Minufiya J. Agric. Res. Vol. 33 No.3: 673 - 687 (2008)

THE EFFECT OF DRYING METHODS AND STORAGE ON COLOR ATTRIBUTES OF PEACH, TOMATO AND MEDICAL HERB PRODUCTS

H. A. Eissa and G. F. Bareh
Food Technology, National Research Centre, 12622 Cairo, Egypt
(Received: Apr. 9 , 2008)

ABSTRACT: *Two drying methods (convectional and solar) were applied for producing slices and sheets of peach and tomato as well as medical herb products (Sage and Thyme). The final products were stored at room temperature up to 12 months. The color characteristic was evaluated using Hunter Lab. The obtained results represented color changes of slices and sheet of both tomato and peach as well as medical herb (sage-salvia and thymus) during air-oven and sun drying. Air convective drying was carried out at 70°C 1.5 m/s and sun drying. Color of the material undergoing drying was measured with Hunter lab colorimeter and expressed in the CIE system with chromaticity coordinates L*, a* and b*. It has been found that drying affected color of the investigated fruits. Luminance increased and chromaticity coordinates moved toward whiteness until specific water content was reached. Thereafter, L*-values decreased and a* and b* coordinates moved towards the color of the raw material. It is suggested that changes of color of drying material were due to removal of water, substitution of water by air and deformation of surface (shrinkage) during drying process. The difference was depended on the source of investigated material. Also, it could be concluded that solar energy drying was superior.*

Key words: *tomato, peach, medical herb, sage-salvia, thymus, convective air-oven, solar energy, drying, color.*

INTRODUCTION

Color of food is mostly due to the presence of natural coloring stuffs material present. Moreover color can also be changed by enzymatic and non-enzymatic reactions.

The optical characteristics of foodstuffs are complex and depend on chemical composition and surface texture. Any color can be matched by mixing together suitable proportions of three primary lights, that is red, blue and green. Expressing each color proportion in a mixture as a fraction, a color space is transformed to the two dimensional chromaticity diagram. Hence, coordinates x and y define position of a color on the chromaticity diagram. An alternative method of determining the color of fruit is measuring surface reflectance instrumentally. Included in these are the tristimulus colorimetric method, which locate a color as a point in three-dimensional space using, in the case of the Hunter Color Meter, the L (white-black), A (green-red) and B (blue-yellow) axes (Francis, 1980). Sulfiting agents have been the conventi chemicals to inhibit browning reactions in fruits and vegetables. However, there have been concerns over the possible harmful effects of sulfiting agents on sensitive consumers, particularly asthmatics. Consequently, the need for safer anti-browning agents has been sought to prevent or minimize characteristic enzymatic and non-enzymatic browning of fruits and vegetables. Several alternatives have been proposed to reduce browning in fresh and processed fruits and vegetables (Sapers, *et al*, 1989; Ponting, *et al*, 1992).

Preserving food by drying is the oldest method of food preservation. Sun drying of fruits and vegetables was practiced before biblical times by Chinese, Hindus, Persians, Greeks and Egyptians. Dried foods have the advantages of taking up very little space, not requiring refrigeration and providing variety to the diet. Barroca *et al.*, (2006) investigated color changes of pear during sun drying. Yahya *et al.*, (2000) showed that the color quality attributes of the dried samples were high. Color attributies indicated severe oxidative heat damage during drying of tomato by Zanoni *et al.*, (1998). However there is no report on color change of fruits and vegetables during drying caused principally by physical modifications of structure and surface of the dried material (Andritsos *et al.*, 2003 and Guadalupe and Diane, 2006).

Therefore, the present investigation was our target for saving foodstuffs in high quality with good sensory properties and an attractive color during storage at room temperatures (20 °C) for 6 – 12 months. The main purpose of this study was to evaluate pre-treatments (sodium metabi-sulphite), drying (solar energy) and air-oven dehydration on color characteristics and sensory attributes of tomato, peach and two medical herbs. The color change of the selected fruits subjected to convective air dehydration and sun drying was aimed, as well as that color of rehydrated material.

MATERIALS AND METHODS

Raw materials

Two cultivars of peach fruit (*Prunus persica*), as free stone peach (Sheikh Zowaied) cultivar and Clingstone peach (Earli grand) cultivar, plus tomato (*Lycopersicon esculatum*) were collected from the farms at North Sinai, Governorate, Egypt. Two medical herbs including Sage (*Salvia officinialis* L.) and Thyme (*Thymus vulgaris* L.) were collected also from North Sinai, Governorate, Egypt.

