Effect of Natural Cabbage and Taro Extracts on Oxidative Enzymes Activity of Frozen and Dried Apple Products

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Abstract: In this study, effect of taro peel and taro pulp extracts compared with those of cabbage on oxidative enzyme activities of frozen apple pulp and dried apple rings was investigated. Therefore, fresh apple rings were dipped in natural extracts from cabbage, taro peel and taro pulp. The effects of this pretreatment, freezing and drying on oxidative enzymes activity, colour characteristics, and total phenol contents of apple pulp and rings were recorded.

The best used concentration of cabbage, taro peel and pulp extracts pre-treatment was found to be 15%, hence it improved the final acceptability and inhibited oxidative enzymes (PPO, POD and catalase) activity for apple pulp and rings. However, it could be noticed that addition of taro pulp extract at 15% in the soaking solution took place, hence the inhibition was 62. 22 %, 65.40 % and 28.68 % for PPO, POD and CAT, respectively in apple pulp. Meanwhile, such addition showed 44.75%, 46.66 % and 80.35 % of PPO, POD and CAT, respectively inhibition in apple rings. Generally, the result showed that utilization of taro pulp extracts at 15% prevented any browning for all frozen apple pulp and dried apple rings compared with untreated samples. The apple pulp and rings pretreated with taro pulp extract caused the highest reduction of oxidative enzyme activities followed by Taro peel extract.

Results indicated that the treatment with cabbage and taro pulp extracts inhibited PPO, POD and CAT activity after dipping reached to 44.75 % and 80.35%, respectively. Dried treated apple rings had the highest values for inhibition oxidative enzymes activity compared with frozen apple pulp and untreated samples. Also, results showed a decrease in the total phenols content of dried apple rings comparing with those of frozen apple pulp after pre-treatment with cabbage and taro extracts.

Key words: Apple, pulp, rings drying, polyphenoloxidase, peroxidase, catalase, colour, extracts, browning, cabbage, taro.

1. Introduction:

The freezing and drying preservation of fruits is one of the growing food industries in Egypt in the last decade. Frozen and dried products find an extending market. Prevention of browning in the apple slices is difficult to achieve because of rapidity of the enzymatic oxidation of phenolic substrates. The most serious problem in the freezing and drying preservation of fruits is the activity of the oxidative enzymes, which results in quality and nutritional deterioration of the food product during the frozen and dried storage. Drying fruits is an established in Egypt, while freezing apple is a promising new trend to produce an intermediate product for many food processed products. Enzymatic browning is one of the most studied reactions in fruits, vegetables and sea foods. Prevention of browning in the apple slices is difficult to achieve because of rapidity of the enzymatic oxidation of phenolic substrates [Annese et al., 1997 and Kim et al., 1993]. A common approach to prevent the enzymatic browning is the use of antibrowning agents that act primarily on enzymes or react with substrates and/or products of enzymatic catalysis, so that the pigment formation is inhibited [McEvily et al., 1992]. The prevalent use of sulfites as inhibitors of enzymatic browning in foods has been restricted by the Food and Drug Administration [Anon, 1987] due to allergic reactions produced sometimes in individuals with respiratory ailments.

The objectives of our study were to: (i) evaluate the potential of taro pulp and peel extracts for inhibition of oxidative enzymes activity (PPO, POD and CAT) in frozen apple pulp and dried apple rings, as compared with the effectiveness of cabbage extract; (ii) study the changes in oxidative enzymes activity and colour characteristics after freezing or drying during storage time for two months at -18° C or for four months at room temperature, respectively.

2. Materials and Methods:

Source of fruit samples:

Commercially grown apple (*Anna delicious*) used for this study was obtained from a local supermarket in Cairo. Fruits were placed in refrigerator at 4° C before using. These fruits were in the early ripening stage (green yellow colour of apple. The selected fruits had a good maturity, colour, free from any undesirable odor, free from any spoilage by microorganisms or enzymes or accidents from transporting process and/or premature or have increasing in maturity.

Preparation of fruit material:

One hour prior to use, fruits were removed from the refrigerator and equilibrated to room temperature. Each apple fruit was rinsed with water, sectioned to slices at least 1.0 cm from the skin end (to exclude the effects of bruising), exposing fresh surface then immediately placed in glass beakers.

Natural extracts pretreatments:

Preparation of Vegetable Extracts: The leaves of white cabbage *(Brassica oleracea L.)*. Taro pulp and peel were mixed with hot water (55°C) at the concentration of 20% (w/v) for 30 sec., cooled, and filtered. Apple rings were dipped in different natural vegetable extracts at 60-65°C for 10 minutes. All natural extracts pretreatments were carried out under atmospheric pressure with different concentrations to reach each 5, 10, 15, 20 and 25%.

At the end of each pretreatment, apple samples were drained and immediately evaluated or subsequent analysis which was carried out for enzyme activities of PPO, POD and CAT. Each pretreatment was analyzed similarly to the initial control. Control samples were dipped in distilled water as shown by Eissa and Salama, (2002).

Storage fruit pulp by freezing:

Natural extracts pretreatment including apple treated and untreated were blended with stab mixer (Braun Type 4169, Spain) to obtain the required apple pulp and packed in glass bottles and stored at -18°C in frozen storage until sample analysis of PPO, POD and CAT enzyme activities and colour characteristics which was carried out at 0, 2, 4, 6 and 8 weeks of frozen storage.

