Influence of Drying Process on the Functional Properties of Some Plants

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Abstract
Four green leafy vegetables of Apiaceae family, celery (Garveolens var. Dulce Apium), coriander (Coriander sativum), dill (Anethum garveolens), and parsley (Crispum petroselinum) were used to assess the effect of different drying methods on the antioxidant capacity. The edible parts of these plants were dried in air, convective oven and microwave oven, extracted with methanol. Moisture, total phenols, carotenoids, chlorophyll content and antioxidant capacity were determined in fresh as well as in the dried samples. Fresh plants were characterized with the highest contents of all tested parameters followed by air dried then oven dried and finally microwave dried herbs. Moisture content ranged from 83.40 to 88.32% in fresh parsley and coriander, respectively. Dried samples with different methods showed moisture content between 5.88in dill and 7.49% in coriander. The highest antioxidant capacity was recorded in fresh coriander (80.44%). Total phenol content of tested plants ranged from 0.38 mg gallic acid/g in microwave dried dill to 1.3 mg gallic acid /g in fresh celery. Total carotenoids content was highly affected with the drying process recording the lowest values in microwave dried dill, coriander and celery (13.1, 14.0 and 14.3mg/kg, respectively). The highest loss of chlorophylls was found in microwave dried coriander (87.5%) compared to the fresh state. The results indicated that air drying at room temperature is the most efficient drying method followed by oven drying at 70°C when conserving the beneficial bioactive components was considered.
Keywords: Antioxidants; drying; medicinal plants; pigments

1. Introduction

There has been an increasing interest in different medicinal and dietary plants as well as their antioxidant capacity. Culinary herbs supply some compounds to the diet that are not provided by mainstream fruit and vegetables. Although they are concentrated sources of many phytochemicals, as well as some core nutrients, they are consumed only in small quantities, so their dietary contribution is relatively small and insufficient to show medicinal effects. However, if eaten regularly, herbs could provide useful amounts of beneficial bioactives, including both ubiquitous and less common phytochemicals. Common culinary herbs can come from various different plant families and differ considerably in taste, aroma and chemical constituents. They are all the leafy parts of the plant and have very strong flavors and aromas. Most common herbs, however, come from two main families, the Apiaceae and Lamiaceae. Family members often have compounds in common, and may therefore also have similar bioactivity as well as aromas. The compounds most studied in herbs are phenolics and essential oil components. Besides the antioxidant activity, phenolic compounds have anti-inflammatory, anti-allergic, anti-microbial and anti-cancer properties (Hedges and Lister, 2007). The fresh herbs are usually consumed with meals or might be dried by different ways. People are used to dry some leafy plant material in order to keep the herbs for future using and reducing the risk of contamination. Drying is an effective method that increases the shelf life of the final product by slowing the growth of microorganisms and preventing certain biochemical reactions that may alter their characteristics. Drying of plants can be performed using different methods. Natural drying (shade and sun drying) and hot air drying are still most widely used methods because of their lower cost (Soysal and Öztekin, 2001). During the drying process, it is well known that numerous physical, chemical and nutritional changes occur in food which can affect quality attributes (Di Scala and Crapiste 2008). The drying process may affect antioxidant capacity and nutritional and physical quality of the herbs (Joshi and Mehta 2010 & Annamalai et al., 2011). The most popular method of drying is convective drying; however, increase in the temperature usually results in quality decrease of the dried herbs (Diaz-Maroto, 2002). Using microwaves shorten the drying time compared to conventional methods and leads to a substantial improvement of the product quality. Vacuum microwave drying of food is getting more popular technology that can overcome many of the shortcomings of the conventional drying technologies (Durance and Liu 1996). There has been much research into microwave drying techniques, examining a broad spectrum of fruits and vegetables (Bouraout et al., 1994; Tulasidas, et al., 1997; Funebo and Ohlsson, 1998) and others, however, more data are still needed on the effect of microwave drying on the potential role of medicinal plants. During drying, enzymatic processes in fresh plant tissues may lead to significant changes in the composition of bioactive constituents of herbs, especially phenolic compounds, ascorbic acid and pigments responsible for the characteristic green colour of fruits and vegetables, like carotenoids (Jambor and Czosnowska 2002; Diplock et al., 1998; Szeto et al., 2002). This research was performed to compare the changes in antioxidant capacity, total phenols and pigments due to air, convective oven and microwave oven drying of celery, parsley, dill and coriander.