Dried Products:

Preparation of peach slices

Freestone and Clingstone peach fruits were washed, cut into halves and destined. The fruits halves were steamed at 90-95°C for 5 minutes, and then the samples were soaked in 0.2% sodium metabisulphite solution for 5 minutes. The samples were spread at one layer over the drying methods trays at 50 °C for 24-36 hours. The dried samples were packed in polyethylene bags, then sealed and kept in deep freeze for use afterwards.

Preparation of peach sheets

The fruits were washed, cut into halves, destined, blanched and blended, filtered through sieves, then 0.2% sodium metabisulphate solution was added Purée was stirred thoroughly and finally transferred to trays for drying in oven at 50 °C for 36-48 hours. The sheets were packed in polyethylene bags then sealed and kept in deep freeze for 12 months.

Processing and concentration of tomato:

The fresh fruits were washed with spray washer. Then, the tomato was divided into equal parts, the first for slices and the second for sheets, was squeezed for juice. Hot break tomato juice was concentrated under vacuum at 60 °C, till the total soluble solids reached 12-13%. Prepared tomato puree was divided into two equal parts, the first part for drying by solar energy (Fig. 1) and the second part for oven drying.

Drying process

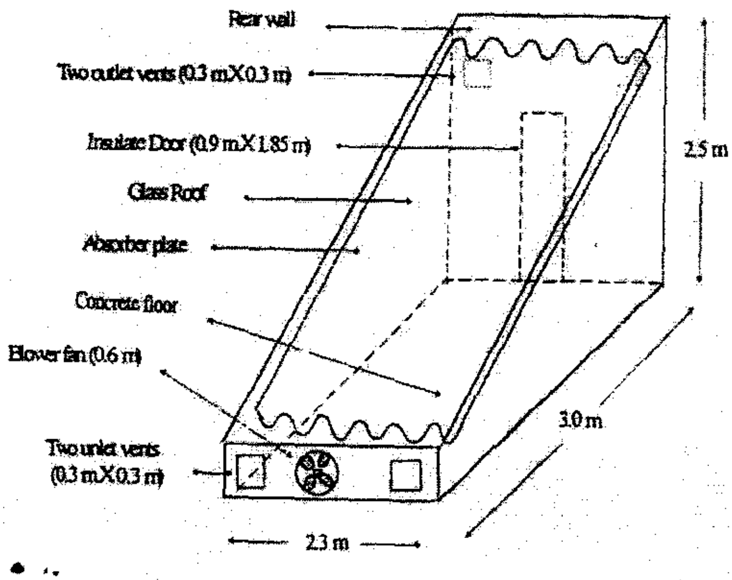


Fig. (1) : Construction of the Pilot Solar Drier

A- Sheets

Dried tomato sheets were prepared from tomato puree (12-13% T.S.S.) by spreading on stainless trays and lift under solar energy drier designed and equipped with thermostat for temperature control .

B- Slices

Tomato fruits were cut into halves then blanched by direct vapor for 1-2 min, then dipped into 0.2% solution of metabisulphite for 5 min after which they were spreaded on stainless trays and subjected to drying in solar drier and oven drier at 50 °C. Both sheets and slices were packed in polyethylene bags, then sealed and kept in deep freeze for use afterwards.

Medical herbs

Both thyme and sage were immediately washed and divided into three parts, the first part was kept as it is fresh, the second part was dried by oven at 40°C, while the third one was dried by solar energy drier at 50-60 °C. The three parts were analyzed for color characteristics and sensory attributes. The samples were packed in polyethylene bags, then sealed and kept at room temperature (25 °C).

Color assessment: -

Color was assessed using spectro-colorimeter (Tristimulus Color Machine) with the CIE lab color scale. This color assessment system is based on the Hunter L*-, a*- and b*- coordinates. L*- representing lightness and darkness, + a*- redness, -a*- greenness, + b*- yellowness and - b*- blueness (Hunter, LabScan XE – Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) (Sapers and Douglas, 1987). The Hue (H)* and Chroma (C)* was calculated according to the method of Palou *et al,* (1999) as follows:

$$H^* = \tan^{-1}[b^*/a^*] \quad \text{.........(1)}$$

$$C^* = \sqrt{a^2 + b^2} \quad \text{.........(2)}$$

RESULTS AND DISCUSSION

Effect of storage period on the characteristic and parameters color of dried tomato products:

Tristimulus reflectance colorimetry (measuring the reflectance L*, a* and b* values) was used to follow the extent of browning in fruit and change of color in food (Robertson and Reeves, 1981). However, differences between initial and final tristimulus values were better indices of enzymatic changes than tristimulus values themselves (Sapers and Douglas., 1987). The results in figures (2-4) showed the effect of storage for 6 months time on dried tomato products graphically. These figures illustrated the clear changes in color of dried tomato products in terms of redness a*, yellowness b* and lightness L* during 6 months of storage.

