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Effect of drying and salting on the flavour compound of Asian white radish

R.C. Coogan, R.B.H. Wills*

Centre for Advancement of Food Technology and Nutrition, University of Newcastle, PO Box 127, Ourimbah, NSW 2258, Australia

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Abstract

Asian white radish (*Raphanus sativus* cv. Hoshiriso) was dried to $<10\%$ moisture using a hot air drier at 40, 50 60 and 70 °C, a heat pump drier at 35, 40, 45 and 50 °C and a freeze-drier, and was salted under pressure with concentrations of 0, 5, 15 and 25% sodium chloride. The primary compound responsible for the flavour of white radish, 4-methylthio-3-trans-butenyl isothiocyanate (MTBITC), was found to be substantially decreased by the hot air and heat pump driers, the loss increasing with increasing drier temperature, but the loss was lower in the heat pump drier than the hot air drier at equivalent temperatures. Osmotic dehydration with salt also caused a substantial loss of MTBITC with the loss increasing with increasing salt concentration. MTBITC loss of about 50% occurred with a heat pump drier at 50 °C, hot air drier at 40 °C and 25% salt. Freeze-dried white radish showed a relatively low loss (15% MTBITC).

1. Introduction

Asian white radish, or daikon, (*Raphanus sativus* L.) is a popular root vegetable throughout Asia. It is processed into a range of fresh, dried, salted and pickled products. and commands about 60% of the processed vegetable market in Japan where it is consumed daily (Carlson, Daxenbichler, Van Etten, Hill, & Williams, 1985; Pan, 1995). The taste of raw white radish involves some irritation in the nasal cavity and a burning sensation on the tongue (Lindsay, 1985). The primary compound responsible for the characteristic sulphurous, pungent flavour and aroma has been identified as 4-methylthio-3-trans-butenyl isothiocyanate (MTBITC) (Friis & Kjaer, 1966). MTBITC is produced from the hydrolysis of 4-methylthio-3-trans-butenyl glucosinolate by the enzyme myrosinase (Friis & Kjaer, 1966) and occurs when cells in the root are disrupted, allowing the enzyme and substrate to mix (Palmieri, Visentin, Tava, & Iori, 1992). Drying is a common method used in the processing of white radish where the water content is reduced, either by mechanical driers or by osmosis, with high concentrations of chemical solutes. MTBITC is a volatile compound and the concentration present could be expected to be affected by the drying process but no such information has previously been reported. This study therefore examined the effect on the flavour of white radish, dehydrated using different types of mechanical driers and by salting.

2. Materials and methods

The moisture content of Hoshiriso white radish roots was determined gravimetrically on 5-g samples that were dried to constant weight in a vacuum oven. Roots were sliced into pieces (10×10×50 mm) with a mechanical slicer (Kroner, Germany). The moisture content of the radish pieces was reduced in a hot air drier, freeze drier on heat pump drier. The hot air drier was a 18 kW multiphase convection hot-air drier (GTD Engineering, Sydney; internal dimensions of 46×81×79 cm) and was operated at 40, 50, 60, and 70 °C. The heat pump drier was a 0.75 kW, single phase heat-pump drier (Greenhalgh, Caloundra Qld; internal dimensions 53×44×35 cm and was operated at 35, 40, 45 and 50 °C. Radish slices in both driers were weighed hourly and measurements continued until the product contained $<10\%$ moisture. The freeze-drier (FD3 Dynavac, Seven Hills, Sydney; (chamber dimensions of 40 mm×40 mm×700 mm) was operated at a pressure of 100×10^{-10} mbar with the condenser temperature at −45 °C.

* Corresponding author. Tel.: +61-243-484140.
E-mail address: ftrbhw@alinga.newcastle.edu.au (R.B.H. Wills).

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Radish pieces were frozen with liquid nitrogen before placing in the drier and weight loss measurements were conducted every 24 h until the product contained <10% moisture.

