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EFFECT OF NATURAL CABBAGE and TARO EXTRACTS ON OXIDATIVE ENZYMES ACTIVITY OF FROZEN AND DRIED BANANA PRODUCTS

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ABSTRACT

In this study, effect of taro peel and taro pulp extracts pre-treatments compared with those of cabbage on oxidative enzyme activities of frozen banana pulp and dried banana rings was investigated. Therefore, fresh banana 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 banana 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 banana pulp and rings. However, it could be noticed that addition of taro pulp extract at 15% in the soaking solution took place as the inhibition of 54%, 44% and 54% for PPO, POD and CAT, respectively increased in banana pulp. Meanwhile, such addition showed 44%, 46% and 60% of PPO, POD and CAT, respectively inhibition in banana rings. Generally, the result showed that utilization of taro pulp extracts at 15% prevent any browning for all frozen banana pulp and dried banana rings compared with untreated samples. The banana 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 54, 44 and 54%, respectively. Dried treated banana rings had the highest values for inhibition oxidative enzymes activity sample compared with frozen banana pulp and untreated samples. Also, results showed a decrease in the total phenols content of dried banana rings comparing with frozen banana pulp after pre-treatment with cabbage and taro extracts.

Keywords: banana, pulp, rings, drying, polyphenoloxidase, peroxidase, catalase, colour, extracts, browning, cabbage, taro.

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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 banana 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 banana is a promising new trend to produce an intermediate product for many food processing.

Enzymatic browning is one of the most studied reactions in fruits, vegetables and sea foods. Prevention of browning in the banana 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 banana pulp and dried banana 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^{o} C or for four months at room temperature, respectively.

MATERIALS AND METHODS

Source of fruit samples:

Commercially grown banana (*Musa Sapie*ntum) used for this study was obtained from a local supermarket in Cairo. Fruits were placed in refrigerator at 4^{o}C before using**.** These fruits were in the early ripening stage (green yellow colour of banana. The selected fruits had a good maturity, colour, free form any undesirable odor, free from any spoil part 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 Banana fruit was simultaneously peeled and sliced to 0.5 -1.0 cm thick rings, 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^{o}C) at the concentration of 20% (w/v) for 30 sec., cooled, and filtered. Banana rings were dipped in different natural vegetable extracts at 60-65^{o}C for 10 minutes. All natural extracts pretreatments were carried out under atmospheric pressure with different concentrations as follows:

Cabbage extracts (5, 10, 15, 20 and 25%)

Taro pulp extracts (5, 10, 15, 20 and 25%)

Taro peel extracts (5, 10, 15, 20 and 25%)

At the end of each pretreatments, banana 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 (Eissa and Salama, 2002).

Storage fruit pulp by freezing:

Natural extracts pretreatment including banana treated and untreated were blended with stab mixer (Braun Type 4169, Spin) to obtain the required banana 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 banana rings treated and untreated were dehydrated by air-oven dehydration. The trays with banana rings were put in an air ventilation oven (SHEL LAB 1370 FX, Germany) at 50°C for 20-22 h. The dried banana 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 Galeazzi *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^{o}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 in absorbance at 420 nm at 25^{o}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) as follows:

H* = tan-1 [b*/a*]…… (1)

C* = square root of [a2* + b2*]...…….…. (2)

BI = [100 (x-0.31)] 10.72…….…….…. (3)

Total phenol determination:

Total phenol content of the untreated and treated samples was 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.

RESULTS AND DISCUSSION

Effect of natural extracts on oxidative enzymes of banana 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 banana pulp and banana 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 banana pulp (control) was 0.064 units/mg, while that of PPO in 5%cabbage treated pulp was 0.046 units/mg. The activity of peroxidase (POD) of fresh banana pulp was 0.054 units/mg, while the activity of POD in (15%) cabbage treated banana pulp 0.031 units/mg. Also, the activity of catalase (CAT) of fresh banana pulp was 0.452 units/mg, while the activity of CAT in 15%cabbage treated banana pulp (0.223 units/mg), while the activity of CAT in (15%) taro pulp treated banana pulp was (0.206 units/mg). The maximum percent of inhibition (%) of polyphenoloxidase PPO enzymes was 51.56, 54 and 50% in banana 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 50.66, 54.42 and 41.81% in banana 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).

