. The percent chlorophyll retention in dehydrated and freeze-dried beans ranged from 73.93 to 83.09%, 76.74 to 90.30% and 77.77 to 85.85% for the first and 90.07 to 90.30%, 89.20 to 93.88% and 91.42 to 95.18% for the latter when packed in carton boxes, polyethylene bags and tin cans, respectively, during 6 months of storage while, the percent retention of carotene after 6 months storage was in the range of 75.06 to 84.30%, 79.02 to 89.44% and 83.40 to 92.48%, respectively in the dehydrated beans and was 81.27 to 88.88%, 81.57 to 92.77% and 86.67 to 91.27%, respectively, for the freeze-dried beans .

Zayed (1965) reported that chlorophyll and carotene content of the dehydrated products prepared from the old-cultivated varieties of green beans grown in Egypt i.e Montcalme, Contender, Seminole and Ideal were reduced during

storage for 6 months by about 63 to 46.58 and 2.2 to 1.9; 50.6 to 40 and 2.5 to 1.9; 52.66 to 33.60 and 2.2 to 1.6 and 49.3 to 43.7 and 2.6 to 2.1 mg/100 g, respectively. It is apparent that the rate of decrease in chlorophyll content after six months of storage for the dry new green bean varieties found in the present study is lower than the rate of decrease reported by Zayed (1965) for dry beans of the old-cultivated varieties and vise versa with respect for carotein content.

With regard to the effect of blanching pretreatment on pigment content of stored dehydrated green beans, Foda et al. (1967) investigated the effect of dehydration process and packaging on quality of stored green beans. The retention percentages of chlorophyll were 34.1, 35.3 and 41.6% for water blanched, steam-blanched and sodium bicarbonate blanched dehydrated beans, respectively. A continuous decrease in chlorophyll content was observed during storage of dry beans for 6 months in polypropylene bags.

The effect of storage on pigment content is obvious whether green beans were either stored after dehydration or freeze-stored. Walker (1963) demonstrated that two forms of chlorophyll degradation occur in stored frozen green beans. The first one is the conversion of chlorophyll to pheophytin, and the second results in destruction of chlorophylls and pheophytins.

Hamed (1980) found that storage of green peas for 28 days at low temperature (1-2°C) led to a decrease in chlorophyll-A from 42.52 to 19.33 mg/100 g; chlorophyll-B from 24.29 to 9.41 mg/100 g dry matters and total chlorophyll from 67.11 to 28.74 mg/100 g dry matter. Furthermore, Saleh (1991) indicated that

during storage at -18°C, the chlorophyll-A and B of unblanched green beans decreased after 6 months of frozen storage from 29.73 to 25.74 and 12.28 to 8.99 mg/100 g dry matter and similar trend was found in water blanched green beans. The previous trend is in accordance with the fact that chlorophyll and carctenoids could be degraded as a result of the activity of certain enzymes. The mechanism of the enzymatic degradation depends on the type of enzymes and the conditions under which these enzymes are active (Saleh, 1991).

4.2.3.7. Total and reducing sugars:

Dehydrated beans processed from both cultivars showed a variable decrease in total and reducing sugars with the advancement of storage period. The magnitate of such decrease was dependent on period of storage in function of kind of blanching treatment and type of package material utilized throughout storage as well as cultivar of processed stored beans (Table 52) All stored dehydrated Morgan beans had total and reducing sugars in the range between 11.32 to 12.02% (average 11.47%) and 9.18 to 9.67% (average 9.44%), respectively after 3 months and between 10.09 to 10.32% (average 10.22) and 8.40 to 8.99% (average 8.70%), respectively, after 6 months of storage, however, dehydrated Giza-3 beans ranged between 11.47 to 12.06% (average 11.77%) and 10.35 to 10.94% (average 10.71%), respectively, after 3 months and between 11.0 to 11.22% (average 11.11%) and 9.72 to 10.01% (average 9.87%), respectively, after 6 months of storage.

