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Effect of thermal treatment on antioxidant activity and colour of carrot purées

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Abstract Total antioxidant activity, levels of bio-active compound groups and instrumental colour of carrot purée subjected to thermal treatment (70°C/2 min) were measured. The method applied to the dosage of ascorbic acid was with 2,6-diclorophenolindophenol. Total phenols (TP) in purée were determined using the Folin-Ciocalteau method and antioxidant activity by the use of DPPH free radical method. The colour of the samples was measured using a Hunter-Lab colour meter. Heat treatment caused a rapid decrease in ascorbic acid. Phenolic contents were in general unaffected by thermal treatment. Colour parameters were significantly affected by thermal treatment. This provides a helpful tool for understanding the effect of processing on colour variation of carrot purée in a broader spectrum. Industrial relevance: This research paper provides scientific evidence of the influence of thermal treatments in retaining important bioactive compounds.

Keywords: antioxidant activity, carrot, total phenols, colour

1. Introduction

Consumer interest in health and wellness prompted the food industry to develop alternative processing technological solutions for preserving foods [1-5]. To prolong the shelf life of food products, processing is often necessary (e.g. freezing, drying, heating) [6]. Freeze-drying produces the highest quality food products, but it is the most expensive method of preservation. Osmotic dehydration is a simple and inexpensive alternative process, which has low capital investment and also offers ways to save highly perishable products and makes them available for regions away from production zones [7]. In order to extend the shelf life of food products, they are usually treated thermally using methods such as hot water immersion [8]. Pressure applications (up to 700 MPa with or without addition of heat) can result in either pasteurization or sterilization of food products depending upon the intensity of combined pressure-heat treatment [9].

Carrot (*Daucus carota* L.) is one of the most important cool season root vegetables grown extensively in various countries, particularly during the winter season in tropical regions and during the summer season in temperate countries. Carrots provide valuable components indispensable for the development and proper functioning of the human body [10]. The carrot is a good source of natural antioxidants, especially carotenoids and phenolic compounds [11]. Carotenoids represent a large group of phytochemicals that may contribute to health and disease prevention [12]. Furthermore, because of the high antioxidant activity, coloring food with black carrot juice is healthy as it may provide health benefits against chronic and life style diseases [13]. Carrot juices are preferably used as a natural source of provitamin A in the production of alpha-tocopherol-beta-carotene drinks because of its high content of β-carotene [14]. The carrot is known for its appreciable amounts of vitamins B_1, B_2, B_6 and B_{12} and minerals. Carrot roots are used as salads, cooked vegetables, in preparations of soups, stews, curries, sweetmeats, juices, flakes and fermented pickles.

While many authors have assessed the effect of thermal processing on the nutritional properties of foods, such as antioxidant capacity [15], few authors

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attempted to link their studies with quality measurement such as instrumental colour analyses. A principal objective of the present study was to assess the effect of thermal treatment for retaining the antioxidant capacity. We also monitored the colour parameters which can be linked to the visual quality of the purées, an important parameter for consumer acceptance.

2. Experimental

2.1. Preparation of vegetable purées

Carrots (*Daucus carota* L.) were obtained from a local market. After washing and dicing samples were blended in a mechanical blender (model, R 555, ROHNSON, Romania). Samples were packed and stored at –20°C until required for thermal treatment.

2.2. Thermal treatment

The packed samples (250 g) were boiled in water for 21 – 26 s at which time they had achieved a core temperature of 70°C. After thermal treatment, samples were removed, cooled at room temperature and tested for antioxidant indices and instrumental colour on the same day.

2.3. Ascorbic acid determination

Determination of vitamin C [16] content in carrot purée was achieved by titration with 2.6-diclorophenolindophenol (reagent Tillmans). The method is based on colour change of the reagent, oxidation or reduction. Thus, the ionized form of 2,6-diclorophenolindophenol is red in acid and blue in basic medium. Dehydroascorbic acid is obtained through reaction with vitamin C, and after reducing the identification reactive, 4-(p-hidroxiphenil-amino)-2.6-dichlorophenol. This method is commonly used, due to the fact that it is easy to use and due to the reagent sensitivity.

2.4. Total phenols

Total phenols [17] were determined using the Folin-Ciocalteau reagent. 100 mL sample was transferred to a volumetric flask, to which 500 mL undiluted Folin-Ciocalteau reagent was subsequently added. After 1 min, 1.5 mL 20% ($w \cdot v^{-1}$) Na_2CO_3 was added and the volume made up to 10.0 mL with H_2O. After 2 h incubation at 25°C, the absorbance was measured at 760 nm and compared to a gallic acid calibration curve. Results were expressed as mg of Gallic acid equivalent per 100 g of dry weight of sample.

