Suitable drying model for infrared drying of carrot

Post-harvest decay of Carrot (*Daucus carota* Linn.) is one of the major causes for its limited use in many countries. Various techniques are used to minimize deterioration after harvesting. Refrigeration and controlled atmosphere storage are commonly used preservation methods. Alternatively, the keeping ability of carrot can be enhanced by drying and subsequent storage. Infrared drying has been investigated as a potential method for obtaining high-quality dried foodstuffs, including fruits, vegetables, and grains. However, infrared drying and drying kinetics of carrot have not been reported till now. Therefore, the scientists at Faculty of Engineering, Department of Chemical Engineering, Fırat University, Turkey conducted studies with three objectives (i) to observe the effect of drying temperature during infrared drying of carrot, (ii) to estimate the constant of selected model equations, diffusion coefficient and activation energy, and (iii) to determine the effect of temperature on constants and coefficients in the selected models and diffusion coefficient.

During experiment infrared drying characteristic of carrot was investigated in the temperature range of 50-80°C. The strong influence of drying temperature on drying rate at early stage of drying was evident. Drying rate almost doubled when the drying temperature was increased from 50-80°C. Five empirical drying models (Newton, modified Page, logarithmic, diffusion approach, and Midilli model) given in literature for describing time dependence of the moisture ratio change fitted to experimental data and model parameters in equations were determined by multiple regression analysis. In case of the model include the combined effects of drying time and drying temperature, the model derived from Midilli model gave the best result. Effective diffusion coefficient in the temperature range 50-80°C was determined as, 7.295×10^-11, 9.509×10^-11, 1.140×10^-10 and 1.501×10^-10 m²/s, respectively. Activation energy was determined as 22.43 kJ/mol [Togrul Hasan, Suitable drying model for infrared drying of carrot, *J Food Eng*, 2006, 77(3), 610-619].

Determination of bioaccessibility of beta-carotene in vegetables

Bioaccessibility of beta-carotene from vegetables is an important factor as far as their health benefits are concerned. The *in vitro* method in use for the determination of beta-carotene bioaccessibility involves simulated gastrointestinal digestion followed by ultracentrifugation to separate the micellar fraction containing bioaccessible beta-carotene and its quantitation. The scientists at Department of Biochemistry and Nutrition, Central Food Technological Research Institute, Mysore, India studied the suitability of two alternatives, viz. membrane filtration and equilibrium dialysis to separate the micellar fraction. Values of beta-carotene bioaccessibility obtained with the membrane filtration method were similar to those obtained by the ultracentrifugation method. Equilibrium dialysis was found not suitable for this purpose. Among the vegetables analyzed, fenugreek leaves had the highest content of beta-carotene (9.15 mg/100 g), followed by amaranth (8.17 mg/100 g), carrot (8.14 mg/100 g) and pumpkin (1.90 mg/100 g). Per cent bioaccessibility of beta-carotene ranged from 6.7 in fenugreek leaves to 20.3 in carrot. Heat treatment of these vegetables by pressure cooking and stir-frying had a beneficial influence on the bioaccessibility of beta-carotene from these vegetables. The increase in the per cent bioaccessibility of beta-carotene as a result of pressure cooking was 100, 48 and 19% for fenugreek leaves, amaranth and carrot, respectively. Stir-frying in the presence of a small quantity of oil led to an enormous increase in the bioaccessibility of beta-carotene from these vegetables, the increase being 263% (fenugreek leaves), 192% (amaranth leaves), 63% (carrot) and 53% (pumpkin) [Veda S, Kamath A, Platel K, Begum K and Srinivasan K, Determination of bioaccessibility of beta-carotene in vegetables by *in vitro* methods, *Mol Nutr Food Res*, 2006, 50(11), 1047-1052].
Manganese (Mn) is an essential trace metal for human and animals, since it is involved in many physiological processes. Manganese at moderate concentrations is known to be essential for the developing and functioning of neuronal activity in the brain. Dietary Mn deficiency, which enhances susceptibility to epileptic functions, appears to affect seriously its homeostasis in the brain. On the other hand, manganese acts also as toxicant because of its pro-oxidant activity: this metal that abnormally concentrates in the brain, particularly in the basal ganglia, may cause neurological disorders similar to Parkinson’s disease. The RDA (Recommended Daily Allowance) for manganese established by the Food and Drugs Administration is 2.5-5.0 mg/day for an adult and 0.25-2.5 mg/day for a 0-14 years old child. Vegetables are known to be a good source of manganese: spinach 0.5-0.8 mg/100 g, green peas 0.3-0.8 mg/100 g, beans 0.4-0.6 mg/100 g.

