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COLOR CHARACTERISTICS AND ENZYME ACTIVITY OF PEROXIDASE AND POLYPHENOLOXIDASE IN DIFFERENT WHEAT CULTIVARS AND THEIR PASTA:

1- EFFECT OF MILLING PROCESS ON COLOR CHARACTERISTICS AND ENZYME ACTIVITY OF PEROXIDASE AND POLYPHENOLOXIDASE IN DIFFERENT WHEAT CULTIVARS

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ABSTRACT

The activity of polyphenoloxidase (PPO) and peroxidase (POD) by milling different durum and soft wheat cultivars was investigated. Also, non-enzymatic browning and color characteristics were determined in milled different durum and soft wheat wheat cultivars. Milling whole-grain into bran and semolina markedly decreased POD and PPO activities in semolina fraction and increased in bran fraction. The highest activity was found in bran fraction. The POD and PPO activities were much higher both in bran fraction and whole kernel for all eight-wheat cultivars than of in semolina fraction. The PPO activity in the bran fraction was three times higher than that semolina fraction, and POD activity was six times greater. No difference in the non-enzymatic browning recorded at 420nm was found between different wheat and different wheat fractions. Results are obvious that milling process of wheat increased the development of red colour parameter a*. The a*-values were in the range of (4.39-6.09) in whole meal, decreased to (1.10-3.02) in semolina fraction and increased to range (6.28-7.65) in bran fraction of different wheat cultivars respectively. The Hunter colour values of semolina fraction of different wheat cultivars were lower than those of bran fraction. Other color parameters such as Hue angle and chroma also indicated that heat from milling process caused a slight color change. Results indicates that whole meal, bran and semolina become yellow-green but was still reddish because the hue angle was positive. The samples of bran fraction had a BI value higher 6 times than those of the semolina fraction. But, BI values of whole meal were lower than those of the bran fraction and higher than in semolina fraction. Results demonstrated that wheat cvs. without bran and/or with low in POD and PPO activities would be suitable for pastamaking.

Keywords: Milling, Polyphenoloxidase, peroxidase, wheat, non-enzymatic browning, and color characteristics.

INTRODUCTION

Balanced diets high in carbohydrates can help to protect against coronory heart disease by decreasing some of the most important risk factors such as blood cholesterol and triglycerides. Since 1980, more emphasis was given to the relative importance of available and unavailable carbohydrates. Thus, various sources of dietary fibers obtained from cereals (brans and germs) were shown to have beneficial effects on triglyceride or cholesterol metabolism in animals as well as in humans.

Peroxidase (POD, EC 1.11.1.7.) and Polyphenoloxidase (PPO, E.C. 1.14.18.1.) are present in most plant tissues where due to their catalytic effect enzymatic browning proceeds. The course of enzymatic browning is affected by phenol compounds as well as O-diphenol oxidase activity (Hsu *et al,* 1988). These enzymes catalyze the oxidation of free, reduced phenolic compounds to quinones, which react to form brown pigments. POD and PPO enzymes are present largely in the bran fraction of milled wheat, and their levels in flour rise with increasing extraction rate (Baik *et al,* 1994). Much of the browning is thought to be caused by two enzymes present in wheat, O-diphenol oxidase, also known as polyphenoloxidase (PPO) and peroxidase (POD) (Baik *et al,* 1995). Enzymatic browning of some plants is caused by the activity of polyphenoloxidase (PPO) on polyphenol substrates. PPO in the presence of oxygen affect polyphenol compounds that oxidise to brown coloured quinones. These could be condensed to insoluble high molecular products in the next step that can cause dark color of wheat products.

POD and PPO (oxidoreductases) are widely distributed in higher plants. POD and PPO have also been used as genetic markers and indicators of food quality. In food products, they often play a negative role. Indeed, they are well known for their contribution to the deteriorative changes in flavor, texture, color and nutritional value of processed fruits and vegetables. While considerable work has been done on plant POD and PPO, little is known relatively about POD and PPO in wheat (Icri *et al,* 1995).

A large variability in POD and PPO activities was found between wheat cultivars. Pasta products made from cultivars containing a high POD and PPO activities develop an undesirable brownish color during processing. POD and PPO activities were positively correlated to the brown index of pasta products. However, no data are available regarding the localization of POD and PPO in wheat kernels, and this study was undertaken to address this situation, especially in relation to pasta brownness. Friedman (1996), found that non-enzymatic browning in some foods could be due to the reactions of sugars, amino acids and ascorbic acid. It leads to the formation of a wide variety of end products including organic acids, furans, furanones, ketones, pyrroles, pyranones, and cyclopentanones. Many of these compounds contribute to the off-flavors in the final product. He demonstrated that enzymatic and non-enzymatic browning reactions of amino acids and proteins with carbohydrates, oxidized lipids, and oxidized phenols cause deterioration of food during storage and processing.