The a*- value of the dried tomato products was found to be 13.34, 15.18, 11.76 and 13.53 in tomato solar sheet, oven sheet, solar slices and oven slices compared to 13.06, 12.53, 16.63 and 15.0 after 6 months storage at room temperature, respectively as shown in Fig 1. Meanwhile, a*-values in tomato oven or solar tomato sheets were not changed during storage at room temperature (25°C) for 12 months, while they increased in tomato oven and solar tomato slices. Regarding the lightness L* and the yellowness b*, storage for 6 months for dried tomato products decreased both of them. The effect of storage for 6 months time on increasing the b* - value from 8.88, 9.22, 10.1 and 10.5 at zero time to 9.92, 8.79, 24.7 and 20.85 after 6 months was quite remarkable. Consequently, the results in figures (2-4) show the color measurement by Hunter lab as "L", "a" and "b" factors for stored peach clingstone products, compared with the control sample. However, the L*, a* and b*-values tomato solar sheet slightly decreased from 26.22, 13.34 and 8.88 at control to 27.19, 13.06 and 9.92 after 6 months storage, respectively. Such stable in lightness L* and yellowness b* as well as the recorded stable in redness a* after 6 months storage are indicators of the inhibition of the browning reactions. This result is considered as an addition to those of Eissa and Moharam., (2001), who proved the effectiveness of chemical treatments as anti-browning agents on the characteristics of color in dried banana slices.

From the same figure (2), it could be noticed also that a* value of dried tomato products was stable during storage for the time of 6 months, while L*, and b* values increased with increasing storage up to 6 months.

Table (1) indicate that the H* decreased in solar sheets and slices than those prepared by oven and stored for 6 months.

Chromaticity (C*) also decreased in both solar sheets and slices than those samples prepared using oven and stored for 6 months as shown in Table (1). However, the C* increased with the increasing of storage for 6 months only up to 2 months and then decreased till 6 months of storage in tomato products. This result shows that the C* was closely stable in all samples with increasing of storage and b*-values of storage for 2 months time up to 6 months, as shown in table (1). Such results are partially confirmed by those of Zanoni *et al.*, (1998) and Isabel *et al.*, (2008). This result is considered as an addition to those of Andritsos *et al.*, (2003) and Guadalupe and Diane, (2006) who proved the effectiveness of chemical treatments as anti-browning agents on the characteristics of color in dried tomato.