2. Materials and methods

2.1. Plant materials

Dill (*Anethum garveolens*), coriander (*Coriander sativum*) celery (*Garveolens var. Dulce Apium*) and parsley (*Crispum Petroselinum*), were purchased from the local market. Each herb was divided into fthis batches. One was immediately used for extraction to measure the tested parameters of the fresh herbs. The other three batches (500 grams each) of the plants leaves were used for each drying process; every experiment was carried out in triplicate.

2.2. Drying processes

In the air-drying process the herbs were evenly spread on a tray, covered with the cotton sheets to keep off dust and insects, turned occasionally and left to dry in the shade place (35°C) in appropriate air flow until the vegetables were brittle and considered to be dry (about two days). In the oven drying process each sample were spread on a tray and placed in the oven. The oven temperature was adjusted to 70°C for 4hthiss. In the Microwave-drying process, glass plates containing the plant materials were placed in a microwave oven with the power strength adjusted to 100 W for 3min.

Determination of moisture content

Moisture content was determined by the standard procedures of the AOAC (2000).

2.3. Samples extraction

The fresh plants were blended with methanol; meanwhile, the dried plants were ground (particle size 500µm). The extraction process was preformed with methanol in two stages. The extracts were separated and subjected to further analysis.

2.4. Determination of total content of total phenols

The method reported by Boyer and Hai Liu (2004) was used to determine total content of phenols in samples. One ml of extract was mixed with 5 ml of 10 % Folin-Ciocalteu reagent in distilled water and 4 ml of 7.5 % sodium carbonate solution. The samples were maintained at room temperature for 30 min, the absorbance at 765 nm was measured. The calibration curve was constructed within the concentration range 0.075−0.6 mg/ml of gallic acid. Means were calculated from three parallel analyses as gallic acid equivalents in g/100 g of dry plant material using the following equation:

$C = a\times \gamma\times (V/m) \times 100$,

Where: C: total amount of phenolic compounds, g/100g as gallic acid; a: dilution number; γ: concentration obtained from calibration curve (mg/ml); V: volume of methanol used for extraction (100ml); m: weight of sample (g).

2.5. DPPH free radical scavenging ability

The antioxidant capacity of samples against DPPH (1, 1-diphenyl-2 picryl hydrazyl) free radical was evaluated as described by Zhang and Hamauzu (2004). One ml extracts was mixed with 1 ml of 0.4 mmol l^{-1} methanolic solution containing DPPH radicals. The mixture was left in the dark for 30 min and the absorbance was measured at 516 nm.

2.6. Pigments content

Following the procedures described by Mosquera et al., (1991) the chlorophyll fraction was measured in a UV spectrophotometer at 670 nm and the carotenoid fraction at 470 nm. The concentration of pigments was expressed using the following equations:

Chlorophylls = Abs (670nm) $\times 10^6 / 613 \times 100 \times$ density (mg/Kg)

Carotenoids = Abs (470) $\times 10^6 / 2000 \times 100 \times$ density (mg/Kg)

2.7. Statistical Analysis.

Differences between means of data were compared by least significant difference (LSD) calculated using the SAS for Windows 2000 Version 8.2 (Little et al., 1996). Pearson correlation coefficient (r) was used to express correlations.

3. Results and discussion

3.1. Moisture content

Moisture content of fresh samples ranged from 83.40 in parsley to 88.32% in coriander (table 1). After drying processes moisture content significantly decreased recording values between 5.88 and 7.49% in dill and coriander, respectively. No significant difference was observed due to the drying method or the type of herb. The moisture content in the dried samples of this study was found to be in the range recorded by Joshi and Mehta (2010) in dried drumstick leaf with different methods with maximum moisture content of 7.39% in the shadow – dried sample.