The peroxidase and the phenols necessary for the develcpment of black point symptoms are also components of barley grains (Cochrane, 1994). Peroxidase plays an important role in stress related process (Breda *et al,* 1993) and is responsible for browning in most damaged tissues. Cochrane (1994) also demonstrated that barley germ aleurone cells could produce endogenous hydrogen peroxide, which is essential for peroxidation to talk place. Regnier and Macheix (1996) found that peroxidase activity was the highest in the susceptible cultivar prior to grain maturity in a black point susceptible durum cultivar and a moderately resistant cultivar.

Cereal bran and germs could be ingested separately as raw (uncooked) food supplements, but consumption of various processed whole-

grain foods is increasing. Therefore the present work was designed to study the effects of milling on polyphenoloxidase and peroxidase enzyme activities in different fractions of different wheat cultivatars. The effects of milling on the non-enzymatic browning and color characteristics different fractions of different wheat cultivatars were also studied. For this study, About eight wheat cultivars those yeild pasta product with very different colors.

MATERIALS AND METHODS

1-Raw durum and soft wheat:

Four-durum wheat (Triticum durum L.) and three soft wheat (Triticum aestivum L.) cultivars (among those most used in Egypt, harvest 2004) were obtained from Crop Research Institute, Agriculture Research Centre, Giza, Egypt. The forth cultivars of durum wheat were Banswef1, Banswef3, Sohag2 and Sohag3, but Sids1, Sakha69 and Giza168 are soft wheat. One other wheat cultivar was a gift of Rogina Egyptian company in 10th Ramadan City.

2-Milled samples:

Kernels from durum and soft wheat and different milling fractions, i.e. whole grain, bran and semolina were obtained during preparation of semolina in an industrial plant by Crop Research Institute, Agriculture Research Centre. All samples were ground using a laboratory apparatus (Barabender, Germany) for three times, then analyzed immediately.

3- Assay of enzymes activity:

3-1-Peroxidase (POD)

Whole grain, bran and semolina were homogenized in 100ml of 0.2mM sod. Phosphate buffer at pH 7 in a laboratory blender. The homogenate was centrifuged at 5000 xg at 4°C for 10 min. The supernatant was stored at 25°C until measurement or assay (Sulman *et al,* 2001).

Peroxidase activity was measured using a reaction mixture consisting of 2.85ml of 0.04% (w/v) guaiacol and 4% H_2O_2 as substrate. The reaction was initiated by adding 100uL of the peroxidase extract and allowing it to react for 1min at 25°C. Absorbance/30second was measured at 350nm for 3min in the linear range of a 4054 UV/ Visible Spectrophotometer, LKB-Biochrom (Sweden), according to the method of Sulman *et al,* (2001). The total activity was expressed in unit per gram.

One unit is the amount of enzyme that gives 0.1 abs. at 25°C in 3ml of reaction mixture.

3-2-Polyphenoloxidase (PPO)

Whole grain, bran and semolina were homogenized in 100ml of 0.2mM sod. Phosphate buffer at pH 7 in a laboratory blender. The homogenate was centrifuged at 5000 xg at 4°C for 10 min. The supernatant was stored at 25°C until measurement or assay (Anderson and Morris 2003).

Polyphenoloxidase (PPO) activity was measured using 2ml catechol 0.1M as substrate. The reaction was initiated by adding 1ml of the polyphenoloxidase extract at 25°C. Absorbance/30second was measured at 475nm for 3min in the linear range of a 4054 UV/ Visible spectrophotometer, LKB-Biochrom (Sweden), according to the method of Anderson and Morris (2003).

One unit of PPO enzyme activity was defined as a change in absorbance of 0.001/min in a 1cm path at 475nm.

4- Non-enzymatic browning determination

Non-enzymatic browning was measured spectrophotometrically by the method of Stamp and Labuza, 1983. Duplicate 2g samples were covered with 30ml ethanol in flasks. The flasks were covered and held about 24hours at room temperature. The samples were filtered and absorbance was measured at 420nm. by 4054 UV/ Visible spectrophotometer, LKB-Biochrom (Sweden).

5- Color determinations:

Hunter a*, b* and L* parameters were measured with a color difference meter or the color of wheat was measured using a spectro-colorimeter (Tristimulus Color Machine) with the CIE lab color scale (Hunter, Lab Scan 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). Color difference, Delta E, was calculated from a*, b* and L* parameters, using Hunter-Scotfield's equation (Hunter, **1975**) as follows.