Fig 2: Effect of storage on a-values of different dried tomatoes

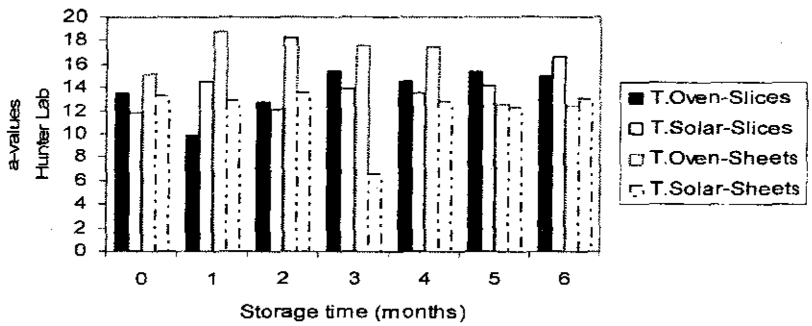


Fig 3:: Effect of storage on L-values of different dried tomatoes

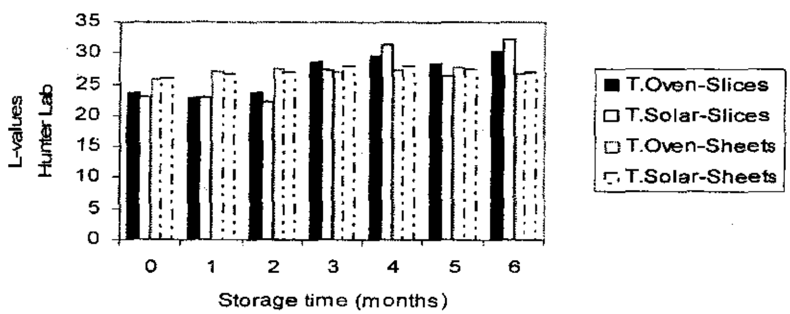


Fig 4: Effect of storage on b-values of different dried tomatoes

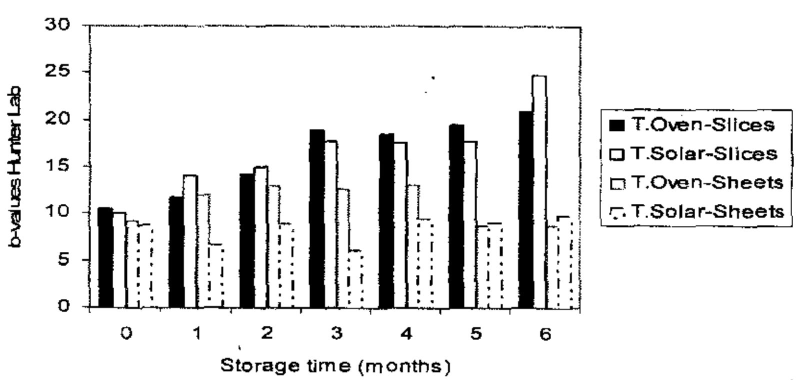


Table (1): Effect of storage period on color attributes of dried tomato.

Storage time months	Oven-sheets		Solar- sheets		Oven-slices		Solar-slices	
	H*	C*	H*	C*	H*	C*	H*	C*
0	0.607	17.76	0.011	16.02	0.013	17.12	0.014	15.50
1	0.011	22.30	0.009	14.64	0.020	22.58	0.016	20.30
2	0.012	21.69	0.011	16.30	0.019	19.00	0.021	19.23
3	0.012	22.40	0.016	09.00	0.021	24.51	0.022	22.50
4	0.013	21.86	0.013	15.98	0.022	23.64	0.022	22.16
5	0.012	15.41	0.012	15.34	0.022	24.78	0.022	22.70
6	0.012	15.30	0.013	16.40	0.024	25.66	0.025	29.83

Effect of storage period on the characteristic and parameters color of dried peach products:

The results that show the effect of storage for 12 months time on color of peach products are graphically presented in figures (5-10).

The a*- value of the dried peach (clingstone) products was 15.02, 17.61, 13.35 and 12.97 in P. solar sheet, oven sheet, solar slices and oven slices compared to 15.36, 17.86, 13.89 and 13.09, respectively after 12 months storage at room temperature, as shown in Fig 1. a*-values in T. oven or solar peach slices and sheets were not changed during storage.

Regarding the lightness L* and the yellowness b*, the effect of storage for 12 months time on Peach products was reversed. The lightness L* as well as the yellowness b* were decreased as a result of increasing the time of storage for 12 months. The effect of storage for 12 months time on decreasing the b* - value from 17.52, 48.21, 15.63 and 23.63 at zero time to 17.43, 48.14, 15.51 and 23.55, respectively after 12 months was quite remarkable.

Consequently, the results in figures (5-10) show the color that measured by Hunter lab as "L", "a" and "b" factors for stored peach clingstone products, and compared with the control sample. However, the L*, a* and b*-values peach solar sheet showed a negligible decrease from 44.94, 15.02 and 17.52 at control samples to 4.83, 15.36 and 17.43 after 12 months storage at 25 °C, respectively. Such stable in lightness L* and yellowness b* as well as the recorded stable in redness a* after 12 months storage 25 °C are indicators of the inhibition of the browning reactions.

Therefore, it could be concluded that the L*, a*, and b* values were closely stable during storage of peach products for 12 months.