Storage fruit rings by drying:

Natural extracts pretreatment including apple rings treated and untreated were dehydrated by air-oven dehydration. The trays with apple rings were put in an air ventilation oven (SHEL LAB 1370 FX, Germany) at 50°C for 20-22 h. The dried apple rings were placed in unsealed individual polyethylene film bags and kept at room temperature (25°C) in dried storage until sample analysis of PPO, POD and CAT enzyme activities and colour characteristics, which was carried out at 0, 1, 2, 3 and 4 months of dried storage.

Analytical methods

Enzyme activities determinations

Extraction of different enzymes under investigation:

Extraction of polyphenoloxidase (PPO, E.C. 1.14.18.1.) peroxidase (POD, E.C. 1.11.1.7) and calalase (CAT, E.C. 1.11.1.6) was carried out using the method described by Galeazi et al., [1981]. Crude enzymes extracts were prepared from the tested samples by extracting with sodium phosphate buffers as follows: 10 g of fresh juices were mixed for 30 sec. with 100 ml of a 0.2 M sodium phosphate buffer at pH 7.0, the suspension was centrifuged at 4°C for 15min at 5000 rpm, HERMLE Z 323 K Germane. The enzyme activity remained in the supernatant as crude of different enzymes.

Assay of polyphenoloxidase (E.C. 1.14.18.1) enzyme activity:

The enzyme activity was assayed according to the method described by Oktay et al., [1995]. Where, PPO enzyme activity was determined by measuring the increase of absorbance at 420 nm and 25° C with, Spectrophotometer UVD-3500, Labomed, USA.

The sample cuvette contained 2.0 ml of 0.1M catechol in sodium phosphate buffer (pH 7.0) with 1.0 ml of the crude enzyme extract. The absorbance at 420 nm was recorded every 30sec., from the recorded time the enzyme extract was added for 3 min at room temperature.

Assay of peroxidase (E.C. 1.11.1.7) enzyme activity:

To a clean dry cuvette of a spectrophotometer, 1.0 ml of crude enzyme extract (from different samples) was added and mixed with 5 ml sodium phosphate buffer solution (pH 7.0), 0.5 ml of 2% O-phenylene diamine, 0.5 ml of 0.3% H_2O_2 and 1ml redistilled water. The optical density of the mixture was recorded at zero time and every 30 sec at 450 nm for the first 3 min of reaction using Spectrophotometer, UVD-3500, Labomed, USA as described by Olmos et al., [1997].

Assay of catalase (E.C. 1.11.1.6) enzyme activity:

Catalase (CAT) enzyme activity was measured by titrimetric method as described by Aebi, (1983).

Colour determinations:

Hunter a*, b* and L* parameters were measured with a colour difference meter using a spectrocolourimeter (Tristimulus Colour Machine) with the CIE lab colour scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Colour Standard as shown by Sapers and Douglas [1987].

The Hue-Angle (H)*, Chroma (C)* and Browning Index (BI) were calculated according to the method of Palou et al., [1999].

Total phenol determination:

Total phenol contents of the untreated and treated samples were measured by the method of Amerine and Ough [1980], the absorbance was measured at 765nm using Spectrophotometer, UVD-3500, Labomed, USA and the results were expressed as milligram of garlic acid as standard equivalent per gram.

3. Results and Discussion:

Effect of natural extracts on oxidative enzymes of apple pulp and rings:

The effect of natural extracts treatments (cabbage, taro pulp and taro peel) at different concentrations, 5, 10, 15, 20 and 25% on polyphenoloxidase (PPO), peroxidase (POD) and catalase (CAT) in apple pulp and apple rings was evaluated. The obtained results are recorded in tables (1 and 2). From the obtained results (Table 1), it could be seen that the activity of polyphenoloxidase (PPO) of fresh apple pulp (control) was 0.0045units/mg, while in 5%cabbage treated pulp was 0.0033units/mg. The activity of peroxidase (POD) of fresh apple pulp was 0.185 units/mg, while in (15%) cabbage treated apple pulp was 0.062 units/mg. Also, the activity of catalase (CAT) of fresh apple pulp was 0.336 units / mg, while in 15%cabbage treated apple pulp 0.241 units/mg and in (15%) taro pulp treated apple pulp was 0.261units/mg. The maximum percent of inhibition of polyphenoloxidase PPO enzymes was 46.44, 62.22 and 57.77 in apple pulp treated by cabbage, taro pulp and taro peel (15%), respectively.

At the same natural extracts and same concentrations the maximum percent of inhibition of catalase CAT enzymes was 34.15, 23.22 and 23.22 in apple pulp treated with 15% of cabbage, taro pulp and taro peel respectively. A process for the inhibition of enzymatic browning (PPO) in fruit juices by the third mechanism, involving the use of cyclodextrins, was described by Sapers et al., [1989].

Results in Table (2) showed that the percent of inhibition of PPO, POD and CAT was high in 15% of taro pulp and peel treated apple rings (44.75, 46.66 and 75.89 %) versus in 43.91, 44.44 and 71.72% cabbage treated rings. It was also observed that the cabbage, taro pulp and taro peel extracts from 5 to 15% treated apple rings had a positive effect controlling or retarding colour changes and inhibition of oxidative enzymatic browning (PPO, POD and CAT) when applied to natural dried apple rings and apple and apple pulp. Therefore, the use of cabbage, taro pulp and taro peel extracts for reducing total phenols as well as the inhibition of oxidative enzymatic browning can be suggested to improve quality and safety of the dried apple rings or apple pulp.