The purpose of a study done by researchers of Italy was to develop a sensitive, accurate and rapid analytical method as anodic stripping chronopotentiometry (dASCP), for reliable trace manganese determination in different vegetables and aromatic herbs, and to employ the optimized technique to assess the effect of boiling and peeling on manganese content of vegetables. The proposed method does not need any laborious sample pretreatment, but a hydrochloric acid extraction.

Among the studied fresh vegetables, the highest content of manganese was found in vegetables with dark green leaves as chicory and spinach (respectively, 3.5 and 3.3 mg/100 g), while vegetables with light green leaves as lettuce, together with carrots, garlic and porc mushrooms had manganese levels lower than 1.0mg/100g. Boiling processing cause a significant decrease of manganese levels in artichokes, tomatoes, chicory, garlic, mushrooms, peeled carrots and potatoes, spinach and string beans ($P \leq 0.005$, ANOVA). Fennels, lettuce, marrow, unpeeled carrots and unpeeled potatoes did not show any statistical significant changes after boiling. Also peeling significantly influenced the content of manganese of carrots and potatoes ($P \leq 0.01$, ANOVA) and favoured manganese loss during boiling [Dugo Giacomo, Pera Lara La, Turco Vincenzo Lo, Palmieri Rosina Matarese and Saitta Marcello, Effect of boiling and peeling on manganese content of some vegetables determined by derivative anodic stripping chronopotentiometry (dASCP), Food Chem, 2005, 93(4), 703-711].

Green beans, peas, pepper, squash, broccoli, leek and spinach are common vegetables consumed as cooked. The cooking processes bring about a number of changes in physical characteristics and chemical composition of vegetables. However, very little information is available in the literature regarding the antioxidant activity and total phenolics of these vegetables. Therefore, a study was undertaken by researchers at Department of Food Engineering, Faculty of Engineering, Ankara University, Ankara, Turkey to investigate the effects of different cooking methods (microwave and conventional) on antioxidant activity and total phenolics of the vegetables. Total phenolics content of fresh vegetables ranged from 183.2 to 1344.7mg/100g (as gallic acid equivalent) on dry weight basis. Total antioxidant activity ranged from 12.2 to 78.2%. With the exception of spinach, cooking affected total phenolics content significantly ($P < 0.05$). The effect of various cooking methods on total phenolics was significant ($P < 0.05$) only for pepper, peas and broccoli. After cooking, total antioxidant activity increased or remained unchanged depending on the type of vegetable but not type of cooking.

Among green vegetables tested, pepper had the highest amount of phenolics and broccoli had the strongest antioxidant activity. This study indicated that vegetables except squash are rich in...
total phenolics showed strong antioxidant activity at the same time. Cooking had no deleterious effect on total antioxidant activity and total phenolics content of vegetables with the exception of some losses of phenolics in only squash, peas and leek. Moreover, moderate heat treatment might have been considered a useful tool in improving health properties of some vegetables [Turkmen Nihal, Sari Ferda and Velioglu Y Sedat, The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables, Food Chem, 2005, 93(4), 713-718].

Epidemiological studies show that the consumption of tomato (*Lycopersicon esculentum* Mill., Hindi — *Tamatar*) and tomato-based products can help to prevent various forms of cancers, especially prostate cancer and heart diseases. Demand for ready-to-use products, which have similar health benefits to the original raw products, has also increased in recent years. Fresh tomatoes can be dried as halves, slices, quarters and powders and used as a component for pizza and various vegetable dishes. Industrial processing of tomatoes to a final moisture content of <15% often involves high temperatures (60-110°C) for a period of 2-10 hours in the presence of oxygen and therefore, the products show some oxidative damage. Considerable losses of ascorbic acid have been reported during the production of dried tomato halves and tomato pulp using high temperatures.