Fig 5: Effect of storage on a-values of different dried peach clingstones

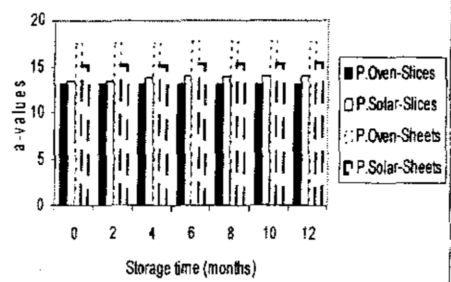


Fig 8: Effect of storage on a-valus in different peach freestones

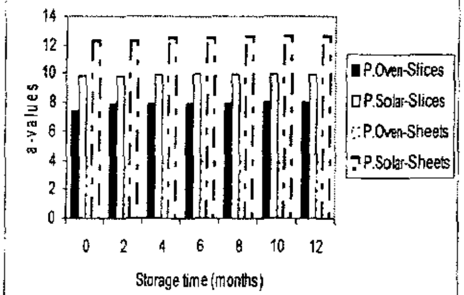


Fig 6: Effect of storage on L-values of peach clingstone

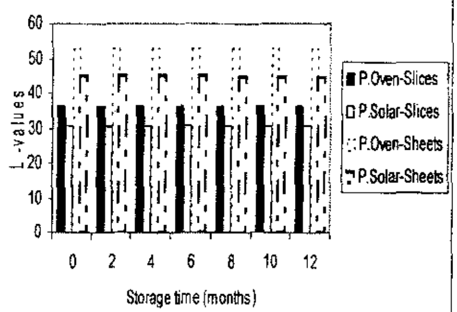


Fig 9: Effect of storage on L-values of different dried peach freestones

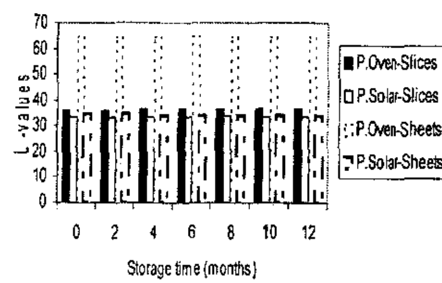


Fig 7: Effect of storage on b-values of dried peach clingstones

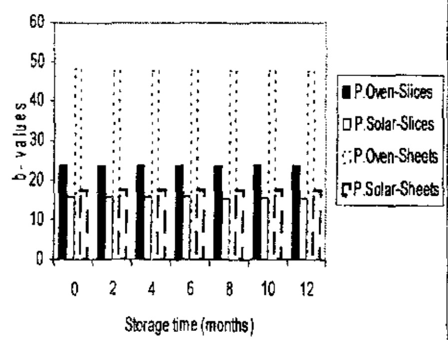
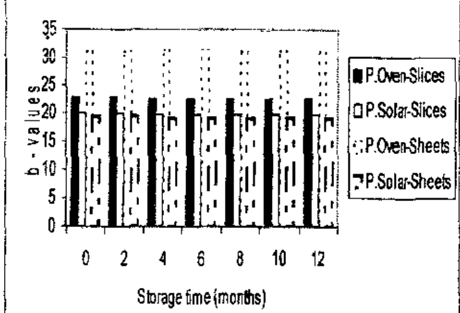


Fig 10: Effect of storage on b-values of different dried peach freestones



In addition to the lightness L*, redness a* and yellowness b*, the treated peach fruit (freestone and clingstone) were also tested for Hue angle (H*) as well as the chramaticity (C*). Hue is the aspect of color that we describe by words such as green, blue, yellow or red. The chroma (chromaticity) refers to reflection at a given wavelength and indicates how much a color differs from gray (Eissa and Moharram, 2001). The results in Table (2) indicate that the H* decreased in solar sheet than in oven sheet peach (freestone) after 12 months. Also, it decreased in solar slices than in oven slices peach (freestone). Concerning chromaticity (C*) table (2) also shows that it decreased in both solar sheets and slices than those of oven after 12 months.

Table (2): Effect of storage period on color attributes of dried peach (Free stone).

Storage time months	Oven-sheets		Solar- sheets		Oven-slices		Solar-slices	
	H*	C*	H*	C*	H*	C*	H*	C*
0	0.149	31.32	0.027	20.45	0.053	23.85	0.035	22.17
2	0.150	31.32	0.027	20.45	0.050	23.99	0.035	22.17
4	0.146	31.93	0.026	22.90	0.049	23.95	0.034	22.15
6	0.141	31.84	0.026	22.93	0.049	23.94	0.034	22.15
8	0.140	31.64	0.026	22.94	0.049	23.91	0.034	22.14
10	0.140	31.44	0.026	22.94	0.049	23.88	0.034	22.09
12	0.140	31.54	0.026	22.93	0.049	23.89	0.034	22.10

Table (3) shows same trend, hence the H* decreased in both solar sheets and slices than in oven ones peach (clingstone) for 12 months.