3.2. Total phenols

No significant difference was noticed between fresh samples in their content of total phenol values that ranged between 1.0 to 1.3 mg gallic/g in dill and celery, respectively (table 2). Figure (1) illustrated the effect of different drying methods on the total phenols of samples. Drying processes generally resulted in a marked depletion of total phenols of fresh plants especially in case of using oven and microwave drying. Intense and prolonged thermal drying may be responsible for a significant loss of total phenols than none heated samples. Microwave drying resulted in reduction of total phenols by 56.1, 35.5, 34.1 and 40.3% in dill, coriander, celery and parsley than did air drying. Fresh dill sample lost its phenol content by 62% due to microwave drying, while 30% loss was due to the oven drying and only 14% loss was observed in the air dried sample referred to the fresh one. This recorded decrease may be due to some phenolic compounds decompose rapidly when dried at elevated temperature (Mueller-Harvey, 2001). The obtained data are in accordance with Annamalai et al., (2011) who reported that microwave dried sample yielded very poor content of total phenolics when compared to the high values of fresh sample. These findings also are in line with Komes et al., (2011) who found that fresh plants were characterized with the highest contents of polpyhenols.

3.3. Pigments content

Carotenoids and chlorophyll the main pigments in green leafy vegetables were the parameters that highly affected by the drying method especially in microwave drying method. The effect of different drying methods on the carotenoids content of the tested samples was demonstrated in figure (3). Carotenoids content ranged from 89.1 to 49.9 mg/kg in parsley and dill leaves, respectively. All methods of drying in this study induced significant decrease in carotenoids content, less effect was observed due to air drying and the most was due to microwave drying methods (77.5% loss in carotenoids content of microwave dried parsley than fresh one) . Except dill sample, oven drying and microwave drying led to significant reduction in total carotenoids than did air drying. Significant decrease was observed in microwave dried (14.3 mg/kg) than oven dried (36.7 mg/kg) of celery. The susceptibility of these bioactive compounds to degradation at higher temperatures may explain this decrease. This was confirmed by the higher content of carotenoids in air-dried samples, where low temperatures are applied during the drying of the plant. Fresh plants recovered good content of chlorophyll content ranged from 46.4 mg/kg in parsley to 39.9 mg/kg in celery when compared to the dried state (18.4 to 4.0mg/kg in coriander. As observed in carotenoids, chlorophyll content was affected by all methods of drying, however the greater effect was recorded in oven and microwave drying than in air drying. The obvious decrease was noticed in microwave dried coriander and dill compared to air dried ones (78.3 and 61.2%). The findings of this study are in agreement with the mentioned data of Komes et al. (2011) that fresh plants were characterized with the highest contents of carotenoids, however, the highest content of chlorophylls was determined in freeze-dried plants they added that microwave drying resulted in a significant degradation of all bioactive compounds in the examined plants compared to freeze-drying and air-drying.

3.4. Antioxidant capacity

Data in table (2) indicated that coriander leaves showed the highest antioxidant capacity (80.44%) than other plants. Drying processes resulted in significant reduction in antioxidant capacity in all tested samples (figure 4). This loss ranged from 6.4 % in air drying of celery to 33.7% in oven drying of coriander. However no significant difference was observed in dried parsley and coriander due to the method of drying. Dill and celery were affected significantly by microwave drying than oven and air drying (91.89 and 44.55% in dill and celery, respectively. No significant difference was noticed also between the last two samples due to use of oven and air drying. The decrease in the antioxidant capacity may refer to the decrease in total phenols and carotenoids contents may be due to the drying process. According to Tomaino et al., (2004) microwave drying process would generally result in a depletion of naturally occurring antioxidants in raw grapes.

Correlation between antioxidant capacity and total phenols as well as carotenoids contents were determined to assess the influence of the total phenols and carotenoids contents on the antioxidant capacity of the fresh and dried leafy vegetables. Results in figure (5) showed that there was a significant relationship between antioxidant capacity and total phenols ($r = 1$). Strong correlation ($r = 1$) between antioxidant capacity and carotenoids contents was observed as explained in figure (6). These results are in agreement with that obtained by Galoburda et al, (2012) and Du et al., (2009) that correlation between DPPH scavenging capacity and TPC exhibited a strong relationship ($r = 0.95$). Podsędek, (2007) found that some species have shown a positive relationship between antioxidant activity and vitamin C, vitamin E, and beta-carotene content as found in this study.