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

Extract Pretreatments	PPO activity units/mg	% inhibition	POD activity units/mg	% inhibition	CAT activity units/mg	% inhibition
Control	0.064	0.00	0.054	0.00	0.452	0.00
Cabbage:						
5%	0.046	28.12	0.039	27.77	0.259	20.57
10%	0.037	42.18	0.034	37.03	0.255	43.58
15%	0.031	51.56	0.031	42.59	0.223	50.66
20%	0.044	31.25	0.040	25.92	0.309	31.63
25%	0.051	20.31	0.042	22.22	0.364	19.46
Taro pulp:						
5%	0.051	20.31	0.043	20.37	0.372	17.69
10%	0.043	32.81	0.040	25.92	0.314	30.53
15%	0.029	54.68	0.030	44.44	0.206	54.42
20%	0.039	39.06	0.039	27.77	0.308	31.85
25%	0.051	20.31	0.043	20.37	0.369	18.36
Taro peel:						
5%	0.047	26.56	0.042	22.22	0.377	16.59
10%	0.039	39.06	0.034	37.03	0.321	28.98
15%	0.032	50.00	0.032	40.47	0.263	41.81
20%	0.048	25.00	0.041	24.07	0.368	18.58
25%	0.050	21.87	0.046	14.81	0.381	15.70

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

Extract Pretreatments	PPO activity units/mg	% inhibition	POD activity units/mg	% inhibition	CAT activity units/mg	% inhibition
Control	0.078	0.00	0.093	0.00	0.045	0.00
Cabbage:						
5%	0.063	19.23	0.079	15.05	0.039	13.33
10%	0.059	24.35	0.061	34.40	0.029	35.55
15%	0.045	42.30	0.052	44.08	0.020	55.55
20%	0.050	35.89	0.061	34.40	0.035	22.22
25%	0.065	16.66	0.073	21.50	0.039	13.33
Taro pulp:						
5%	0.064	17.94	0.078	16.12	0.038	15.55
10%	0.058	25.64	0.062	33.33	0.025	44.44
15%	0.043	44.87	0.050	46.23	0.018	60.00
20%	0.051	34.61	0.062	33.33	0.036	20.00
25%	0.067	14.10	0.072	22.58	0.032	13.33
Taro peel:						
5%	0.065	16.66	0.079	15.05	0.039	13.33
10%	0.059	24.35	0.064	31.18	0.029	35.5
15%	0.046	41.02	0.053	43.01	0.025	44.44
20%	0.053	32.05	0.063	32.25	0.035	22.22
25%	0.066	15.38	0.075	19.35	0.040	11.11

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 banana rings (44.87, 46.23 and 60%) versus in (42.35, 44.08 and 55.55%) cabbage treated rings. It was also observed that the cabbage, taro pulp and taro peel extracts from 5 to 15% treated banana 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 banana rings and banana and banana pulp. or all the previous causes the use of cabbage, taro pulp and taro peel extracts for reduced total phenols as well as the inhibition of oxidative enzymatic browning can be suggested to improve quality and safety of the dried banana rings or banana pulp.

Natural extracts pre-treatments, especially cabbage, taro pulp and taro peel extract may be effective inhibitors of PPO, POD and CAT catalyzed browning. While cabbage extract itself was not as effective as taro extracts in inhibiting browning in dried banana rings and frozen banana pulp, it still may be useful where use of some chemicals are to be avoided. These data suggested that in addition to producing dried banana rings by inhibiting browning (oxidative enzymes; PPO-POD-CAT) without imparting objectionable colour and flavor, these pre-treatments (cabbage, taro pulp and taro peel extracts) incorporating the anti-browning compounds also maintained higher pigments levels, retained colour stable (white and red peel) higher galactomannan content in taro pulp (ferros sugar) whitch separated between substrate and enzyme, had no browning and had no deterioration in sugar levels indicative of better maintenance of quality after drying of banana rings and frozen banana pulp. Also, this technique is important to prevent of decrease in market value and the concomitant economic losses (Eissa and Salama, 2002, Eissa *et al.*, 2003).