Also, the same results in Table (3) indicate that the chromaticity (C*) decreased in both solar sheets and slices than in oven samples after 12 months. Such results are partially confirmed by those of Ávila and Silva (1999).

Table (3): Effect of storage period on color attributes of dried peach (Cling stone).

Storage time months	Oven-sheets		Solar- sheets		Oven-slices		Solar-slices	
	H*	C*	H*	C*	H*	C*	H*	C*
0	0.047	51.32	0.020	23.10	0.031	26.95	0.020	20.56
2	0.047	51.31	0.020	23.10	0.031	26.96	0.020	20.56
4	0.047	51.34	0.020	23.10	0.031	26.96	0.019	20.73
6	0.047	51.35	0.019	23.20	0.031	26.96	0.019	20.81
8	0.047	51.36	0.019	23.20	0.031	26.96	0.019	20.81
10	0.047	51.34	0.019	23.20	0.031	26.97	0.019	20.81
12	0.047	51.34	0.019	23.20	0.031	26.94	0.019	20.55

Effect of storage period on the characteristic and parameters color of dried sage-salvia and thymus products:

Figures (11-13) illustrate the changes in color of dried salvia and thymus products in terms of redness a*, yellowness b* and lightness L* during storage for 6 months. The a*- value of the dried salvia and thymus products was found to be –0.72, -1.58, 0.47 and 0.18 in T. solar, T. oven, S. solar and S. oven compared to –1.02, -1.44, 0.58 and 0.58 after 6 months storage, respectively at room temperature, as shown in Fig 1. a* -values in tomato oven or solar peach slices and sheets were not changed during storage.

Regarding the lightness L* and the yellowness b*, the effect of storage for 6 months time on dried salvia and thymus products was reversed. The lightness L* as well as the yellowness b* were decreased as a result of increasing the time of storage for 6 months. The effect of storage for 6 months time on decreasing the b* - value from 9.27, 12.37, 7.68 and 11.08 at zero time to 10.48, 12.9, 9.33 and 12.54 after 6 months, respectively was quite remarkable. Consequently, the results in figures (11-13) show the color measured by Hunter lab as "L", "a" and "b" factors for dried salvia and thymus products, compared with the control sample. However, the L*, a* and b*-values T. solar slightly increased from 50.59, -0.72 and 9.27 at control samples to 51.16, -1.02 and 10.48 after 6 months of storage, respectively. From the same figures (11-13), it could be noticed also that the L* a*, and b* values of dried salvia and thymus products increased with increasing of storage for 6 months.

The results in Table (4) reveal that the H* decreased in both solar sag salvia and thyme thymus than in oven samples after 6 months. The result in this table shows that the H* was closely stable in all samples with increasing of storage and a*-values of storage for 2 months time up to 6 months.

The results in Table (4) reveal that the chromaticity (C*) decreased in solar sag-salvia than in oven sag-salvia for 6 months. Also, it decreased in solar thyme-thymus than in oven thyme-thymus. However, C* increased with the increasing of storage up to 2 months and then started to decreased till 6 months of storage in sag-salvia and thyme-thymus products. Such result shows that the C* was closely stable in all samples with increasing of storage and b*-values of storage for 2 months time up to 6 months.

Finally, it could be concluded that the storage for 12 months of Peach products greatly inhibited the changes of physical and chemical reaction and reduced the changes in their color and flavor. Also, the results concluded that the storage for 6 months of tomato, sag and thymus products greatly inhibited the changes of physical and chemical reaction and reduced the changes in their color.