Delta E = $(\text{delta } a^2 + \text{delta } b^2 + \text{delta } L^2)^{1/2}$

where : $a-a_o$, $b-b_o$ and $L-L_o$; subscript "$_o$" indicates color of control or untreated sample.

The Hue (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 $[a^{2*} + b^{2*}]$. .....(2)

BI = [100 (x-0.31)] 10.72..... .....(3)

Where:-

$X = (a^* + 1.75L^*) / (5.645L^* + a^* - 3.012b^*)$

RESULTS AND DISCUSSION

1-Effect of milling on enzymatic browning of POD and PPO activities in wheat fractions of different wheat cultivars:

Milling whole-grain of various cereals to white flours with extraction rates in the range 70-72% led to considerable losses of the activity of POD and PPO enzyme (Figs 1-8) from 20 to 90%. These data confirmed a previous report on soft wheat flours with variable extraction rates (Cara *et al,* 1992). This led to the assumption that the essential part of the POD and PPO enzyme activities of various cereals is localized in the germ and in the outer layers of the kernel.

With Rogena wheat, the PPO and POD enzyme activities were determined separately in whole-grain, bran and semolina containing fraction. The bran showed a very high PPO or POD activity (0.000932 and 0.001196unit/ml), while the whole grain exhibited only moderate activity (0.000583 and 0.000431unit/ml) representing 62 and 44% that of the whole grain. The semolina fraction showed a very low PPO and POD activity

(0.00039 and 0.000287unit/ml), as seen in Fig (1-8). The data indicated that the inhibitory activity did not exhibit great losses i.e. a loss of 5% in the bran, and 33% in the semolina fraction, as seen in Figs (1-8).

The total POD and PPO activities of three major kernel fractions, semolina (mainly corresponding to the starchy endosperm with minor contamination by other parts of the seed), bran (including the pericarp, the seed coat, and the aleurone layer in a regular milling) and whole kernel of eight wheat cultivars (Sids1, Sakha69, Giza168, Banswef1, Banswef3, Sohag2, Sohag3 and Rogina) showed quantitative differences between the eight cultivars and also between the three kernel fractions, as seen in Figs (1-8). The POD and PPO activities were much higher both in bran and whole kernel for all eight wheat cultivars than in semolina. Thus, the POD activity in the bran was 3.5x higher for Sakha69, Giza168, Banswef1, Sohag2, Sohag3 and Rogina than PPO activity for Sids1 and Banswef3. But in semolina and whole kernel samples, the POD activity was higher in Sakha69, Giza168, Banswef1, Sohag2 and Sohag3 than in PPO activity for sids1, Banswef3 and Rogina. Similar results could be observed by Marrie-Pierre *et al* (2000), who reported that the POD activity was much higher both in bran and in semolina for Ardente than for Primadur.

The PPO activity in the bran was three times higher than the level of semolina, and POD activity was six times greater. Also, similar results could be observed by Vadlamani and Seib (1996), who reported that the PPO activity in the milled bran was six times higher than the level of milled flour, and POD activity was three times greater.

However, both the PPO and POD activities for the eight cultivars were similar in the whole kernel fraction.

For Banswef1, the POD and PPO activities were similar in bran and in semolina; for Sohag3 it was 14x higher in bran than in semolina.

Among the three kernel fractions, the greatest POD and PPO activities were concentrated in bran fraction. The POD and PPO activities in the bran were 3 and 6x higher than the sum of the POD and PPO activities of whole kernel and semolina of eight wheat cultivars, respectively, as seen in Figs (1-8).

Great difference was found regarding the distribution of POD and PPO activities in the kernel between the studied eight cultivars, as seen in Fig 1-8. These results are not in accordance with those observed by Marrie-Pierre *et al* (2000), who reported that no difference was found regarding the distribution of POD activity in the kernel between the studied two cultivars (Ardente and Primadur).

Altogether, the histological localization techniques used here showed that POD and PPO were distributed in many different parts of the kernel but the distribution was not homogenous. Great varietal differences were revealed between eight wheat cultivars, as seen in Fig 1-8.