Effect of natural extracts on oxidative enzymes in total phenol contents of banana pulp and banana 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 content 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 banana pulp treated with 15% extracts, while total phenols content was increased from 0.13 to 0.14 mg/100 ml in the banana rings treated with 15% extracts. The obtained results are in agreement with those results of Singh *et al.* (2006).

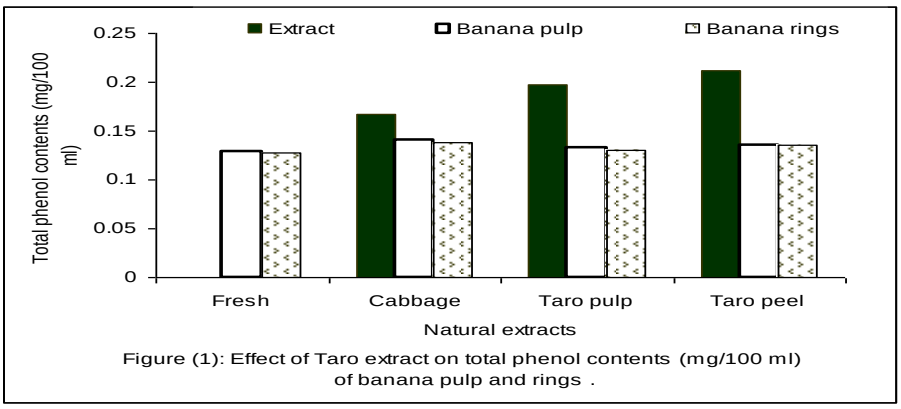

Figure (1): Effect of Taro extract on total phenol contents (mg/100 ml) of banana pulp and rings .

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

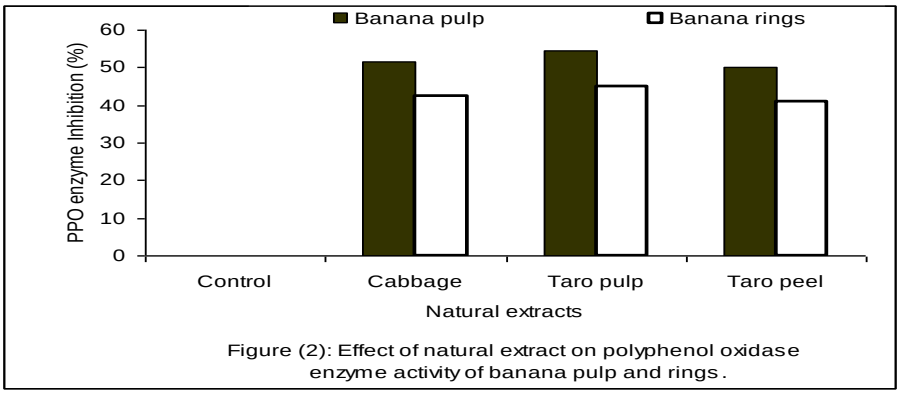

Figure (2): Effect of natural extract on polyphenol oxidase enzyme activity of banana pulp and rings.

Figure (3) showed that the inhibition percentage of POD was higher in taro pulp extracts treated banana rings than other treatments, but it was lower in taro peel extracts in banana pulp than other treatments. However, taro and cabbage extracts inhibited POD enzyme activity to be higher than 42 - 46% in all banana pulp and rings products. These results are in agreement with that reported by Unal (2007)