Compared to the levels present in dehydrated beans before storage (at zero time), dehydrated Morgan beans stored in glass

Table (52): Effect of storage period (3-6 months) on sugar content of dried green beans stored in different packaging materials. (g/100 g of dry weight)[1]

Duration of storage period (month)	Blanching Treatment	Variety of green bean					
		Morgan			Giza-3		
		Sugar content					
		Reducing sugars	Total sugars	Average	Reducing sugars	Total sugars	Average
0	W[2]	9.95	12.72	11.34	11.96	13.90	12.93
	M[3]	10.75	13.79	12.27	12.47	14.10	13.29
		Glass jar packages					
3	W	9.48	11.37	10.43	10.83	11.88	11.36
	M	9.67	12.02	10.85	10.94	12.06	11.50
6	W	8.82	10.24	9.53	9.76	11.12	10.44
	M	8.99	10.32	9.66	9.86	11.22	10.54
		Polypropylene packages					
3	W	9.18	11.32	10.25	10.35	11.47	10.91
	M	9.44	11.95	10.70	10.71	11.65	11.18
6	W	8.40	10.09	9.25	9.72	11.00	10.36
	M	8.60	10.24	9.42	10.01	11.12	10.57

1. Average of duplicate analysis.
2. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

jars showed a decrease in total and reducing sugars of about 10.6 and 4.7%, respectively, after 3 months for water-blanched samples, and of 12.8 and 10.0%, respectively, for $MgSO_4$-blanched while with those stored in polypropylene packages the decrease was of 11.0 and 7.7%, respectively, for water-blanched and of 13.3 and 12.2%, respectively, for $MgSO_4$-blanched. After six months, such decrease in beans stored in glass jars reached 19.5 and 11.4%, respectively, for water-blanched beans and of 25.2 and 16.4%, respectively, for $MgSO_4$-blanched beans while with those stored in polypropylene packages the decrease was of 20.7 and 15.6%, respectively for water-blanched and of 25.7 and 20.0, respectively, for $MgSO_4$-blanched beans.

On the other hand, dehydrated Giza-3 beans previously blanched by either of the two treatments and stored in glass jars showed an average decrease in total and reducing sugars by about 14.5 and 10.9%, respectively, after 3 months and by 20.2 and 19.7%, respectively, after 6 months of storage, while with those stored in polypropylene packages the average decrease was of 17.5 and 13.8%, respectively, after 3 months and of 21.0 and 19.2%, respectively, after 6 months of storage.

Compared to the levels present before storage (at zero time), there was no significant variation in the Giza-3 stored group between those previously blanched in water and those blanched in $MgSO_4$ before dehydration with regard to total and reducing sugar contents. In contrast, there was a certain variation within the stored Morgan group according to the kind of previous blanching treatment applied before dehydration. Therefore, the rate of decrease in total and reducing sugars

content after storing dry Morgan beans for periods up to 6 months in either of the two packaging materials was slightly higher for those dehydrated beans previously blanched in water than those blanched in $MgSO_4$ before dehydration.

With both cultivars, dehydrated beans stored in glass jars for periods up to 6 months exhibited a slight higher total and reducing sugars content than their corresponding dry beans stored in polypropylene packages. However, regardless of the type of packaging material and previously blanching treatment, dehydrated Giza-3 beans stored for 3 or 6 months exhibited slight higher amounts of total and reducing sugars than those for the corresponding dried Morgan beans.

In agreement to our data, Saleh, (1991) found that reducing and total sugars of blanched and unblanched green beans (Giza-3 variety) were decreased by 10.14 to 7.27 and 10.97 to 8.89%, respectively after 6 months of storage at -18°C (g/100 g dry matter) in blanched beans while increased by 10.71 to 10.87 and 11.24 to 15.48%, respectively, in unblanched beans. He also noticed that total sugars of green beans showed a general decrement trend due to blanching, this may be due to the conversion effect in addition to the leaching of sugars in the blanching solution.

4.2.3.8. Enzyme activities after storage:

Activities of polyphenol oxidase and peroxidase enzymes were measured in stored dehydrated green bean of both cultivars in glass jars (Table 54) and polypropylene packages (Table 55) at room temperature for 9 months. Enzyme activities decreased by storage and the rate of such decrease was in function of kind of previous blanching treatments and kind of green beans cultivar of stored beans as well as type of packaging utilized throughout storage.

1) Activities in stored beans in function of processing:

All stored dehydrated Morgan beans previously blanched in water and $MgSO_4$ showed a decrease in PPO enzyme activity than the level present before storage(at zero time)by about 65.5 and 62.4%, respectively, upon storage in glass jars as well as 44.2 and 39.0%, respectively, upon storage in polypropylene packages and similarly, POD enzyme activity decreased by 70.8 and 75.1%, respectively, and by 49.2 and 42.9%, respectively. On the other hand, in dehydrated Giza-3 beans, PPO activity decreased by about 52.5 and 55.2%, respectively upon storage in glass jars and by 45.0 and 52.0%, respectively, upon storage in polypropylene packages while POD enzyme activity decreased by 75.2 and 70.1%, respectively, upon storage in glass jars and by 50.9 and 36.7%, respectively, upon storage in polypropylene packages.