Fig (1): Effect of milling on POD and PPO activities in sids w heat fraction

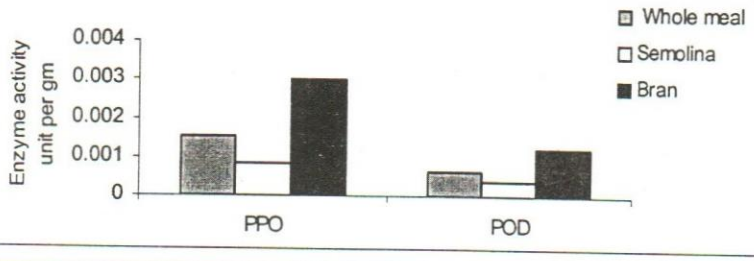


Fig (2): Effect of milling on POD and PPO activities in Banswef 1 wheat fraction

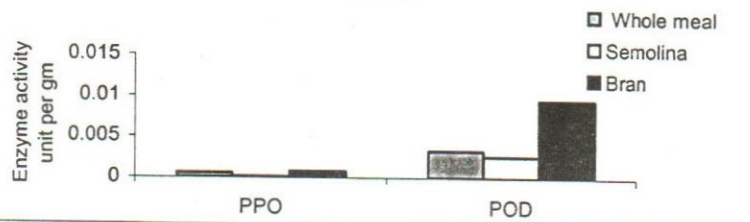


Fig (3): Effect of milling on POD and PPO activities in Banswef 3 wheat fraction

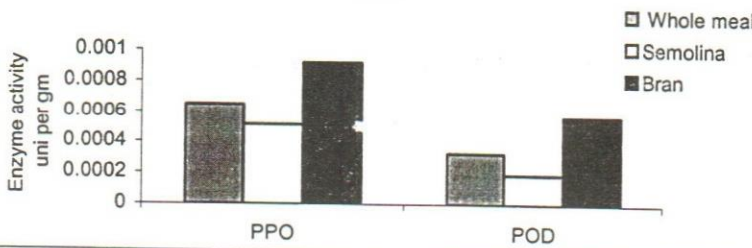


Fig (4): Effect of milling on POD and PPO activities in Sohag 2 w heat fraction

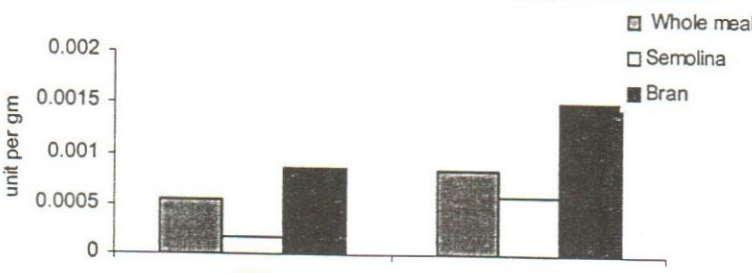


Fig (5): Effect of milling on POD and PPO activities in Sohag 3 w heat fraction

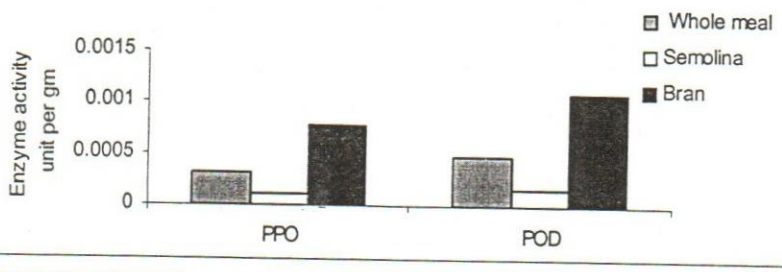


Fig (6): Effect of milling on POD and PPO activities in Giza168 wheat fraction

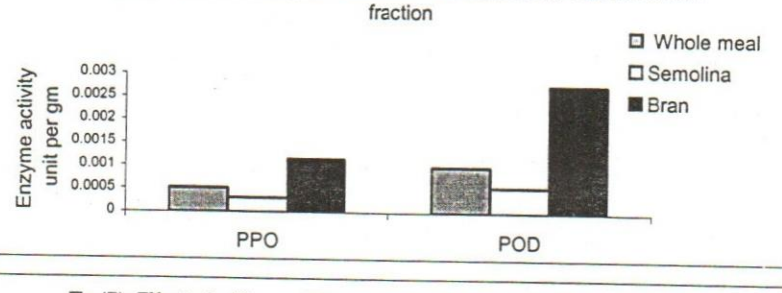


Fig (7): Effect of milling on POD and PPO activities in Sakha69 w heat fraction

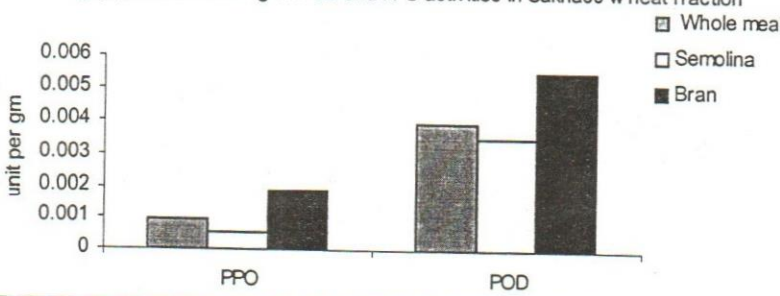
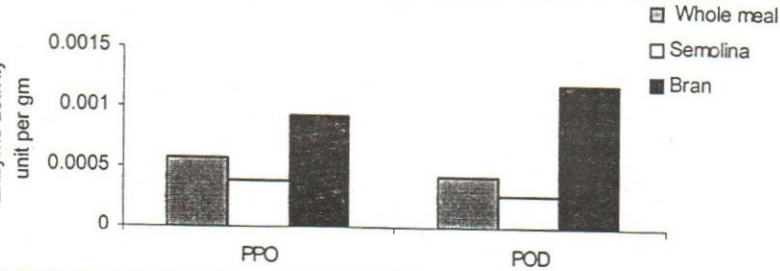


Fig (8): Effect of milling on POD and PPO activities in Rogena w heat fraction



The variation in enzyme activities observed in this study showed very important data about the localization and distribution of PPO and POD inside the wheat kernel. PPO and POD activity measurements showed great differences between eight wheat cultivars. Among kernel fractions, the greatest differences were between samples of semolina, which is used to produce pasta (Marrie-Pierre *et al,* 2000).

In the milling fractions, different POD and PPO activities (Figs 1-8) were found. The greatest specific POD and PPO activity was found in the bran.

On the other hand, the localization of POD in cap root cells may suggest that these enzymes are associated with the secretion function of these cells or act as a barrier to pathogenic attack. Outside the embryo tissue, POD were localized in the cell wall of different layers in the periphery of kernel, except for the aleurone layer, where POD was found inside the cells. POD could also be synthesized in these cells and then could be addressed toward the cell walls where they become active. This would explain why there was a gradient of POD activity from the outside toward the center of the kernel (Marrie-Pierre *et al,* 2000 and Doehlert and McMullen, 2000).

Kruger and Laberge (1974) found that in the early kernel development of bread wheat, POD and PPO activities were situated largely in the pericarp and in the green layers. With kernel maturation, the activities in these layers decreased, while it increased in the other parts of the kernel (endosperm, embryo, aleurone layer, and scutellum). Thus at the end of maturation the highest activity was found in the embryo and subaleurone layers.