This study concluded that fresh plants were characterized with the highest contents of phenols, carotenoids, chlorophyll and antioxidant capacity than dried ones. Applying three methods of drying (air, convective oven and microwave oven) resulted in a loss of all tested parameters in the tested plants especially in the thermal drying state. In spite of the variation in total phenols and carotenoids content between samples, total phenols and carotenoids content of all tested samples were affected in same manner by different methods. Air drying showed the least effect in reducing phenolic compounds compared to the fresh state, meanwhile, antioxidant capacity decrease in all dried samples compared to fresh ones. Considering the beneficial effect of leafy vegetables, air drying was found out to be an appropriate drying method than convective and microwave drying.

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Table 1. Change in moisture content (%) with different methods of drying

Samples	Fresh	Microwave drying	Oven drying	Air drying
Dill	87.58	5.93	6.01	5.88
Coriander	88.32	7.15	7.15	7.49
Celery	84.75	6.65	6.76	6.90
Parsley	83.4	6.65	7.11	6.79

LSD =1.66 (P<0.05)

Table 2. Antioxidant capacity and some components of fresh samples

Samples	Total phenols (mg/g)	Antioxidant capacity (%)	Carotenoids content (mg/kg)	Chlorophyll content (mg/kg)
Dill	1.00[a]	77.90[a]	49.9c	40.6[a]
Coriander	1.15[a]	80.44[a]	59.4c	44.9[a]
Celery	1.30[a]	62.93[b]	77.10[ab]	39.9[a]
Parsley	1.01[a]	78.04[a]	89.10[a]	46.4[a]

Mean values in a column with different letters are significantly different at p < 0.05

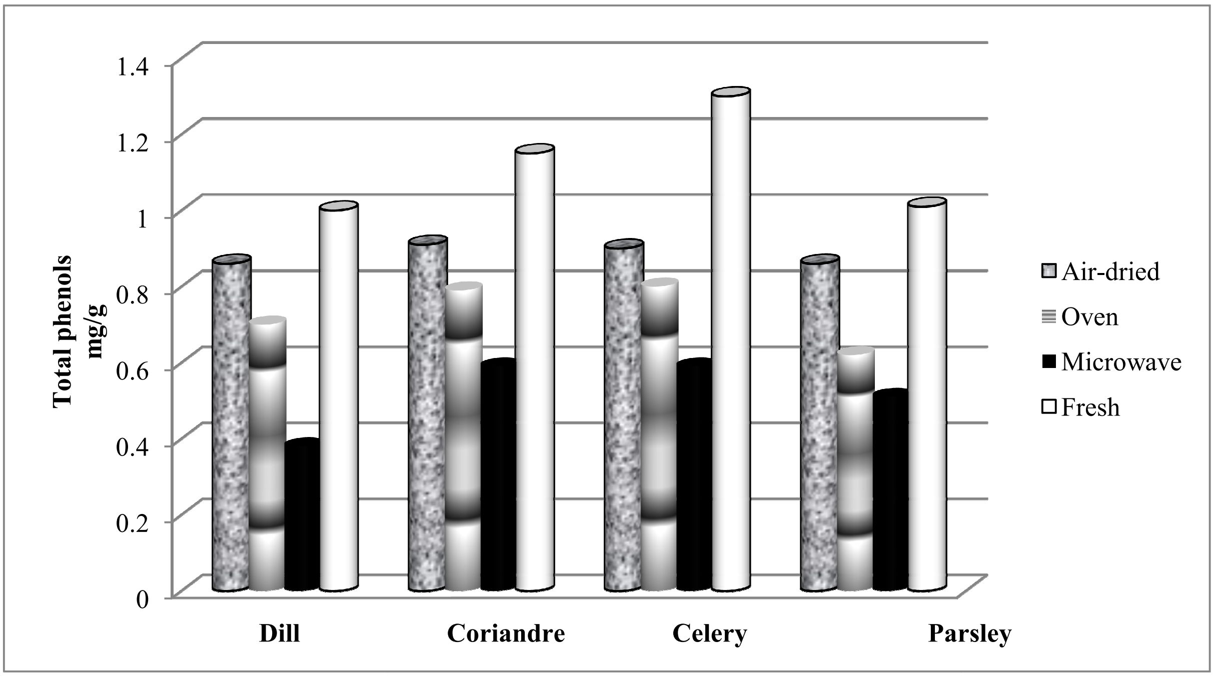

Figure 1. Effect of different drying methods on total phenols of some leafy vegetables