2) Activities in stored beans in function of cultivar:

Enzymatic activities of stored Morgan beans were higher than those in stored Giza-3 beans, regardless of packaging material and also blanching treatment before dehydration and storage.

Table (53): Polyphenol oxidase and peroxidase enzyme activity in fresh, blanched and dehydrated green bean cultivars.[1]

Cultivars	Fresh state	After blanching treatments				After dehydration at 65°C for 6 hrs.							
		Enzyme activity[2]		% residual activity		Enzyme activity			% residual enzyme activity				
									From fresh state			From blanched state	
		W[3]	M[4]	W	M	No blanching	W	M	No blanching	W	M	W	M
						Polyphenol oxidase							
Morgan	34.47	14.61	10.28	42.38	29.82	28.91	8.92	5.050	83.87	25.87	14.65	61.05	49.12
Giza-3	10.78	6.55	4.20	60.76	38.96	6.80	4.84	2.810	63.07	44.89	26.06	73.89	66.90
						Peroxidase							
Morgan	46.74	9.65	8.23	20.64	17.60	22.36	3.94	2.680	47.83	8.43	5.73	40.82	32.56
Giza-3	14.18	7.27	3.32	51.26	23.41	6.87	3.46	0.996	48.44	24.40	7.02	47.59	30.00

1. Average of three trials. 2. u/min/ml.
3. W: Blanched in water at 80°C for 4 min.
4. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min.

Table (54): Polyphenol oxidase and peroxidase enzyme activity present in dehydrated green bean stored in glass jar packaging for 9 months.[1]

Cultivars	PH of dehydrated	Enzyme activity[2]		% residual activity from that of the fresh state		% residual activity from that of blanched state		% residual activity from that of dehydrated state			
								No blanching		Blanching	
		W[3]	M[4]	W	M	W	M	W	M	W	M
Polyphenol oxidase											
Morgan	5.12	3.080	1.900	8.94	5.51	21.08	18.48	10.65	6.57	34.53	37.62
Giza-3	5.24	2.300	1.260	21.34	11.69	35.11	30.00	33.82	18.53	47.52	44.84
Peroxidase											
Morgan	5.12	1.150	0.666	2.46	1.42	11.92	8.09	5.14	2.98	29.19	24.85
Giza-3	5.24	0.859	0.298	6.05	2.10	11.82	8.98	12.50	4.34	24.83	29.92

1. Average of three trials. 2. u/min/ml.

3. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

4. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

Table (55): Polyphenol oxidase and peroxidase enzyme activity in dehydrated green beans stored in polypropylene packaging for 9 months.[1]

Cultivars	Enzyme activity[2]		% residual activity from that of the fresh state		% residual activity from that of blanched state		% residual activity from that of dehydrated state			
							No blanching		Blanching	
	W[3]	M[4]	W	M	W	M	W	M	W	M
Polyphenol oxidase										
Morgan	4.98	3.080	14.45	8.94	34.09	29.96	17.23	10.65	55.83	60.90
Giza-3	2.66	1.350	24.68	12.52	40.61	32.14	39.12	19.85	54.96	48.04
Peroxidase										
Morgan	2.00	1.530	4.28	3.27	20.73	18.59	8.94	6.84	50.76	57.09
Giza-3	1.70	0.630	11.99	4.44	23.38	18.97	24.75	9.17	49.13	63.25

1. Average of three trials. 2. U/min/ml.
3. W: Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
4. M: Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

4) Activities in function of type of package during storage:

Regardless of the kind of green bean cultivars and type of blanching treatment, polypropylene-stored beans had higher PPO and POD enzyme activities than the corresponding glass jar-stored beans. The higher PPO enzyme activity in polypropylene-stored Morgan and Giza-3 beans than the corresponding glass jar-stored beans was by 38.2 and 13.5%, respectively, for water-blanched dehydrated beans and by 38.3 and 6.7%, respectively, for $MgSO_4$-blanched beans, and similarly POD enzyme activity was higher by 42.5 and 49.5% respectively for stored water-blanched as well as 56.5 and 52.7%, respectively. It appeared that the difference in PPO activity due to type of package during storage is more pronounced in Morgan beans than in Giza-3.