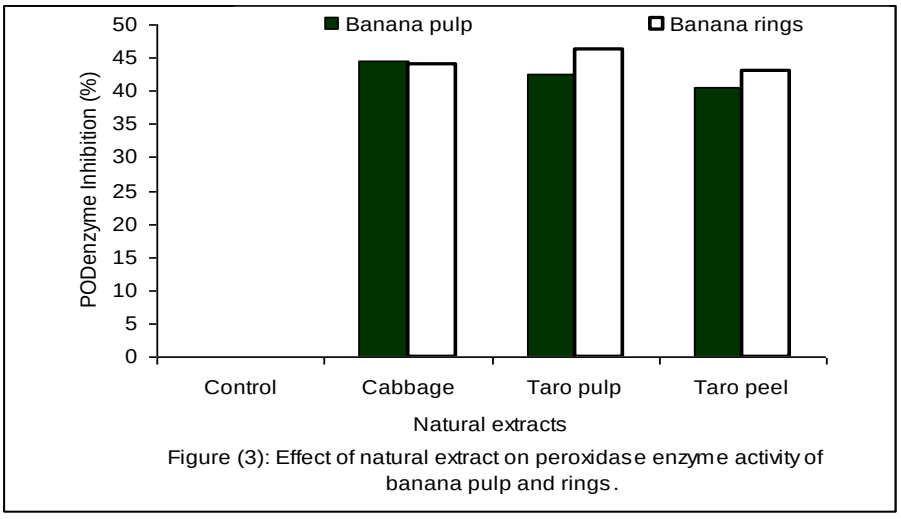

Figure (3): Effect of natural extract on peroxidase enzyme activity of banana pulp and rings.

Figure (4) showed that the inhibition percentage of CAT was higher in taro pulp extracts treated banana pulp and rings products. However, taro and cabbage extracts inhibited CAT enzyme activity to be higher than 50 - 55% in all banana pulp and rings products. Also, the inhibition percentage of CAT by

all extracts was in all banana products higher than PPO and POD inhibition (Fig. 4). These results are in agreement with the results of Singh *et al.* (2006).

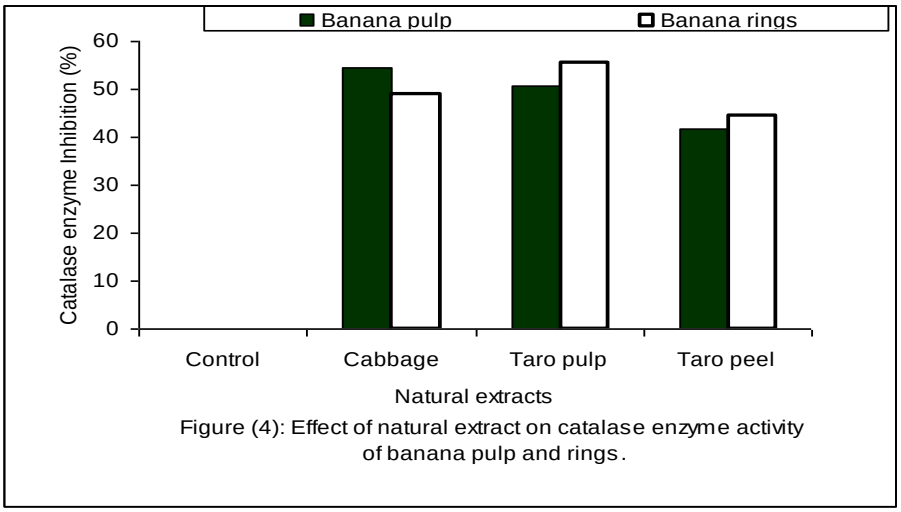

Figure (4): Effect of natural extract on catalase enzyme activity of banana pulp and rings.

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

The surface colour of banana 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, shown in Table (3) for treated banana pulp, 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 banana pulp decreased the development of red colour a*-value as non-enzymatic browning. The Hunter colour values of taro peel extract samples in banana pulp were lower than those of taro pulp extract samples.

Moreover, the Hunter colour values of taro peel pretreatment in banana 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 banana pulp, as well as PPO and POD enzyme activity were higher in control samples than in cabbage and taro extracts samples (Tables 3). The main colour change in untreated banana 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 banana pulp (Table 3).