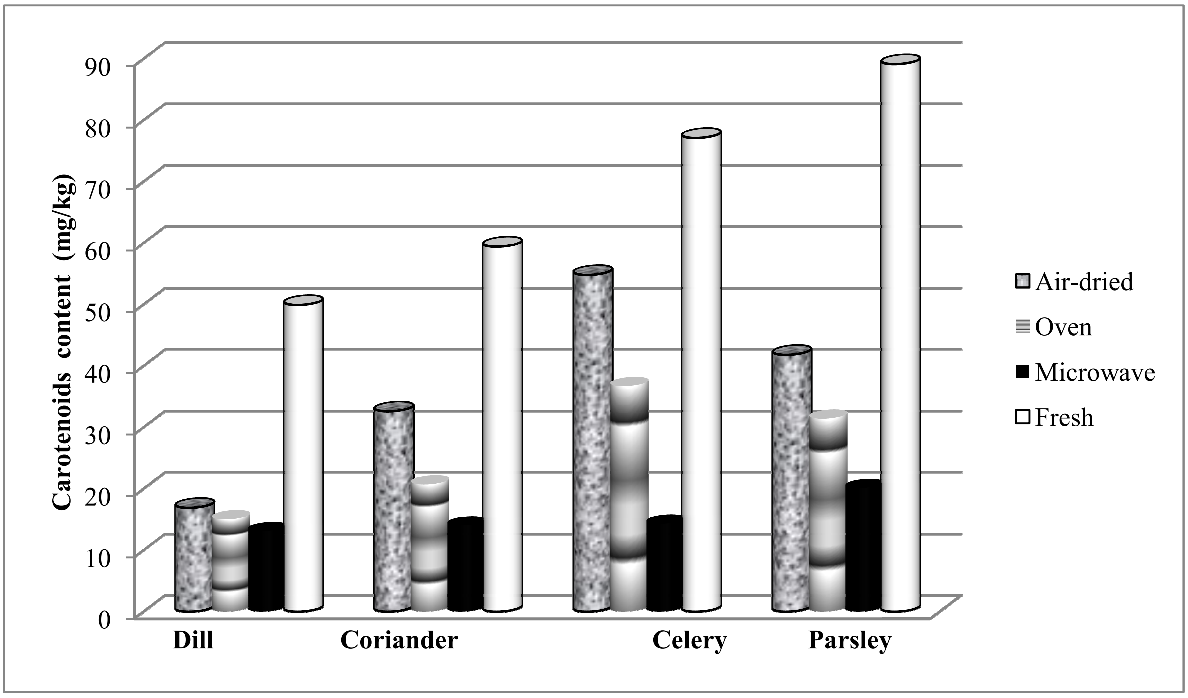

Figure 2. Effect of different drying methods on carotenoids content of some leafy vegetables