Effect of natural extracts on oxidative enzymes in total phenol contents of apple pulp and apple rings:

The obtained results (Fig. 1) showed a good relationship between total phenols content (mg/100 ml) and the percent of browning inhibition with the increasing of cabbage, taro pulp and taro peel extracts concentration from 5% to 15% at room temperature. Total phenols contents were 0.17, 0.20 and 0.21 mg/100 ml in cabbage, taro pulp and taro peel extracts with the concentration of 15%, respectively. However, total phenols content was increased from 0.13 to 0.14 mg/100 ml in the apple pulp treated with 15% extracts, while total phenols content was increased from 0.13 to 0.14 mg/100 ml in the apple rings treated with 15% extracts. The obtained results are in agreement with those results of Singh et al., [2006].

Figure (2) showed that the inhibition percentage of PPO was higher in taro pulp extracts treated apple rings than that of cabbage extracts, also it was lower in taro peel extracts in apple pulp than other treatments. However, taro and cabbage extracts inhibited PPO enzyme activity up to 54 - 44% in all apple pulp and rings products.. These results are in agreement with that reported by Alonso et al. [2006].

Figure (3) showed that the inhibition percentage of POD was higher in taro pulp extracts treated apple rings than other treatments, but it was lower in taro peel extracts in apple pulp than other treatments. However, taro and cabbage extracts inhibited POD enzyme activity to be higher than 42 - 46% in all apple pulp and rings products. These

results are in agreement with that reported by Unal, [2007]

Figure (4) showed that the inhibition percentage of CAT was higher in taro pulp extracts treated apple pulp and rings products. However, taro and cabbage extracts inhibited CAT enzyme activity to be higher than 50 - 55% in all apple pulp and rings products. Also, the inhibition percentage of CAT by all extracts was in all apple products higher than PPO and POD inhibition. These results are in agreement with the results of Singh et al.. [2006].

Effect of natural extracts on colour characteristics of frozen apple pulp and dried apple rings during storage:

The surface colour of apple pulp was measured with a colour difference meter, using the Hunter Lab colour scale. The inhibitory effect of various natural cabbage and taro extracts pre-treatments based on measurements at their maximum concentrations is shown in table (3). Treated apple pulp colour, was found to be in a decreasing order as follows: taro peel > taro pulp > cabbage. It is obvious that taro pulp and peel extract pre-treatments of apple pulp decreased the development of red colour a*-value as non-enzymatic browning. The Hunter colour values of taro peel extract samples in apple pulp were lower than those of taro pulp extract samples.

Moreover, the Hunter colour values of taro peel pretreatment in apple pulp was lower than that of cabbage and taro pulp extracts pre-treatments. These results indicated that the browning (redness) increased in control samples than in cabbage and taro extract samples for apple pulp, as well as PPO and POD enzyme activity were higher in control samples than in cabbage and taro extracts samples (Table 3). The main colour change in untreated apple pulp and those pretreated by cabbage, taro pulp and taro peel extracts was due to increase in BI and a*-value, which were in high correlation with browning measurement. Other colour parameters such as hue angle and chroma also indicated that heat caused a slight colour change. Taro pulp extract samples had a BI lower than cabbage and taro peel extracts samples. But BI values of Taro extracts treated samples were lower than those of cabbage-treated samples and lower than that of untreated samples (Table 3). These results are in a good agreement with those of Ozoglu and Bayindirh [2002] and Eissa et al., [2003]. In general, taro pulp, taro peel and cabbage extract pretreatments improved the colour of apple pulp (Table 3). From the above mentioned results it could be concluded that the pretreated apple pulp with taro peel extracts have the best colour values (a* and BI) and lower non-enzymatic browning compared with the other extracts pretreatments.

The inhibitory effect of cabbage, taro pulp and taro peel extracts pre-treatments based on measurements at their maximum concentrations is shown in table (4).Treated dried apple inhibitory, was found to be in the following decreasing order: taro peel > taro pulp > cabbage. It is obvious that cabbage, taro pulp and taro peel extracts pretreatments of dried apple decreased the development of red colour a*-value as non-enzymatic browning. The Hunter colour values of taro peel extract samples in dried apple were lower than those of taro pulp extract samples.

However, PPO and POD enzyme activity was higher in control samples than in cabbage and taro extracts pre-treatment samples. These results indicated that the browning (redness) increased in control samples than in natural cabbage and taro extracts pre-treatments samples for (Tables 4). The main colour change in untreated dried apple and those pretreated by cabbage, taro peel and pulp extracts was due to increase in BI and a*-value, which were in high correlation with browning measurement. Other colour parameters such as hue angle and chroma also indicated that heat caused a slight colour change. Taro pulp extracts samples had a BI lower than taro peel extract and cabbage extract samples. But BI values of Taro extracts treated samples were lower than those of cabbage-treated samples and lower than that of untreated samples (Table 4).

These results are in a good agreement with those of Ozoglu & Bayindirh [2002] and Eissa et al., [2003]. In general, taro pulp and peel extract pretreatments improved the colour of dried apple. However, cabbage taro pulp and taro peel extracts samples had the same colour values as evidenced by optical density (A420nm), compared with increasing of colour values in untreated dried apple samples.

From the above mentioned results it could be concluded that the pretreated dried apple with taro peel extracts had the best colour values (a* and BI) and lower non-enzymatic browning compared with the other pretreatments. The best inhibition of oxidative enzymes (PPO and POD), good colour characteristics and lower non-enzymatic browning in dried apple were due to pretreatment with taro pulp, taro peel and cabbage extracts (15%).

Effect of freezing storage on the inhibition of oxidative enzymes activity of apple pulp:

Results in Fig. (5) showed that the apple pulp characteristics were affected by different natural extracts pre-treatments. Treated apple caused inhibition for PPO enzyme compared to untreated

apple. The inhibition percentages for cabbage, taro pulp and taro peel extracts treatment were 39.01-29.72%, 45.45-40.54 and 39.39 - 29.72% at the same time, respectively.