2-Effect of milling on non-enzymatic browning of wheat fractions in different wheat cultivars:

The major non-enzymatic reaction of greatest interest to scientists is the Maillard reaction, which is the dominant browning reaction. The chemical reactions between protein and carbohydrate during milling process could be attributed to Mailllard reaction that caused undesirable changes in the color of the wheat and their products.

Little difference in the non-enzymatic browning recorded at 420nm was found between different wheat cultivars and different wheat fractions. The non-enzymatic browning recorded at 420nm was between 0.076-0.101 in whole meal, followed increased to value 0.090-0.109 in bran fraction and it was 0.088-0.108 in semolina fraction of different wheat cultivars respectively, as seen in table 1.

However, the bran and semolina fractions samples had higher values of color as optical density (A_{420nm}) compared to the whole meal samples in different wheat cultivars. This could be attributed to the reaction occurred between amino groups and active carbonyl groups. These results confirmed with those of Dunber (1986), who found that non-enzymatic browning in the reactions between amino groups and active carbonyl groups leads eventually to the formation of insoluble dark colored poymers collecting known as "melanoiden pigments". Also, Friedman (1996), reported that non-enzymatic browning in some foods could be due to the reactions of sugars, amino acids, and ascorbic acid.

Table (1): Effect of milling on non-enzymatic browning (A_{420nm}) in the fractions of different wheat cultivars.

Wheat cultivars	Non Enzymatic browning (A_{420nm}) in milling fractions		
	Whole meal	Bran	Semolina
Rogena	0.081	0.109	0.108
Bansweef 1	0.101	0.108	0.103
Bansweef 3	0.085	0.105	0.108
Sohag 2	0.097	0.105	0.102
Sohag 3	0.087	0.109	0.105
Sakha 69	0.097	0.109	0.102
Giza 168	0.080	0.099	0.088
Sids1	0.076	0.090	0.092

3- Effect of milling on color characteristics of wheat fractions in different wheat cultivars:

Color is only part of the overall appearance, but is probably a major quality factor in wheat. The surface colour of milled of whole meal, bran and semolina fractions were measured using the Hunter Lab colour scale. This instrument defines colour numerically in terms of its lightness or "L" value (0 = black, 100 = white), "a "value (greenness 0 to -100, redness 0 to +100) and "b" value (blueness 0 to -100 ,yellowness 0 to +100). The mean (average) and standard deviation for the colour of 10 slices were calculated.