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

Extract Pretreatments	Time (week)	L*	a*	b*	A 420	C*	H*	BI
Fresh	0	33.85	9.58	23.76	2.50	25.61	68.04	239.12
	2	33.85	9.37	23.54	2.67	25.33	68.28	235.38
	4	33.86	8.37	23.19	2.76	24.65	70.15	226.78
	6	35.86	9.24	24.89	2.98	26.54	69.61	232.25
	8	38.82	9.28	25.98	3.61	27.58	70.28	218.89
Cabbage extract	0	62.56	6.45	34.40	13.38	34.99	79.38	153.15
	2	54.76	6.98	29.67	12.50	30.47	76.76	153.76
	4	52.72	7.13	23.06	10.71	24.13	72.80	120.53
	6	47.13	8.04	20.15	8.30	21.69	68.28	122.39
	8	42.56	7.97	16.88	6.64	18.66	64.75	115.48
Taro pulp Extract	0	58.43	7.53	30.41	11.55	31.32	76.10	146.52
	2	53.78	7.56	23.65	10.34	24.82	72.28	121.99
	4	49.20	7.88	18.94	9.81	20.51	67.38	108.45
	6	46.32	8.25	18.65	8.05	20.39	66.13	116.00
	8	47.74	7.92	18.41	9.10	20.04	66.68	109.42
Taro peel extract	0	61.65	7.27	32.98	13.14	33.77	77.52	149.99
	2	54.89	7.34	23.54	10.67	24.65	72.70	117.72
	4	49.00	7.48	18.95	9.68	20.37	68.43	107.94
	6	48.02	7.77	19.43	8.99	20.92	68.20	114.37
	8	43.65	8.09	17.54	7.07	19.31	65.24	116.74

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

From the above mentioned results it could be concluded that the pretreated banana 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) for treated dried banana 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 banana decreased the development of red colour a*-value as non-enzymatic browning. The Hunter colour values of taro peel extract samples in dried banana 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 banana 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).

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

Extract Pretreatments	Time (month)	L*	a*	b*	A 420	C*	H*	BI
Fresh	0	34.70	7.71	21.29	3.13	22.64	70.00	193.70
	1	33.85	7.98	21.12	3.05	22.57	69.32	199.66
	2	33.65	8.56	20.86	2.94	22.54	67.63	200.56
	3	32.34	9.12	20.56	2.76	22.49	66.03	210.60
	4	32.54	9.46	20.06	2.82	22.17	64.75	204.01
Cabbage extract	0	27.78	7.82	14.77	2.62	16.71	62.12	171.19
	1	29.22	7.66	14.17	3.02	16.10	61.61	152.78
	2	28.43	7.61	13.74	2.87	15.70	61.08	152.97
	3	29.46	7.74	14.32	2.66	16.27	61.61	153.23
	4	29.47	7.72	14.38	2.93	16.32	61.74	153.75
Taro pulp extract	0	24.13	7.24	11.42	2.30	13.52	57.67	153.93
	1	26.75	7.21	11.57	2.82	13.63	57.99	137.11
	2	27.65	7.69	12.62	2.84	14.77	58.63	145.68
	3	27.64	7.44	11.98	3.03	14.10	58.15	137.34
	4	27.56	7.52	11.98	2.92	14.14	57.83	138.21
Taro peel extract	0	25.00	8.17	12.73	2.31	15.12	57.34	169.32
	1	28.32	7.27	12.43	3.01	14.39	59.68	137.40
	2	27.08	7.58	12.60	2.71	14.70	58.93	148.74
	3	27.77	7.25	12.12	3.02	14.12	59.09	137.21
	4	27.76	7.22	12.18	2.91	14.15	59.39	137.79

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 banana. 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 banana samples. From the above mentioned results it could be concluded that the pretreated dried banana 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 banana was due to pretreatment with taro pulp, taro peel and cabbage extracts (15%).