Results in Fig. (6) showed that the apple pulp characteristics were affected by different natural extracts pre-treatments. Treated apple caused inhibition for POD enzyme compared to untreated apple. The percentage of inhibition for cabbage extract were 52.49-39.47%, while taro pulp and taro peel extracts the inhibition values were 54.90-42.10 and 49.01-36.84%, respectively at the same time.

Results in Fig. (7) showed that natural extract treated apple pulp caused inhibition for catalase (CAT) enzyme compared to untreated apple. The inhibition percentage for cabbage, taro pulp and taro peel extracts treatment were 52.83-41.93%, 53.12 - 42.74% and 52.54 - 42.33% at the same time respectively.

Finally, natural extracts treatment lead to PPO, POD and CAT inhibition. It is safe for health and more stable during storage compared to chemical pretreatment. These results are in agreement with the results of Eissa and Salama [2002] and Lee et al., [2007].

Effect of drying storage on the inhibition of oxidative enzymes activity of apple rings:

Effect of drying storage of apple rings for a period of 4 months after pre-treatments with cabbage extract 15%, taro extract 15%, and taro peel extract 15% is shown in Fig (8). The obtained results indicated that treated apple caused an inhibition for the PPO enzyme compared to untreated apple. The percentage of inhibition for cabbage extract was 89.31-37.36%, while for taro pulp and taro peel extracts the inhibition values were 91.98-37.82% and 90.83-37.67%, respectively at the same time.

From results of Fig. (9), it is clear that the apple rings characteristics were affected by different treatments. Treated apple caused inhibition in POD enzyme compared to untreated apple.

The percentage of inhibition for cabbage extract was 81.06 - 38.46%, while for taro pulp and taro peel extracts the inhibition values were 81.48 - 43.58% and 81.27-41.02%, respectively at the same time.

Also, natural extract treated apple rings caused an inhibition in catalase (CAT) enzyme compared to untreated apple (Fig. 10). The inhibition percentages for cabbage, taro pulp and taro peel extracts treatment were 29.86-15.97%, 30.55-16.86% and 29.51-16.56% at the same time, respectively.

Finally, the results indicated that used natural extracts treatment caused a considerable inhibition for PPO, POD, CAT enzymes and that is safe for health and more stable during storage compared to chemical pre-treatment. These results are in agreement with those of Eissa and Salama [2002], Eissa et al., [2003] and Lee et al., [2007].

Table (1): Effect of Taro extracts pre-treatments on oxidative enzymes activity of fresh apple pulp.

Extract Pretreatments	PPO activity units/mg	% inhibition	POD activity units/mg	% inhibition	CAT activity units/mg	% inhibition
Control	0.0045	0.00	0.185	0.00	0.336	0.00
Cabbage:						
5%	0.0033	26.66	0.145	21.62	0.284	22.40
10%	0.0028	37.77	0.091	50.81	0.261	28.68
15%	0.0016	46.44	0.062	66.48	0.241	34.15
20%	0.0026	42.22	0.139	24.86	0.263	28.14
25%	0.0036	20.00	0.145	21.62	0.268	26.77
Taro pulp:						
5%	0.0034	24.44	0.131	29.18	0.281	23.22
10%	0.0022	51.11	0.111	40.00	0.271	25.95
15%	0.0017	62.22	0.064	65.40	0.261	28.68
20%	0.0027	40.00	0.117	36.75	0.281	23.22
25%	0.0029	35.55	0.153	17.29	0.290	20.76
Taro peel:						
5%	0.0035	22.22	0.152	17.83	0.321	12.29
10%	0.0024	46.66	0.114	38.37	0.311	15.02
15%	0.0019	57.77	0.099	46.37	0.281	23.22
20%	0.0029	35.55	0.125	32.43	0.291	20.49
25%	0.0036	20.00	0.161	12.97	0.321	12.29

Table (2): Effect of Taro extracts treatments on oxidative enzymes activity of fresh apple rings.

Extract Pretreatments	PPO activity units/mg	% inhibition	POD activity units/mg	% inhibition	CAT activity units/mg	% inhibition
Control	0.715	0.00	0.045	0.00	0.448	0.00
Cabbage:						
5%	0.624	12.72	0.039	13.33	0.435	29.01
10%	0.515	27.97	0.032	28.88	0.424	53.57
15%	0.401	43.91	0.025	44.44	0.413	71.72
20%	0.497	30.48	0.035	22.22	0.425	51.33
25%	0.585	18.18	0.039	13.33	0.440	17.85
Taro pulp:						
5%	0.613	14.26	0.038	15.55	0.434	31.25
10%	0.504	29.51	0.032	28.88	0.423	55.80
15%	0.395	44.75	0.024	46.66	0.412	80.35
20%	0.502	29.79	0.036	20.00	0.426	49.10
25%	0.594	16.92	0.040	11.11	0.440	17.85
Taro peel:						
5%	0.623	12.86	0.039	13.33	0.436	26.78
10%	0.512	28.39	0.033	26.66	0.425	51.33
15%	0.400	44.05	0.026	42.22	0.414	75.89
20%	0.488	31.74	0.038	15.55	0.427	46.87
25%	0.595	16.78	0.040	11.11	0.443	11.16

Table (3): Effect of extract pre-treatments and storage time on colour characteristics of frozen apple pulp.