Absorption at 420 nm, the CIE L*, a*, and b* values colour parameters were found to be suitable indicators for the brown pigment formation due to non-enzymatic browning after milling process.

Color characteristic measurement directly in the wheat samples with a Hunter Lab Ultra Scan revealed that color did not changed over different wheat samples respectively (Table 2). In this case (L*-values) brightness increased, (a*-values) redness increased and (b*-values) yellowness increased.

The effects of milling of wheat in increasing of the browning reaction or color characteristics are listed in Tables 2 & 3. It is obvious that milling process of wheat increased the development of red colour a*. For example, the a*-values were in the range of (4.39-6.09) in whole meal, decreased to (1.10-3.02) in semolina fraction and increased to (6.28-7.65) in bran fraction of different wheat cultivars respectively, as seen in Table (2). The Hunter colour value of semolina fraction with different wheat cultivars was lower than that of bran fraction.

As shown in Table (2), the a*-values were in the range of (4.39-6.09) in whole meal, decreased to (1.10-3.02) in semolina fraction and increased to range (6.28-7.65) in bran fraction of different wheat, respectively. These results indicated that the browning (redness) was increased in bran wheat fraction than in semolina and whole meal fractions for different wheat cultivars, respectively. However, PPO and POD enzyme activity were higher in bran fraction than both in semolina and whole meal fraction, seen in Figs 1-8.

Also, the L*-values were in the range of (69.53-77.92) in whole meal, increased to (80.60-89.65) in semolina fraction and decreased to range (64.01-69.18) in bran fraction of different wheat cultivars, respectively.

Table (2): Hunter Lab colors in the fractions of different wheat cultivars .

Milling fractions	Color values	Hunter Lab color values in different wheat cultivars							
		Rogena	Banswef1	Banswef3	Sohag2	Sohag3	Sakha69	Giza168	Sids1
Whole wheat	L*	71.99	72.37	71.21	73.36	69.53	77.92	69.62	72.80
	a*	5.30	4.56	4.65	4.75	4.40	3.05	6.09	4.39
	b*	22.61	21.27	21.68	21.58	20.19	14.21	21.92	17.04
Semolina	L*	85.01	82.50	82.43	81.25	80.60	89.65	86.87	86.47
	a*	1.95	2.67	2.56	3.01	3.02	1.10	2.16	1.98
	b*	25.42	16.49	17.24	17.62	17.07	8.70	13.61	11.32
Bran	L*	68.09	65.16	65.63	64.01	65.20	69.18	68.46	66.12
	a*	7.14	7.05	7.27	7.65	7.38	6.28	7.15	7.29
	b*	24.92	24.50	24.20	25.38	24.62	21.23	24.01	23.79

Table (3): Hunter Lab colors parameters in the fractions of different wheat cultivars.

Milling fractions	Color values	Hunter Lab color values in different wheat cultivars							
		Rogena	Banswef1	Banswef3	Sohag2	Sohag3	Sakha69	Giza168	Sids1
Whole wheat	H*	77.88	77.70	77.58	77.89	77.89	76.81	75.55	74.47
	C*	14.53	20.66	22.09	22.17	21.75	23.22	17.59	22.75
	BI	41.19	69.83	70.98	73.66	70.67	77.29	55.78	79.41
Semolina	H*	82.79	79.96	80.30	81.55	80.80	85.61	80.07	80.98
	C*	8.77	17.33	17.87	17.43	16.70	25.49	11.49	13.78
	BI	19.80	47.53	48.62	46.05	44.15	66.35	28.07	33.72
Bran	H*	73.51	73.31	73.22	73.27	73.94	74.01	72.96	73.41
	C*	22.14	25.70	26.51	25.27	25.49	25.92	24.88	25.05
	BI	77.81	99.93	106.19	97.10	98.78	95.52	94.56	91.27

In order to maintain quality, the color of food products must be measured and standardized. If a food is transparent, like a juice or a colored extract, colorimeters or spectrophotometers can be used for color measurement. The color of liquid or solid foods can be measured by comparing their reflected color to define (standardized) color tiles or chips. For a further measurement of color, reflected light from a food can be divided into three components: value, hue, and chroma. The color of a food can be precisely.

Hue angle was increased in semolina fraction (79.96-85.61) and decreased in bran fraction (72.96-74.01) compared with whole meal (74.47-77.89) in different wheat cultivars, respectively (Table 3). Whereas, hue angles of whole meal were smaller than hue angles of semolina fraction and were greater than in bran fraction in different wheat cultivars, respectively, as seen in Table 3.