2.4. 2,2-Di (4-tert-octylphenyl)-1-pycrilhydrazyl (DPPH) scavenging capacity assay

The method used for determining the antioxidant activity [18, 19, 20] of carrot purée extracts is based on scavenging 2,2-Di (4-tert-octylphenyl)-1-picrylhydrazyl (DPPH) radicals. The decrease in absorbance was measured at 515 nm against a blank without extract, using a spectrophotometer. Using a calibration curve with different amounts of DPPH, the IC_{50} was calculated. Antioxidant activities were expressed as the IC_{50} i.e., the concentration of antioxidant required to cause 50% reduction in the original concentration of DPPH radicals under the experimental conditions given. For ease of interpretation antiradical powers were also calculated and defined as the inverse of the IC_{50} value. Finally, the antioxidant capacity of the extracts was compared to that of a synthetic antioxidant (Trolox) and expressed as Trolox equivalent antioxidant capacity values (TEAC).

2.5. Instrumental colour analysis

The colour of the samples was measured using a Hunter-Lab colour meter. The instrument was calibrated using the black and white tiled provided. Colour was expressed in Hunter Lab units L^*, a^* and b^*. Samples of purée were filled into plastic Petri dishes (i.d. 50 mm) taking care to exclude air bubbles and placed under the aperture of the colour meter. Five replicate measurements were performed and results were averaged. In addition, hue angle and chroma were calculated by the following equations:

$$Hue\ angle = tan^{-1}(b^*/a^*) \quad (1)$$

$$Chroma = \sqrt{a^2 + b^2} \quad (2)$$

2.7. Statistics

Samples were assayed in triplicate and results are given as averages ± SD. Student's t test was used

for the statistical evaluation and $p < 0.05$ was considered statistically significant.

3. Results and Discussions

3.1. Effect of thermal processing on antioxidant activity of carrot purée

Anti-radical activity and other antioxidant indices of carrot purée subjected to thermal treatment are presented in **Table 1**. The anti-radical activity of the thermally treated sample was a little higher than for the untreated purée sample. Ascorbic acid levels were nondetectable in all samples. Ascorbic acid levels in the present study were very much susceptible to degradation following processing [4]. The content of total phenols was lower in the sample thermally processed.

Table 1. Effect of thermal treatment on anti-radical activity, total phenols and ascorbic acid content in carrot purées

Sample	Anti-radical activity $(g/L)^{-1}$	Total phenols mg GAE/100 g	Ascorbic acid mg/100 g
Untreated	0.025 ± 0.004	101.20 ± 4.97	nd[a]
Thermally treated	0.029 ± 0.009	91.01 ± 6.89	nd

Values are means ± standard deviation, $n = 3$

[a] Not detectable

Phenolic contents reported here were within the range of those reported elsewhere [8].

3.2. Effect of thermal processing on colour parameters of carrot purée

A significant decrease in colour intensity was observed for thermally treated carrot purée in comparison to the untreated purée. Also, a slight but significant increase in redness was fund for thermally treated carrot purée. Changes in lightness of carrot purée were quite apparent as indicated in **Table 2**, where L^* value of purées were significantly higher for the treated sample as compared to the fresh sample. The dominant colour of carrot purée is a mix of red and yellow.

Since carotenoids are the major pigments present in carrots the increase in hue angle may be a reflection of changes in total carotenoid contents [8]. For example, the carotenoid content was affected by thermal treatment, and this was reflected in the lower hue angle for this sample (Table 2). However this change was not consistent and it appears that a more complex mechanism may be required to explain variations in colour parameters for the carrot purée.

Table 2. Effect of thermal treatment on colour parameters of carrot purées

Samples	L^*	a^*	Colour intensity	Hue angle
Untreated	30.29 ± 0.025	13.54 ± 0.046	34.56 ± 0.032	49.51± 0.098
Thermally treated	30.98 ± 0.034	14.87 ± 0.098	33.24 ± 0.0067	47.78± 0.077

Values are means ± standard deviation, $n = 3$

3.3. Relationship between colour parameters and antioxidant activity

The hue angle and the colour intensity calculated from colour parameters L^*, a^* and b^* of carrot purée samples are illustrated in Table 2, whereas antioxidant indices are shown in Table 1. The redness value increased significantly ($p < 0.05$) when subjected to thermal treatment. This increase was reflected in high antioxidant activity as shown in Table 1. In fact antioxidant activity levels of carrot purée were positively correlated with Hunter a^* values ($r = 0.65$, $p < 0.05$). No significant correlation was observed between antioxidant activity and hue angle.

Higher redness at thermal treatment may be due to better extractability of carotenoids due to disintegration of chromoplast [21, 22].

4. Conclusions

While increases in antioxidant content as noted for carrot purées may appear to be difficult to explain in the present study, this effect has been well documented elsewhere and would appear to be related to an increase in extractability of antioxidants components following thermal treatment rather than

an absolute increase. Nguyen and Schwartz (1999) suggested that homogenization and heat treatment disrupt cell membranes and protein-carotenoid complex, making carotenoids more accessible for extraction [23]. Ascorbic acid levels were nondetectable in all samples. The content of total phenols was lower in the samples thermally processed. The dominant colour of carrot purée is a mix of red and yellow. However, some of the effects of thermal treatment on colour parameters are still ambiguous, therefore additional research is necessary to understand those relationships.

5. References

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