Recently, a new method has been developed to produce semi-dried tomatoes by drying at 42°C for 18 hours to a final dry matter (DM) content of about 19%. The bright-red semi-dried tomatoes are then packed in air-tight plastic bags after the addition of canola oil to extend their shelf-life. It is hypothesized that these semi-dried tomatoes would retain high levels of antioxidant compounds. Therefore, a study was conducted by researchers at Animal and Food Sciences Division, Lincoln University, Canterbury, New Zealand to investigate the potential retention of the major antioxidant compounds in three commercially grown tomato cultivars. Three tomato cultivars (‘Excell’, ‘Tradiro’ and ‘Flavourine’) grown under hydroponic conditions in a commercial greenhouse in New Zealand were semi-dried at 42°C. The semi-dried tomatoes contained low levels of 5-hydroxymethyl-2-furfural (HMF) and were significantly (*P* < 0.05) darker (lower CIELAB *L* *a* values) and had a higher mean *a*/*b* value (1.6) than the fresh tomatoes (1.2). The mean total phenolics in the semi-dried samples of tomatoes [300 mg gallic acid equivalents, GAE/100 g dry matter (DM)] was significantly lower than that of fresh tomatoes (404 mg GAE/100 g DM). The mean total flavonoid and lycopene contents in the fresh samples (206 mg rutin equivalents/100g DM, 63 mg/100g DM, respectively), also showed a significant decrease after semi-drying (179 mg rutin equivalents/100g, 54 mg/100g DM, respectively). Ascorbic acid content in fresh tomatoes (284 mg/100g DM) decreased to 223 mg/100g DM after drying. The total antioxidant activity of the semi-dried tomatoes (1783 µmole trolox equivalents antioxidant capacity (TEAC)/100g DM) was significantly (*P* < 0.05) lower than that of the fresh samples (2730 µmole TEAC/100g DM).

The study shows that semi-drying of tomatoes allows the retention of colour with only low levels of HMF in the final product. This method of drying is particularly suitable for processors who are interested in retaining maximum ascorbic acid contents. Retention of high levels of antioxidants is important as the product is likely to undergo further heat treatments in the home and this will lead to additional losses of antioxidants [Toor Ramandeep K and Savage Geoffre P, Effect of semi-drying on the antioxidant components of tomatoes, Food Chem, 2006, 94(1), 90-97].
Antioxidant responses in minimally processed and refrigerated celery

During minimal processing, fruits and vegetables are treated in a series of stages, where, their structure and tissues are generally damaged or removed. By cutting, the size of diverse organs is reduced to obtain ready-to-use products that are packaged in small portions for convenience. During handling, cutting, washing and rinsing, important mechanical damage occurs, which is accompanied by oxidative stress. Disinfection by immersion in chlorinated water is still widely used for simplicity and low cost, though it constitutes an additional damaging factor because of hypochlorous acid reactivity. Celery (*Apium graveolens* Linn.) is a plant material that easily adapts to minimal processing and constitutes an important regional crop.

Researchers of Argentina studied the effect of storage temperature (0, 4 and 10°C) and time on the antioxidant capacity of cut celery packaged in polystyrene trays sealed with PVC film. Samples were taken at 0, 7, 14, 21 and 28 days of storage to determine total phenols, chlorogenic acid and ascorbic acid. The browning potential and antioxidant capacity of the product were also evaluated. The antioxidant power presented similar behaviour for the three temperatures tested, decreasing after the first 7 days and then increasing up to day 14. Such increase coincided with an elevation of the ascorbic acid content, which was stronger for higher temperatures. As a general conclusion, minimally processed celery retained its initial antioxidant capacity for a period of 21 days at 0°C, showing the lowest levels of browning potential at this temperature [Viña Sonia Z and Chaves Alicia R, Antioxidant responses in minimally processed celery during refrigerated storage, *Food Chem*, 2006, 94 (1), 68-74].

Antioxidant activity and phenolic content of raw and blanched *Amaranthus* sp. In practice, spinach is cooked with water for quite some time before being consumed. Hence, the effects of blanching times (10 and 15 min) on the loss of antioxidant activity and polyphenol content were also studied. Four *Amaranthus* species locally known as spinach, namely, ‘bayam putih’ (*A. paniculatus*) (BP), ‘bayam merah’ (*A. gangeticus*) (BM), ‘bayam itik’ (*A. blitum*) (BI) and ‘bayam panjang’ (*A. viridis*) (BPG), were selected for study. Total antioxidant activity of water-soluble components in raw spinach was in the order of BI ≈ BM ≈ BPG > BP, whereas free radical-scavenging activity was in the order of BI > BPG > BM > BP. The total phenolic contents of BM and BP were significantly higher (*P < 0.05*) than other samples. Antioxidant activities and phenolic contents of all the species were in the order of raw > blanched 10 min > blanched 15 min. Blanching up to 15 min may affect losses of antioxidant activity and phenolic content, depending on the species.