Extract Pretreatments	Time (week)	L	a	b	A 420	C	H_{tan}-1	BI
Fresh	0	54.01	10.37	34.24	7.25	35.77	73.14	197.74
	2	54.21	10.21	34.12	7.13	35.61	73.33	195.39
	4	52.92	4.40	23.55	9.12	23.95	79.41	115.54
	6	55.76	5.74	29.34	8.96	29.89	78.93	144.81
	8	57.47	6.25	33.44	8.54	34.01	79.41	165.68
Cabbage extract	0	62.56	3.65	22.42	14.29	22.71	80.75	86.92
	2	59.43	4.65	20.54	13.54	21.05	77.25	86.25
	4	57.59	3.57	19.47	12.49	19.79	79.60	81.96
	6	58.32	3.24	20.32	2.53	20.57	80.94	83.82
	8	59.80	1.26	21.42	12.88	21.45	86.63	81.56
Taro extract	0	59.72	3.10	23.29	12.97	23.49	82.4	94.82
	2	59.32	3.20	23.11	12.87	23.33	82.11	94.99
	4	56.80	3.22	22.16	11.62	22.39	81.73	95.54
	6	60.65	2.96	22.34	12.45	22.53	82.46	88.31
	8	65.01	2.31	22.42	13.42	22.53	84.12	80.04
Taro peel extract	0	56.85	4.16	24.85	10.71	25.19	80.49	111.71
	2	49.23	6.23	29.56	6.45	30.20	78.09	175.29
	4	45.06	10.44	34.19	3.99	35.74	72.99	259.21
	6	51.54	8.43	31.43	7.69	32.54	74.99	184.15
	8	54.33	6.18	24.93	9.36	25.68	76.06	124.17

L*, a* and b* values by Hunter Lab instruments.

Table (4): Effect of extract pre-treatments and storage time on colour characteristics of dried apple rings.

Extract Pretreatments	Time (month)	L	a	b	A 420	C	H_{tan}-1	BI
Fresh	0	67.15	6.39	28.06	15.81	28.77	77.17	109.04
	1	65.34	7.56	28.00	14.56	29.00	74.88	115.11
	2	63.21	8.23	28.10	13.38	29.28	73.66	122.02
	3	60.43	9.09	28.42	11.40	29.83	72.28	132.92
	4	59.14	9.95	28.70	10.14	30.37	70.85	140.23
Cabbage extract	0	59.89	4.66	19.51	14.33	20.05	76.58	80.91
	1	59.76	5.67	22.76	12.67	23.45	75.80	98.29
	2	58.65	7.45	23.84	11.57	24.97	72.65	110.13
	3	58.63	8.65	26.47	10.34	27.84	71.90	126.57
	4	58.63	9.74	27.39	10.69	29.07	70.41	134.09
Taro extract	0	55.86	9.43	27.46	9.05	29.03	71.03	142.38
	1	55.96	9.43	27.34	8.94	28.92	70.97	141.34
	2	55.84	9.34	27.09	8.65	28.65	70.97	140.05
	3	54.43	9.23	26.20	8.45	27.77	70.60	139.13
	4	54.34	9.05	26.86	8.50	28.34	71.39	142.96
Taro peel extract	0	48.54	10.95	27.37	6.23	29.47	68.20	175.28
	1	46.77	10.99	27.37	5.43	29.49	68.20	184.49
	2	44.65	11.65	27.45	4.62	29.81	67.04	199.40
	3	42.83	12.03	27.65	3.55	30.15	66.50	214.49
	4	41.84	12.77	27.70	3.74	30.50	65.26	224.58

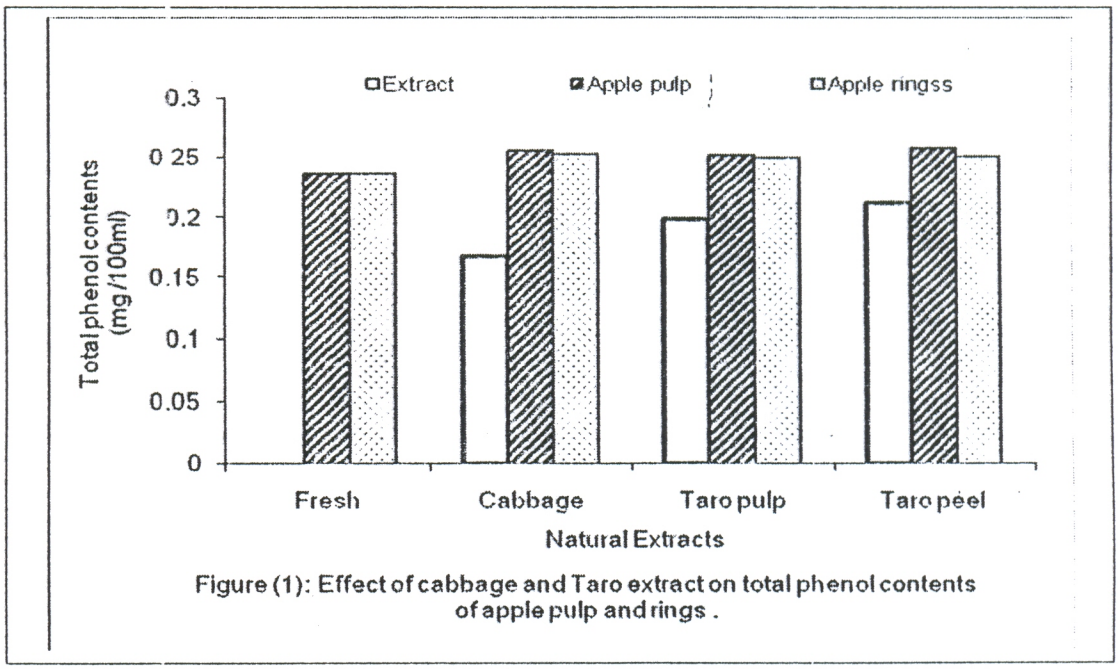

Figure (1): Effect of cabbage and Taro extract on total phenol contents of apple pulp and rings .