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

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

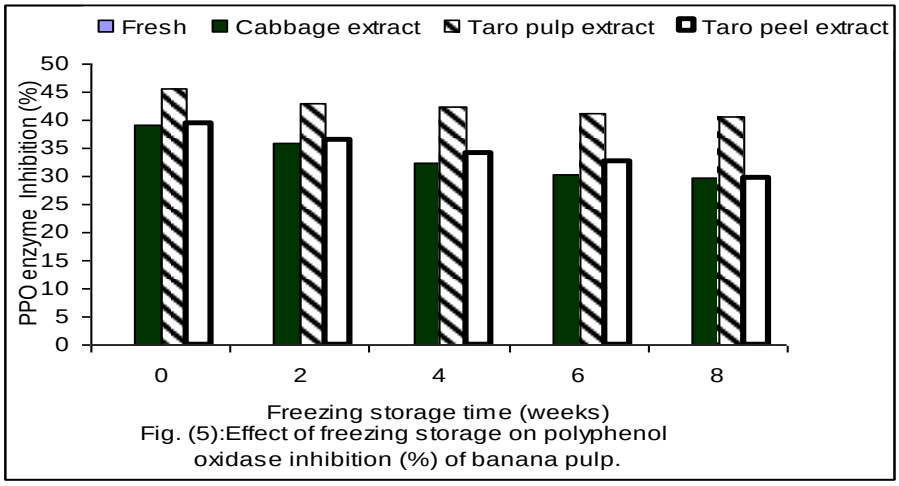

Fig. (5):Effect of freezing storage on polyphenol oxidase inhibition (%) of banana pulp.

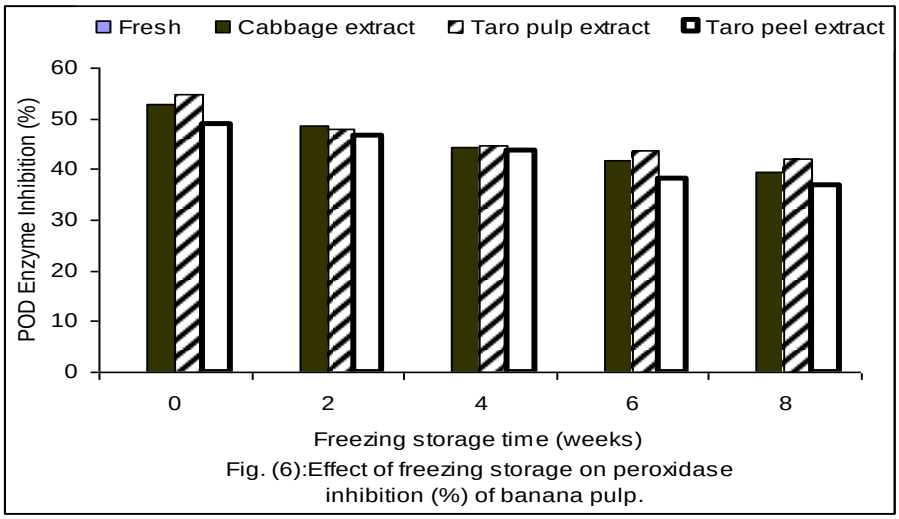

Fig. (6):Effect of freezing storage on peroxidase inhibition (%) of banana pulp.

Results in Fig (7) showed that natural extract treated banana pulp caused inhibition for catalase (CAT) enzyme compared to untreated banana. 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).

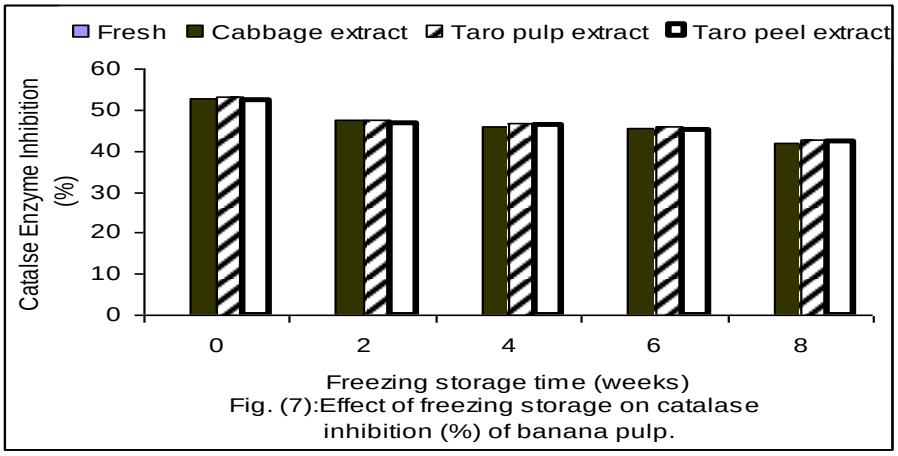

Fig. (7):Effect of freezing storage on catalase inhibition (%) of banana pulp.