This result supports that the radical-scavenging activity would decrease if the vegetables were exposed to heat, such as with blanching. Blanching causes solubilization of phenolic compound and hence leads to loss of total phenolic compounds from the final product. The study shows that *Amaranthus* sp. contain water-soluble components that possess antioxidant activity, based on the two different assays. Blanching up to 15 minutes may affect the antioxidant activity and phenolic content in raw leaves [Amin I, Norazaidah Y and Hainida KI Emmy, Antioxidant activity and phenolic content of raw and blanched *Amaranthus* species, *Food Chem*, 2006, 94(1), 47-52].
Vegetable

Composition and nutritive value of proteins in pea during germination

The pea (*Pisum sativum* Linn., Hindi — *Matar*) is a legume with great nutritional potential due to its high protein content and it has been suggested as an alternative protein source to soybean in countries where the former legume is not a native crop, or in situations where soybean cannot be used due to allergic reactions or intolerances. However, the potential benefits might be limited by the presence of antinutritional factors, including trypsin inhibitor activity (TIA), phytic acid and α-galactoside oligosaccharides.

The effects of germination for 2, 4 or 6 days, with and without light, on the proteolytic activity, the contents of soluble protein and non-protein nitrogen, and the amount of available starch of pea as well as their nutritive utilization by growing rats were studied by researchers in Spain. The objective of the study was to establish optimal conditions of light and germination period to decrease the dietary factors that could negatively affect the intake and nutritive utilization of protein, with the aim of obtaining pea flours with improved functional value for use by the food industry. Food intake increased significantly when the peas were germinated for 2 or 4 days. This improvement was correlated with the reduction of factors responsible for flatulence. Digestive utilization of nitrogen was similar (among all the groups fed germinated-pea flour) to raw-pea flour. The values for nitrogen balance, percentage of retained to absorbed nitrogen, protein efficiency ratio and index of available carbohydrates were significantly higher among the animals that consumed peas allowed to germinate for 2 or 4 days than among the animals given the raw-pea or 6-day-germinated pea diets. Thus, the germination of peas for 2 days would be sufficient to significantly improve the palatability and nutritive utilization of protein and carbohydrates. The presence or absence of light during the germination process did not affect the results achieved.

It is concluded that short germination periods of 2 or 4 days, with or without light were optimal for improving the organoleptic and nutritional properties of peas. These germination periods are sufficient to produce an appreciable reduction in the factors responsible for flatulence, thus increasing intake and improving the utilization of available proteins and carbohydrates. Such germination periods for peas produce sufficient advantages for this food to be recommended for geriatric and infant nutrition [Urbano Gloria, Aranda Pilar, Vilchez Antonio, Aranda Carlos, Cabrera Lydia, Porres Jesús M and López-Jurado Maria, Effects of germination on the composition and nutritive value of proteins in *Pisum sativum* L., *Food Chem*, 2005, 93 (4), 671-679].

Drying kinetics and quality of potato chips

Potato chips are popular snacks throughout the world, hence, its production on large scale is done using various new techniques. Low fat content, colour, softness, longer shelf-life, etc. are some of the quality measures. The research workers at Thailand studied the effects of pretreatment (i.e., hot water blanching), drying methods and conditions on the drying kinetics and quality of potato chips in terms of colour, texture and browning index, which can be used as an indicator of quality deterioration causing from excessive heat treatment. Low-pressure superheated steam drying (LPSSD) and the conventional hot air drying were selected for comparative purpose. During experiment fresh potato was stored at 4°C. Prior to starting of each experiment it was washed, peeled and sliced into chips of 3.5±0.3mm thickness. The sliced potato chips were blanched in hot water at 90±2°C for 0, 1, 3, and 5 minutes with the ratio of potato to water of 0.015g/g. Chips were then immediately cooled down in cold water (4°C) and placed on a paper towel to remove excess water prior to drying.

It was found that LPSSD took shorter time to dry the product to the final desired moisture content than that required by hot air drying when the drying temperatures were higher than 80°C. Longer blanching time and lower drying temperature resulted in better colour retention and led to chips of lower browning index. Blanching also reduced the hardness and shrinkage of the product; however, the use of different blanching periods did not significantly affect the product hardness. Drying methods had no obvious effect on the product quality except the browning index [Leeratanarak Namtip, Devahastin Sakamon and Chiewchan Naphaporn, Drying kinetics and quality of potato chips undergoing different drying techniques, *J Food Eng*, 2006, 77(3), 635-643].