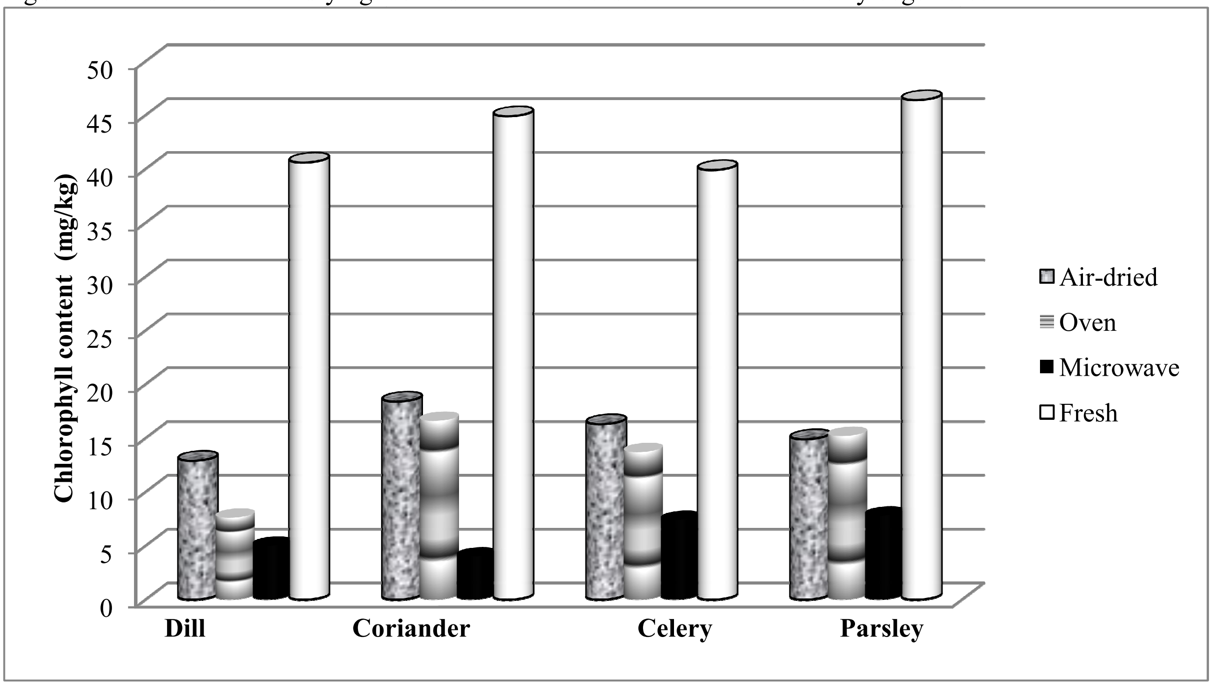

Figure 3. Effect of different drying methods on chlorophyll content of some leafy vegetables

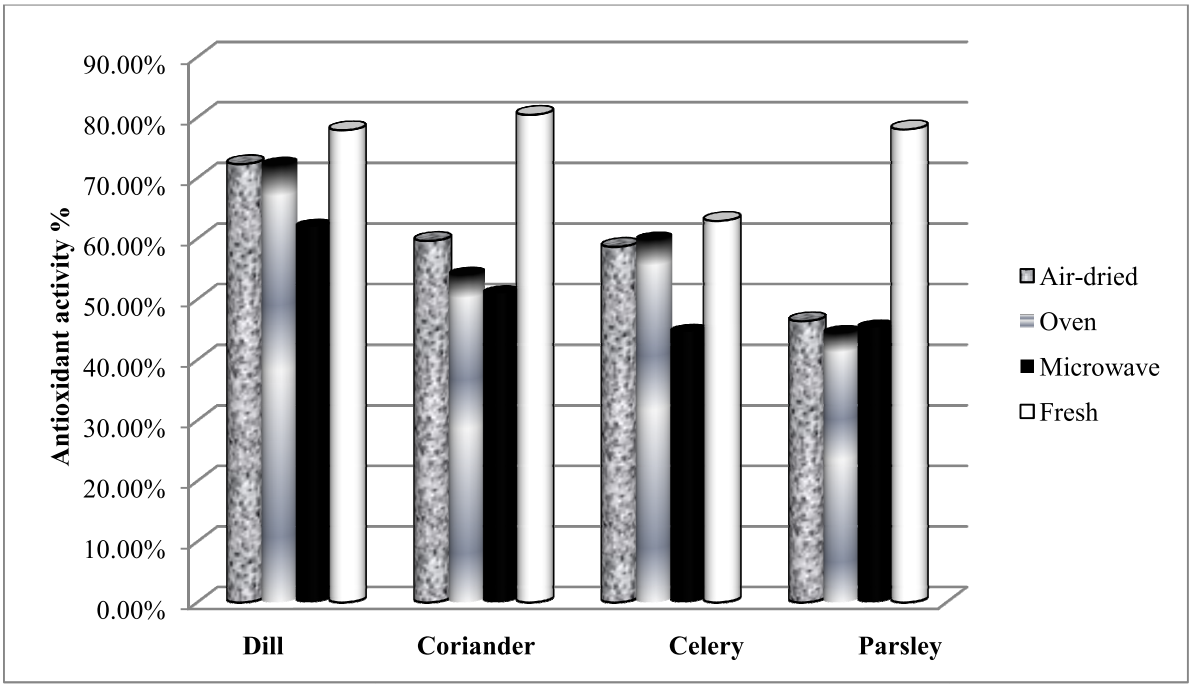

Figure 4. Effect of different drying methods on antioxidant activity of some leafy vegetables