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

Effect of a drying storage of banana 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 banana caused an inhibition for the PPO enzyme compared to untreated banana. The percentage of inhibition for cabbage extract were 89.31-37.36%, while taro pulp and taro peel extracts the inhibition values were 91.98-37.82% and 90.83-37.67%, respectively at the same time.

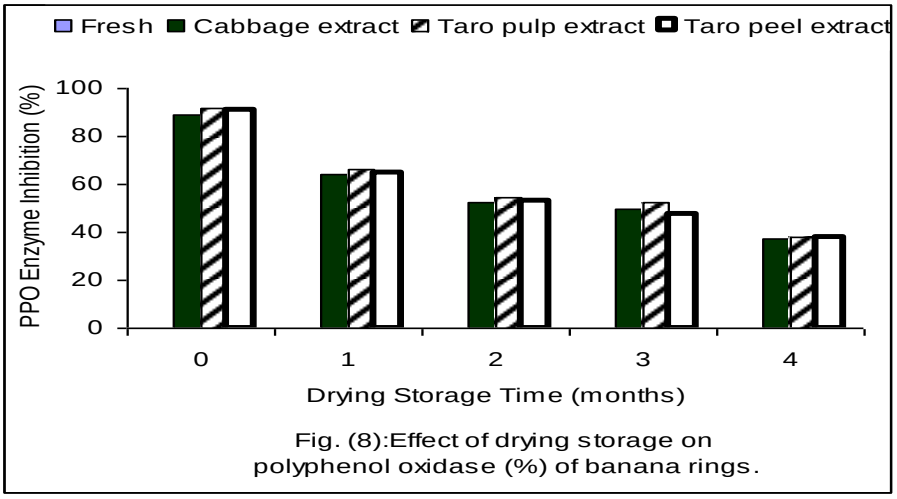

Fig. (8):Effect of drying storage on polyphenol oxidase (%) of banana rings.

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

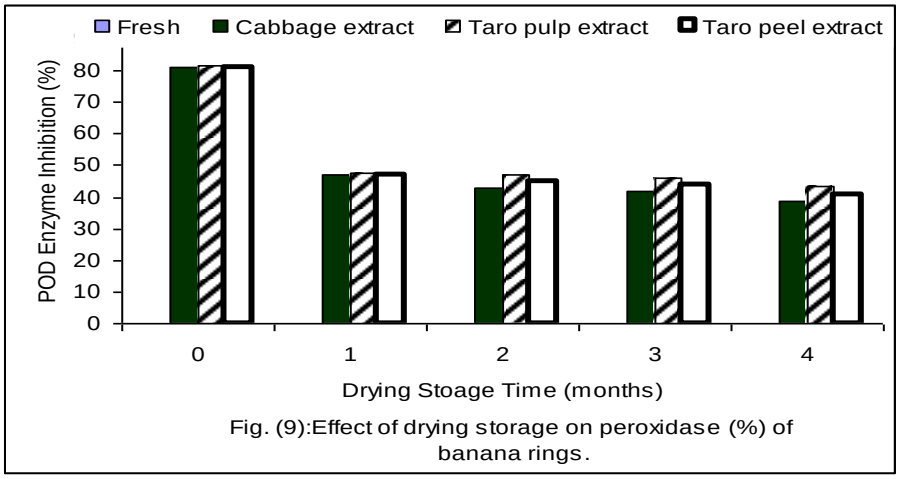

Fig. (9):Effect of drying storage on peroxidase (%) of banana rings.

The percentage of inhibition for cabbage extract were 81.06-38.46%, while 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 banana rings caused an inhibition in catalase (CAT) enzyme compared to untreated banana (Fig. 10). The inhibition percentage 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.