The finding of the present study of lower POD activity after storing dehydrated green beans for 9 months is in contrast of the various reports that sometimes peroxidase activity is regenerated after inactivation by heat treatment. Regeneration of peroxidase was reported to take place after one to two days at room temperature and may take several months at -18°C (Pinsent, 1962). In addition, Zouiel and Esselen(1959)found that the regeneration of green beans and turnip peroxidase occurred when heated samples were stored at room temperature for 24 hrs.

However, there are many factors which affects regeneration of POD original activity such as heating conditions pH and storage temperature (Saperes and Nickerson, 1962), severity of heat treatment applied, and the conditions at which the

inactivated system has been kept prior to regeneration (Chichester et al.,1969).

Saad (1989) stressed upon the presence of slight percentage of PPO enzyme not destroyed by heat treatment of blanching and drying that generally considered as negligible i.e heat resistant isoenzymes. These may, on the one hand, give rise to interior browning in the dried tested samples and, on the other promote, in some products, reactivation of the enzymes. These findings were in agreement with those of Martinez et al.,(1965).

On the other hand during prolonged storage activity of PPO enzyme was reported to be slowly lowered even in the frozen state and this loss is irreversible and is accompanied by contemporaneous oxidation of the cuprous copper to cupric copper (Shallenberger and Jansen, 1977).

4.2.3.9. Total bacterial count (TBC):

The bacterial count of green beans was carried out on freshly prepared dehydrated beans before and after storage in two different packages for 6 months at room temperature. Data from (Table 56) showed slight increase in TBC in proportion to the increase in period of storage and in function of the kind or previous blanching treatments , kind of green bean cultivars as well as type of packaging utilized throughout storage period.

Compared to the levels present in dehydrated beans at zero time, dehydrated Morgan beans previously blanched in water and $MgSO_4$ and stored in glass jars and polypropylene packages showed higher TBC by 2.5 and 4.8% and by 5.0 and 9.5%, respectively, after 3 months as well as 19 and 20% and by 20 and 23.8%, respectively, after 6 months of storage. However, the TBC of

Table (56): Total count of bacteria present in dehydrated green beans of two Egyptian cultivars stored for (3-6 months) in two different packaging materials.[1]

Duration of storage period (month)	Blanching treatment	Green bean cultivars			
		Morgan	% increase*	Giza-3	% increase
0	W[2]	4.0×10^1	-	3.3×10^1	-
	M[3]	2.1×10^1	-	2.0×10^1	-
		Glass jar packages			
3	W	4.1×10^1	2.5	3.5×10^1	6.1
	M	2.2×10^1	4.8	2.2×10^1	10.0
6	W	4.4×10^1	10.0	3.8×10^1	15.2
	M	2.5×10^1	19.0	2.3×10^1	15.0
		Polypropylene packages			
3	W	4.2×10^1	5.0	3.8×10^1	15.2
	M	2.3×10^1	9.5	2.4×10^1	20.0
6	W	4.8×10^1	20.0	3.9×10^1	18.2
	M	2.6×10^1	23.8	2.5×10^1	25.0

1. Average of duplicate analysis.
2. W = Blanched in water at 80°C for 4 min and dehydrated at 65°C for 6 hrs.
3. M = Blanched in 0.5% $MgSO_4.7H_2O$ at 80°C for 4 min and dehydrated at 65°C for 6 hrs.

* Compared to the level present at zero time.

dehydrated Giza-3 beans increased by only 6.1 and 10.0% and by 15.2 and 20.0%, respectively, after 3 months as well as 15.2 and 15% and by 18.2 and 25.0%, respectively, after 6 months of storage.

Compared to the levels present before storage (at zero time), the rate of increase in TBC of dehydrated beans from both cultivars stored in either of the two packages was higher in the $MgSO_4$-blanched stored beans than in the water-blanched group. In addition, regardless of the type of blanching and packaging materials, stored dehydrated Morgan beans exhibited higher TBC than those of the corresponding stored dry Giza-3 beans. Meanwhile, stored dehydrated beans from both cultivars in polypropylene packages exhibited considerable tremendous higher TBC (by about 100%) than those of stored in glass jar packages. This could be attributed to the difference in the nature of the two packages, especially permeability.

Blanching in either water or $MgSO_4$ at 80°C for 4 min and the applied dehydration conditions were successful in controlling TBC of dehydrated beans before storage and also during the subsequent storage although Tolba (1985) reported that TBC was increased slowly during storage of dried green beans (variety lima). Roberts and McWeeny (1972) and Downen (1977) prefered blanching of green beans in boiling water containing sulfur compounds as such treatment caused reduction of the microbial load.