Fig 11: Effect of storage on a-valus in different dried salvia and thymus

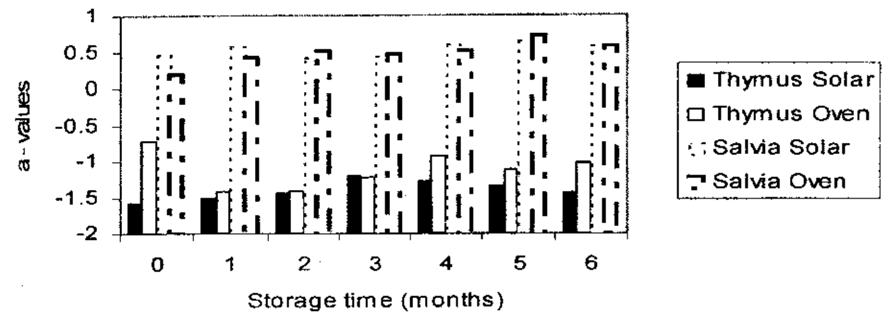


Fig 12: Effect of storage on L-value of different dried salvia and thymus

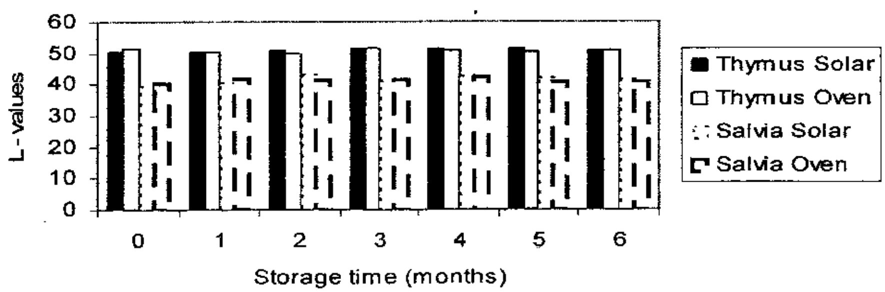


Fig 13: Effect of storage on b-values of different dried salvia and thymus

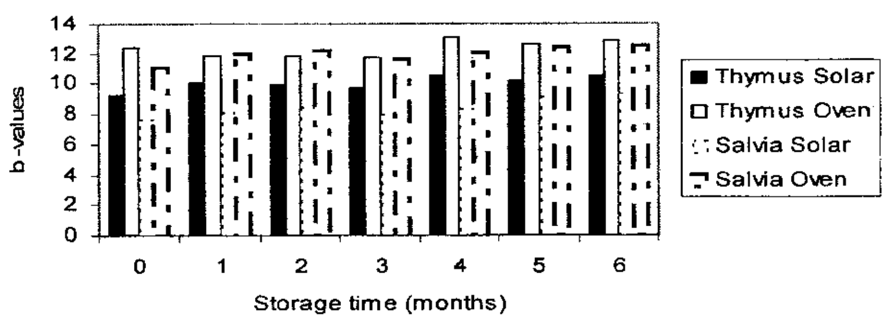


Table (4): Effect of storage period on color attributes of dried (sage and thymus).

Storage time months	Oven-sage-salvia		Solar-sage-salvia		Oven-Thyme-Thymus		Solar-Thyme-Thymus	
	H*	C*	H*	C*	H*	C*	H*	C*
0	1.846	11.08	0.293	7.69	-17.20	12.39	-5.87	9.40
1	0.525	11.93	0.253	8.13	-08.33	11.91	-6.72	10.19
2	0.444	11.94	0.359	8.51	-08.31	11.96	-6.84	10.02
3	0.458	11.59	0.319	7.99	-09.32	11.80	-8.00	9.75
4	0.439	12.23	0.244	8.39	-14.22	13.17	-8.19	10.55
5	0.314	12.11	0.250	9.16	-11.34	12.65	-7.59	10.26
6	0.396	12.55	0.288	9.35	-12.65	12.94	-7.27	10.57

The relationship between the color attributes and used drying methods of peach products after 12 months and tomato, sag-salvia and thyme-thymus products after 6 months:

Table (5) lists the values of the different color parameters L*, a*, b*, C* and H* of the Peach dried slices and sheet products for 12 months storage and of tomato, sage-salvia and thyme-thymus for 6 months at room temperature 25°C. A technique of regression analysis was used to predict the coefficient of the correlation between the five color parameters (L*, a*, b*, C* and H*) for both dried methods (convective air-oven dehydration and solar sun drying). The estimated values of r^2 was found to range between 0.70 in case of dried Clingstone peach sheet and 0.95 in case of dried Clingstone peach slices after 12 months storage. Also, it was 0.90 in case of dried Freestone peach sheet and 0.99 in case of dried Freestone peach slices after 12 months storage. The estimated values of r^2 were found to range between 0.99 in case of dried tomato sheet and slices after 6 months storage. Also, it was 0.99 in case of dried sage-salvia and 0.98 in case of dried thyme-thymus after 12 months storage.

These results are partially confirmed by those of Eissa and Moharram (2001) who proved that the estimated values of r^2 was found to range between 0.70 in case of H* to 0.99 in case of a* in dried banana slices.