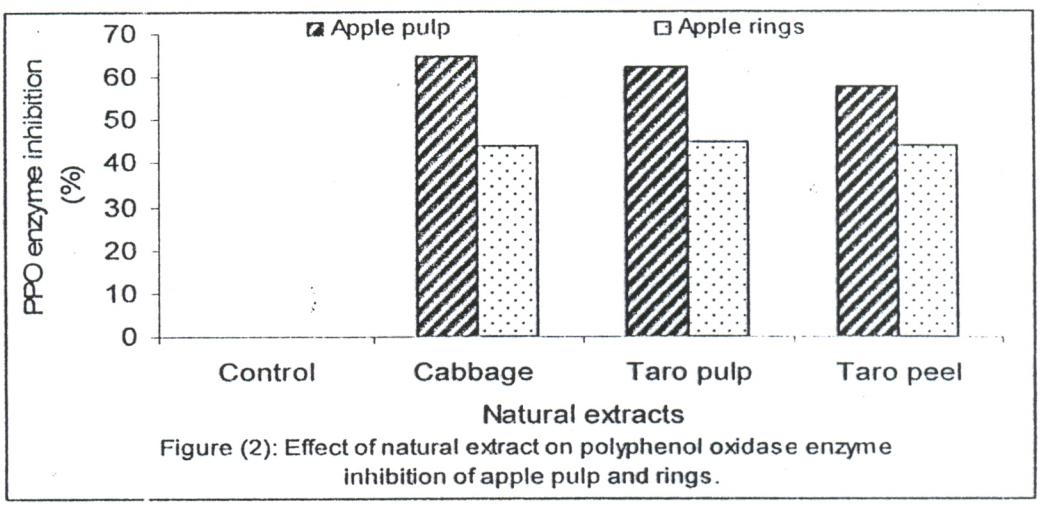

Figure (2): Effect of natural extract on polyphenol oxidase enzyme inhibition of apple pulp and rings.

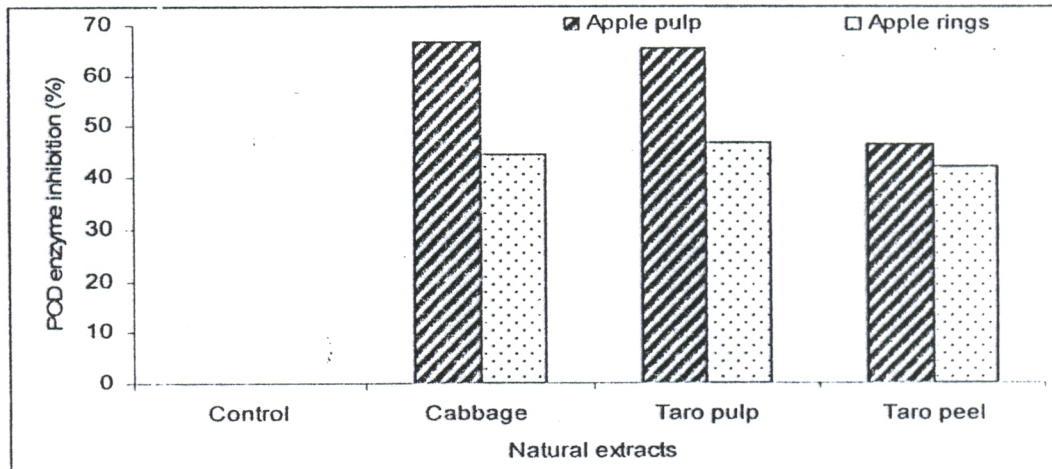

Figure (3): Effect of natural extract on peroxidase enzyme inhibition of apple pulp and rings.

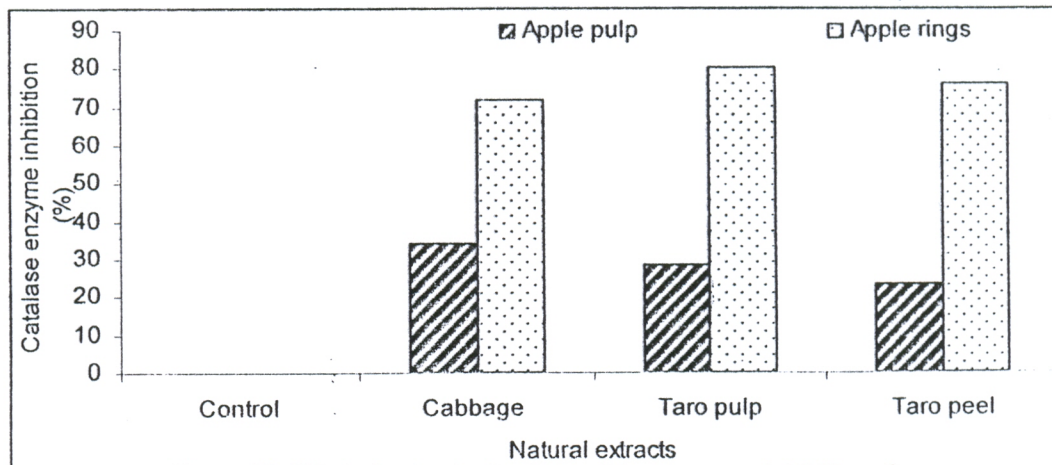

Figure (4): Effect of natural extract on catalase enzyme inhibition of apple pulp and rings.