Chroma (saturation index) in whole meal was in the range of (14.53-23.22), but chroma of semolina fraction (8.77-17.87) was lower than that of bran fraction (22.14-26.51) in different wheat cultivars, respectively, as seen in table (3). This indicates that whole meal, bran and semolina become yellow-green but was still reddish because the hue angle was positive, as seen in Table (3). Hunter Color results indicate that the bran was darker and redder after milling process. These results are in accordance with the same results of D'Egidio and Pagani (1997) discussed that the effect of milling process on color in raw material and durum wheat processing which affect pasta colors.

According to the obtained results in this study, the main color change in bran fraction was due to increase in chroma, browning index and a*-value, which were in high correlation to browning measurement. Sapers and Douglas (1987) reported that decrease and increase in the CIE L* value and a* value respectively correlated well with increases in apple browning.

Other color parameters such as Hue angle and chroma also indicated that heat caused a slight color change. Similar results have been noted by Lee, 1997 who showed that the color parameters such as reflectance, Hue angle and chroma also indicated that heat caused a slight color change of grapefruit juice. The browning index was calculated using the aforementioned equation (eqn.3), for whole meal, semolina and bran fractions and the results represented in Table (3). It is clear that the bran fraction higher in BI values. The BI values of bran fraction were higher 6 times than those of the semolina fraction. But, BI values in whole meal were lower than those of bran fraction and higher than in semolina fraction, as seen in Table (3). These results are in good agreement with those of Palou *et al* (1999), Lee (1997) and Genovese *et al,* (1997).

CONCLUSION

The POD and PPO activities were much higher in both bran fraction and whole kernel for all eight-wheat cultivars than in semolina fraction. However, POD and PPO activities have been associated with the brown color of pasta and our results tend to confirm this assumption.

Results could be concluded that the more efficient way to improve the color of the pasta appears to be selection of new cultivars that are especially lacking or reducing POD and PPO activities from the whole kernel.

REFERENCES

Anderson J. and C.Morris (2003). Purification and analysis of wheat grain polyphenoloxidase (PPO) protein. Cereal Chem. 80: 135-143.

Baik B., Z. Czuchajowska and Y. Pomeranz (1994). Comparison of polyphenoloxidase activities in wheats and flours from Australian and U.S. cultivars. J. Cereal Sci. 19:291.

Baik B., Z. Czuchajowska and Y. Pomeranz (1995). Discoloration of dough for oriental noodels. Cereal Chem. 72:198.

Breda, M., Quesada M., Kononowicz A., Bressan R., Hasagawa P. and Valpuesta V. (1993) Plant Mol. Biol. 25:105-114.

Cara L., P. Borel, M. Armand, H. Lafont, G. Lesgards and D. Lairon (1992). Milling and processing of wheat and other cereals affect their capacity to inhibit pancreatic lipase in vitro. Journals Food Sci..57:466-469, 484.

Cochrane M.P. (1994). Annals of Botany 73:121-128. C.F. Sulman Maria, G.Fox , A. Osman, I. Andy, P. Williamson and M. Mirian (2001). Proceedings of the 10th Australlian Barley Technical Symposium.

D'Egidio M. and M. Pagani (1997). Effect of the different stages of durum wheat chain on pasta colour. Italian-Food-&-Beverage-Technology. 10: 17-20

Doehlert-DC and McMullen-MS, (2000). Genotypic and environmental effects on oat milling characteristics and groat hardness. Cereal-Chem. 77: 148-154.

Dunber J. (1986). Use of sulfur dioxide in commercial drying of fruits and vegetables. Food Technology in New Zealand, 21: 11.

Fraignier M., N. Ferriere and K. Kobrehel, (2000). Distribution of peroxidases in durum wheat (Triticum durum). Cereal chem.77: 11-17.

Friedman M. (1996). Food browning and its prevention:An overview.J. Agric. Fd Chem.44: 631-653.

Genovese D., M. Elustondo and J. Lozano (1997). Color and cloud atabilization in cloudy apple juice by steam heating during crushing. J. Food Sci. 62: 1171-1175.

Hsu A. J., G. Shieh, D. Bills and K. White (1988). Inhibition of mushroom polyphenoloxidase by ascorbic acid derivatives. J. Food Sci. 53: 765-767,771.

Hunter R. S. (1975). Scales for measurements of color differences. In Measurement for Appearances, J. Wiley, Ed., p. 133. Interscience. New York.

Iori R., C. Barbara and P. Sandro (1995). Cathodic peroxidases of durum wheat flour. Cereal Chem. 72: 176-181.

Kruger J.and D. Laberge (1974). Changes in peroxidase activity and peroxidase isozyme patterns of wheat during kernel growth and maturation. Cereal Chem. 51:345-354.

Lee H. (1997). Issue of color in pigmented grapefruit juice. Fruit processing. 4: 133-135.