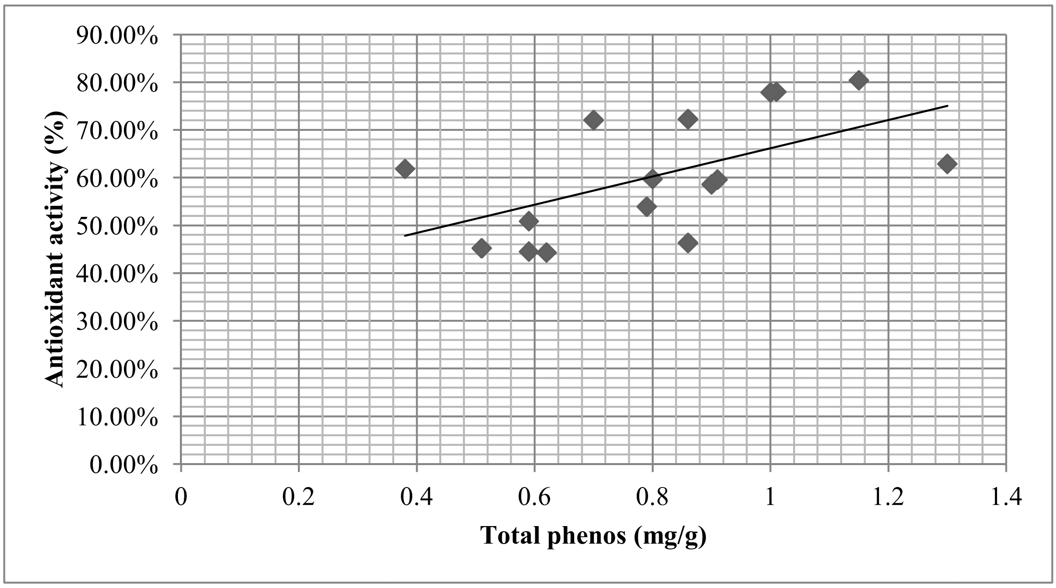

Figure 5. Correlation between antioxidant capacity and total phenol content

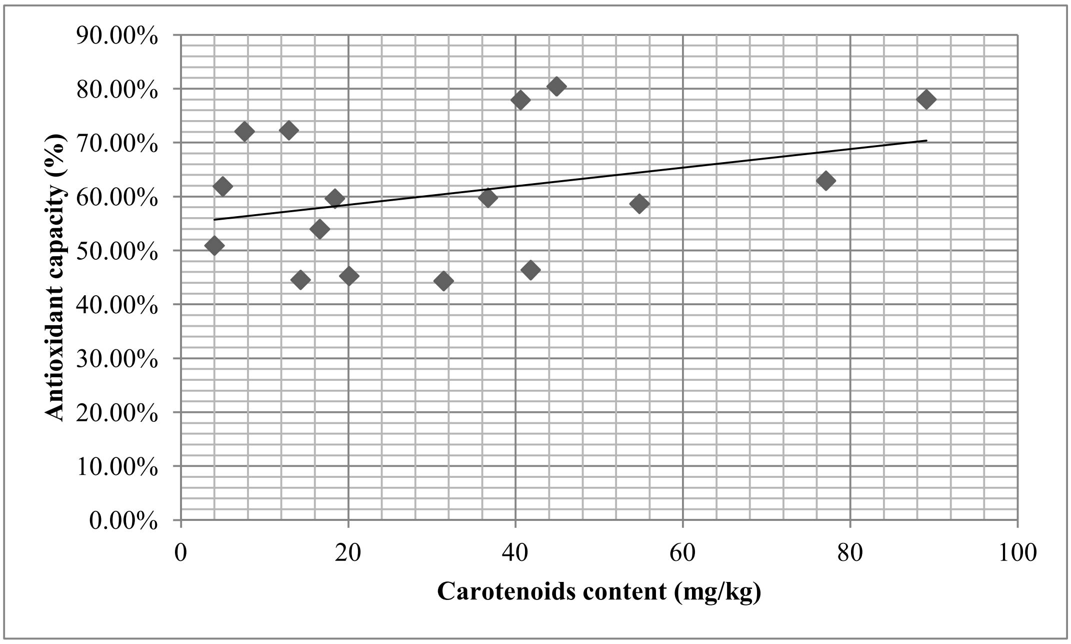

Figure 6. Correlation between antioxidant capacity and total carotenoids content