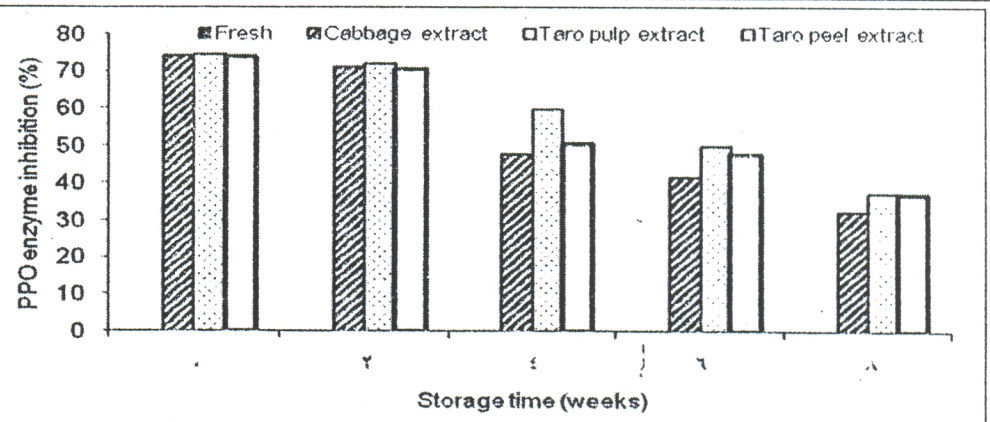

Figure (5): Effect of freezing storage on polyphenol oxidase inhibition of apple pulp

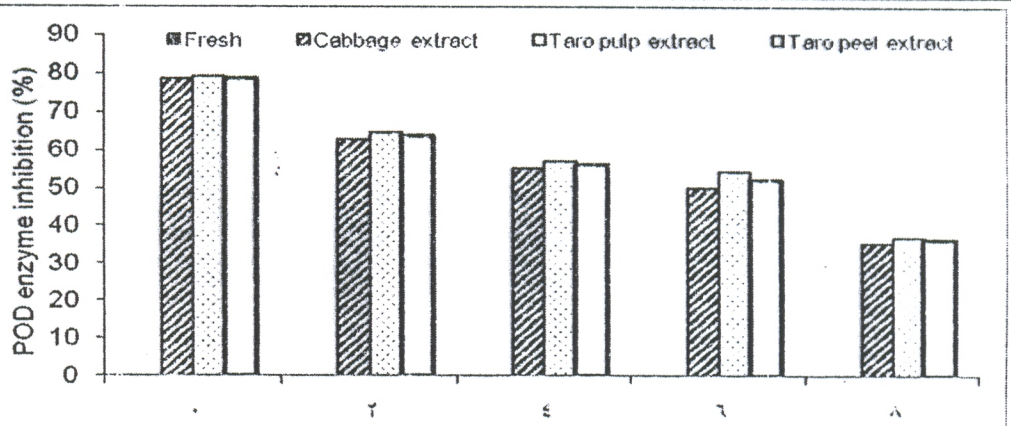

Figure (6): Effect of freezing storage on peroxidase inhibition of apple pulp.

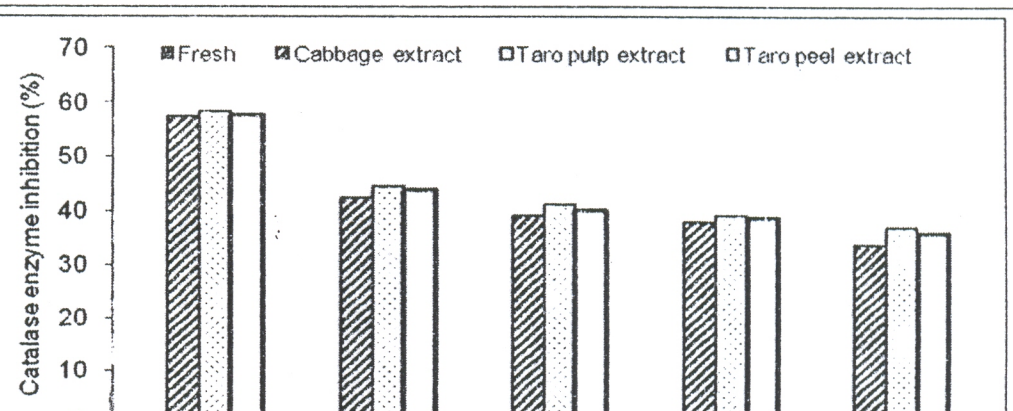

Figure (7): Effect of freezing storage on catalase inhibition of apple pulp.

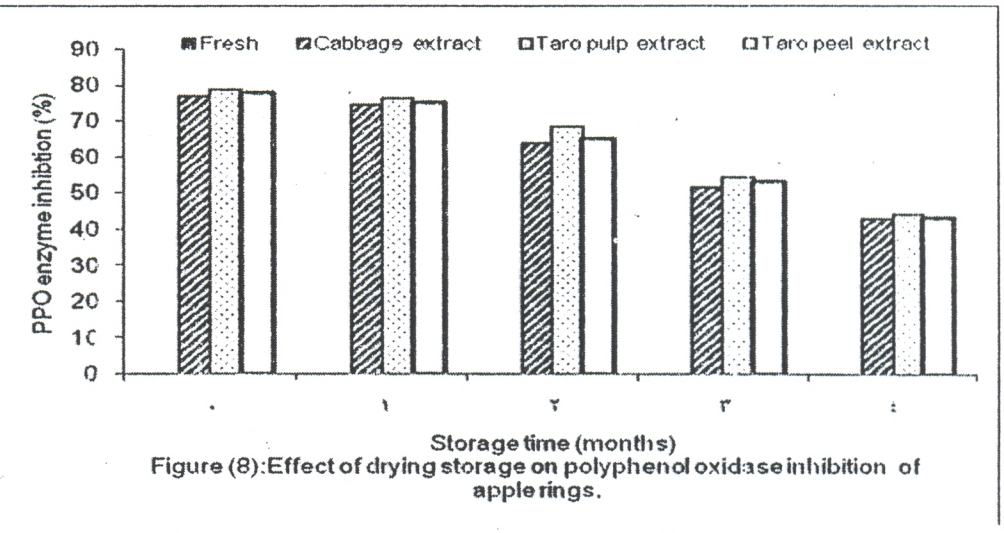

Figure (8):Effect of drying storage on polyphenol oxidase inhibition of apple rings.