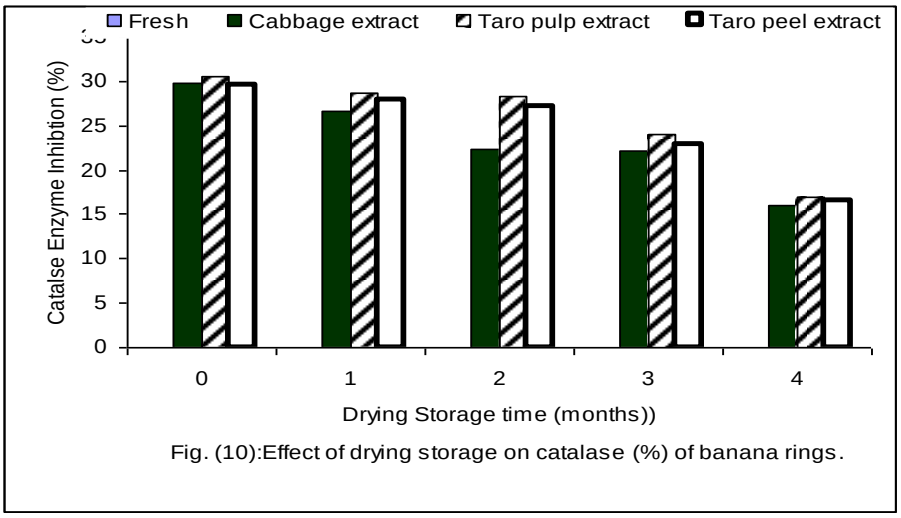

Fig. (10):Effect of drying storage on catalase (%) of banana rings.

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).

CONCLUSION

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 banana pulp and dried banana 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 banana rings and frozen banana pulp. Our data suggest that the pre-treatments of banana rings with cabbage and taro extracts incorporating the anti-browning compounds. Dried banana rings and frozen banana 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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تـأثير مستخلصـات الكرنـب و القلقـاس الطبيعيـة علـى نشـاط الانزيمـات المؤكسـدة لمنتجات الموز المجمد و المجفف

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تـم فـى هـذه الدراسـة معرفـة تـأثير المعـاملات المبدئيـة لمستخلصـات لـب و قشـر القلقاس مـع مقارنتهـا بمستخلصـات الكرنـب علـى نشـاط الانزيمـات المؤكسـدة للـب و حلقـات الموز لمعرفـة تـأثير المعـاملات المبدئيـة و التجميد و التجفيف علـى نشـاط هذه الانزيمـات و خصـائص اللـون و محتـوى الفينـولات الكليـة . حيـث وجـد أن التركيـز الأفضـل استخداماً لمستخلصـات الكرنـب و مستخلصـات لـب و قشـر القلقـاس هـو ١٥% و الـذى يحسن المنتج النهـائى و يثبط الثلاث إنزيمـات المؤكسدة (PPO, POD and CAT) و أوضـحت النتـائج ان درجـة التثبيط العاليـة للثلاث انزيمـات المؤكسدة فـى لـب و حلقـات المـوز كانـت باسـتخدام مستخلصـات لـب القلقـاس ثـم بمستخلصـات قشـر القلقـاس بينمـا العينـات المعاملـة بمستخلصـات الكرنـب و العينـات الغيـر معاملـة بينـت انخفـاض بسيط فـى نشـاط الانزيمـات المؤكسدة الثلاثة و قد ثبت ان حلقـات المـوز المعاملـة باسـتخدام مستخلصـات لـب القلقـاس ثـم بمستخلصـات قشـر القلقاس و المجففة كانت عينات ذات درجة التثبيط العالية للثلاث انزيمـات المؤكسدة مقارنـة بعينات لب الموز المجمد و العينات الغير معامله. نتـائج محتـوى الفينـولات الكلية أشارت الى أن حلقات الموز المجففة بعد المعاملـة المبدئيـة باسـتخدام مستخلصـات لـب القلقاس و بمستخلصـات قشر القلقاس بمستخلصـات الكرنـب كانـت أقل فـى محتـوى الفينـولات الكلية عن لب الموز المجمد بعد المعاملة المبدئية باستخدام نفس المستخلصـات .

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