Marrie-Pierre, F., M. Nicole and K. Karoly (2000). Distribution of peroxidases in durum wheat. Cereal Chem. 77: 11-17.

Palou E., A. Lopez-Malo, G. Barbosa-Canovas, J. Chanes-Welti and W. Swanson (1999). "Polyphenoloxidase and colour of blanched and high hydrostatic pressure treated banana puree" J. Food Sci. 64: 42-45.

Regnier T. and J. Macheix (1996). J. Agric. Fd Chem. 44: 1727-1730. C.F. Sulman Maria, G.Fox , A. Osman, I. Andy, P. Williamson and M. Mirian (2001). Proceedings of the 10th Australlian Barley Technical Symposium.

Sapers G. and F. Douglas (1987). Measurement of enzymatic browning at cut surfaces and in juice of raw apple and pear fruits. J. Food sci.52: 1258-1262, 1285.

Stamp J. and T. Labuza (1983). Kinetics of the Maillard reaction between Aspartame and Glucose in solution at high temperatures. J. Food Sci. 48: 543-544,547.

Sulman Maria, G. Fox, A. Osman, I. Andy, P. Williamson and M. Mirian (2001). Relationship between total peroxidase activity and susceptibility to black point in mature grain of some barley cultivars. Proceedings of the 10th Australlian Barley Technical Symposium.

Taha S. and F. Sagi (1987). Relationships between chemical composition of durum wheat semolina and macaroni quality. II. Ash, carotenoid pigments, and oxidative enzymes. Cereal Res. Comm. 15: 123-129.

Vadlamani K. and P. Seib (1996). Reduced browning in raw oriental noodles by heat and moisture treatment of wheat. Cereal Chem. 73: 88-95.

الخصائص اللونية و نشاط إنزيمي البولى فينول اوكسيديز و البيروكسيديز في أصناف مختلفة من القمح و المكرونة الناتجة منهم:

١- تأثير عملية الطحن على الخصائص اللونية و نشاط إنزيمي البولى فينول اوكسيديز و البيروكسيديز في أصناف مختلفة من القمح

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تأثير عملية الطحن على الخصائص اللونية و التلون غير الإنزيمي و نشاط أنزيمي البولى فينول اوكسيديز و البيروكسيديز فى ثمانية أصناف من القمح و فى نواتج الطحن (الردة و السيمولينا). لوحظ ان طحن الحبة الكاملة الى الردة و السيمولينا يقلل بشكل ملحوظ كل من نشاط أنزيمي البولى فينول اوكسيديز و البيروكسيديز فى السيمولينا و يزيدا في الردة. و كان نشاط انزيمى البولى فينول اوكسيديز و البيروكسيديز أعلى فى الردة و الحبة الكاملة عن السيمولينا فى أصناف القمح الثمانية. و كان نشاط انزيمى البولى فينول اوكسيديز أعلى ثلاث مرات في الردة عن السيمولينا و نشاط البيروكسيديز كان أعلى ست مرات. كما لوحظ انه لا يوجد اختلاف كبير فى التلون غير الإنزيمي عند امتصاص ضوئى ٤٢٠نانوميتر بالاجزاء المختلفة من الطحن و بالأصناف المختلفة من القمح. والنتائج أوضحت ان عملية الطحن للقمح تزيد من تركيز اللون الأحمر. فمثلا قيم ال a كانت في مدى ٤,٣٩-٦,٠٩ بالحبة الكاملة و انخفضت إلى ١,١-٣,٠٢ فى السيمولينا و زادت الى ٦,٢٨-٧,٦٥ فى الردة بالترتيب بأصناف القمح المختلفة.أيضا أوضحت النتائج أن قيم اللون باستخدام جهاز Hunter فى السيمولينا بالأصناف المختلفة من القمح كانت اقل عن التى توجد بالردة. و الثوابت الأخرى اللونية مثل Hue angle and chroma أيضا تشير الى أن الحرارة الناتجة من الطحن سببت تغير بسيط فى اللون. كما أشارت النتائج إلى أن الحبة كاملة و الردة و السيمولينا أصبحت لونها أصفر مخضر لكن لاتزال قريبة من اللون الأحمر و ذلك يرجع إلى أن قيم hue angle كانت موجبة. و ان قيم دليل التلون البني (BI) في الردة كان أعلى ست مرات عنة في حالة السيمولينا. لكن دليل التلون البني (BI) في الحبة الكاملة كان اقل فى حالة الردة و أعلى في السيمولينا. و أخيرا أوضحت النتائج أن أصناف القمح المختلفة بدون الردة و/أو ذات النشاط المنخفض من إنزيمي البولى فينول اوكسيديز و البيروكسيديز تكون مناسبة لصناعة المكرونة.