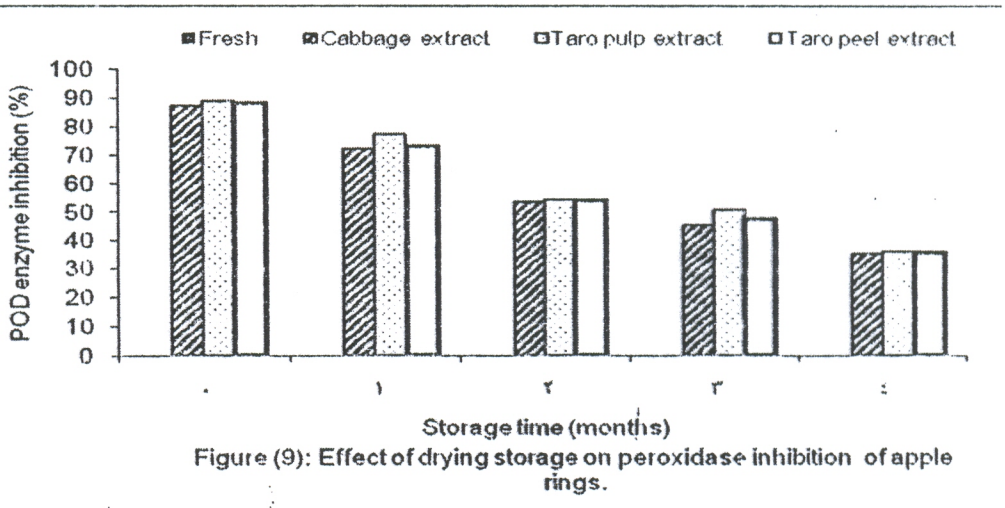

Figure (9): Effect of drying storage on peroxidase inhibition of apple rings.

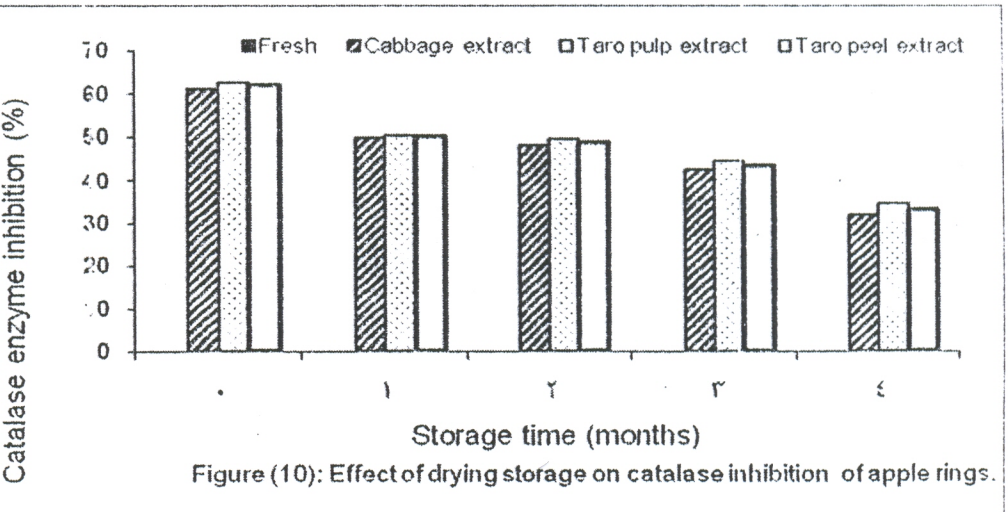

Figure (10): Effect of drying storage on catalase inhibition of apple rings.

4. Conclusions:

There are numerous natural extracts compounds capable of reducing the oxidative enzymatic browning. The use of cabbage and taro extracts pre-treatments is still stimulated to meet the demands for production of healthy fruit products having high quality. Therefore, studying and evaluating the efficiency of cabbage and taro extracts pre-treatments to inhibit the enzymatic browning (PPO, POD and CAT) in both frozen apple pulp and dried apple rings were carried out. Also, the most fruits that have high ratio of the enzymatic browning (PPO, POD and CAT) should be treated with safety anti-browning agents to inhibit these enzymes without any efficient effect on sensory properties in fruits for consumer.

Natural extracts pre-treatments, especially cabbage and taro extracts may effectively inhibit the PPO-catalyzed browning. Cabbage extract itself was not so effective as taro extracts for inhibiting browning in dried apple rings and frozen apple pulp. Our data suggest that the pre-treatments of apple rings with cabbage and taro extracts incorporating the anti-browning compounds. Dried apple rings and frozen apple pulp after pre-treatment with cabbage and taro peel extracts maintained higher total phenol contents, retained colour stable (white and red peel), had no browning and an indicative of better maintenance of quality. Also, this technique is an important to get a good quality product..

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