However, the results showed that the attributes and characteristic color was different in all color parameters or had high relationship about 0.99 between the different used dried methods after 12 month for peach dried products and 6 months for tomato, sage-salvia and thyme-thymus storage.

Table (5): Correlation between the different color parameters instrumentally measured, L*, a*, b*, H* and C* of dried slices and sheet products after storage at 25°C for 6 and 12 months.

Drying Treatments	a*-value	L*-value	b*-value	C*	H*	R^2 -values
Clingstone (oven) sheets	17.86	52.81	48.14	51.34	0.047	0.70
Clingstone (solar) sheets	15.25	44.83	17.43	23.10	0.020	
Clingstone (oven) slices	13.09	36.33	23.55	26.96	0.031	0.95
Clingstone (solar) slices	13.89	30.69	15.51	20.73	0.019	
Freestone (oven) sheets	3.91	65.01	31.3	31.54	0.140	0.90
Freestone (solar) sheets	12.58	33.86	19.17	22.93	0.026	
Freestone (oven) slices	7.97	36.30	22.53	23.89	0.049	0.99
Freestone (solar) slices	9.93	33.60	19.75	22.10	0.034	
Tomato (oven) sheets	12.53	26.90	8.79	15.30	0.012	0.99
Tomato (solar) sheets	13.06	27.19	9.92	16.40	0.013	
Tomato (oven) slices	15.00	30.24	20.82	25.66	0.024	0.99
Tomato (solar) slices	16.64	32.30	24.75	29.83	0.025	
Sage-salvia (Oven)	0.58	40.78	12.54	12.55	0.396	0.99
Sage-salvia (Solar)	0.58	41.98	9.33	9.35	0.288	
Thyme-Thymus (Oven)	-1.02	50.67	12.9	12.94	-12.65	0.98
Thyme-Thymus (Solar)	-1.44	51.16	10.48	10.57	-7.27	

Conclusions

The use of solar energy improved the quality of tomato, peach and medical herbs. From these results, it is concluded that the storage at 25 °C for 12 months of Peach products quite inhibited the changes of physical and chemical reaction and reduced the changes in color of peach samples. Moreover, storage for 12 months at 25 °C was much effective than any other storage for 6 months peach samples as it maintained the color and flavor of natural dried peach samples (sheets or slices). Also, the results concluded that the storage for 6 months at 25 °C of tomato, sage and thymus products effectively inhibited the changes of physical and chemical reaction and reduced the changes in color of tomato, sag and thymus samples. However, the results showed that the attributes and characteristic color were different in all color parameters or had high relationship about 0.99 between different used dried methods after 12 month at 25 °C for peach dried products and 6 months at 25 °C for tomato, sage-salvia and thyme-thymus storage.

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تأثير طرق التجفيف و التخزين على صفات اللون لمنتجات الخوخ والطماطم والأعشاب الطبية

هشام أمين على عيسى و جميل فايز بارح

قسم الصناعات الغذائية – المركز القومى للبحوث – القاهرة – مصر

الملخص العربى

تم استخدام طريقتى التجفيف بالفرن العادى و بالطاقة الشمسية فى انتاج كل من شرائح و لفائف الخوخ و الطماطم و بعض النباتات الطبية (المرمرية والزعتر) و تم تخزين المنتجات النهائية على درجة حرارة الغرفة لمدة ١٢ شهرا مع تقييم درجة اللون باستخدام جهاز **Hunter Lab**

و اشارت النتائج المتحصل عليها الى أن طريقة التجفيف المستخدمة أدت الى زيادة كل من **Luminance and chromaticity** و قد ازدادت درجة الدكانة حيث قلت قيمة (**L-value**) بينما لم تتاثر كل من قيمة (**a-value and b-value**) و ذلك مقارنة بالمادة الخام المستخدمة قبل عمليات التجفيف و يعزى سبب التغيرات التى حدثت فى لون سطح المواد المجففة الى فقد الماء و دخول الهواء مما يؤدى الى تدهور خواص سطح المادة المجففة (الانكماش).

و ترجع الاختلافات فى قيم اللون التى تم قياسها الى اختلاف نوع المادة المجففة بالاضافة الى التغيرات الحادثة فى سطح المادة و تركيبها الداخلى نتيجة لعملية التجفيف.

و يمكن التوصية بأن طريقة التجفيف بالطاقة الشمسية كانت أفضل من الطرق التقليدية و كما أمكن المحافظة على اللون أثناء فترة التخزين.