For salting, a commercial procedure, described by Watanabe (1988), was used. Whole radish roots were placed horizontally as a single layer in a plastic container (50×40×50 cm). Salt (commercial grade, Saxa, Sydney) was added at the rate of 0, 5, 15 and 25 g per 100 g radish. Two cement blocks (45×25×10 cm), each weighing 13.5 kg, were placed on top of the layer of roots, exerting pressure evenly to assist salt distribution. The blocks were left in place for 72 h, after which time roots were placed in fresh-flowing water for 30 min to remove excess salt, and the moisture content of the roots was determined.

The method of analysis of MTBITC was that developed by Okano, Asano, and Ishii (1990). Dried samples were placed in a blender (341b199 Waring, New Hartford CN), with the volume of water that had been lost during drying to ensure that the same ratio of water to dry material was maintained as in the fresh sample. Juice from the reconstituted or fresh sample was squeezed by hand from the pulp. Hexane (5 ml) was added to a sample of juice (5 ml) and placed in a sealed 12-ml vial that was shaken vigorously for 40 s. on a Vortex mixer. The vial was centrifuged at 4000 rpm for 10 min, and the solvent fraction removed with a Pasteur pipette into a sealed vial and stored at −20 °C until analysis. An aliquot (2.5 μl) was injected into a flame ionisation gas chromatograph (Varian 3400, Walnut Creek CA) using a 2 m stainless steel column of SE-30 (8%) on DCMS-WAKS, Chromosorb 100-120 (Alltech, Sydney).

The column temperature was programmed for 1 min at 135 °C then increased at 20 °C/min to 180 °C. Operating parameters were injector temperature 185 °C, detector temperature 200 °C, nitrogen carrier gas 30 ml/min, hydrogen flow rate 30 ml/min and air 200 ml/min. The retention time of MTBITC was about 4.2 min.

3. Results and discussion

3.1. Effect of mechanical drying

The losses of MTBITC in white radish pieces dried to <10% moisture content by hot air, heat pump or freeze driers are shown in Table 1.

The heat pump drier resulted in a significant linear loss of MTBITC (y) as the temperature (x) increased from 35 to 50 °C ($y = -2.4\times + 163$; $P < 0.05$) with almost half the MTBITC lost at 50 °C. The hot air drier gave a similar significant linear loss ($y = 1.5\times - 11$; $P < 0.05$) of MTBITC between 40 and 70 °C with >90% of MTBITC lost at 70 °C. At equivalent temperatures, there was a significantly higher ($P < 0.05$) loss of MTBITC when drying by hot air than by heat pump. In addition, the drying time in the heat pump drier was less than in the hot air drier, being 10-h shorter when both driers were operated at 40 °C and 7 h shorter at 50 °C. Heat pump drying therefore offers the dual advantage of a better retention of MTBITC and a shorter drying time.

The amount of MTBITC lost during freeze drying of 15% was less than that of all temperature regimes used in the heat pump and hot air driers; the equilibrium temperature in the freeze-drier chamber was 15 °C. Freeze-drying is, however, not a commercially feasible option for white radish due to the relatively low cost of the raw material and the high cost of freeze-drying.

3.2. Effect of osmotic drying

The loss of MTBITC in radish roots after salting, under pressure, is shown in Table 2 to increase with increasing amount of applied salt. There was a significant inverse relationship between loss of MTBITC (y) and salt concentration (x) ($y = 160\times + 11$; $P < 0.05$) with about half the MTBITC lost at 25% salt compared to a 15% decrease without salt. As expected, there was a significant increase in water loss (y) with increase in salt concentration (x) ($y = 15.4\times - 1.3$; $P < 0.05$).

Table 1
Loss of MTBITC in white radish pieces after drying at various temperatures in a hot air, heat pump and freeze drier

Drier	MTBITC loss (%) during drying at (°C)						
	15	35	40	45	50	60	70
Heat Pump		24±4.0[a]	34±24.0	36±8.0	44±9.0		
Hot Air			46±13.0		73±5.0	85±10.0	90±12.0
Freeze-Drier	15±3.0						

[a] Mean±standard deviation (n = 10 replicates/treatment).

Table 2
Effect of osmotic drying on loss of MTBITC in white radish roots by application of sodium chloride under 12 kg pressure for 72 h at 20 °C

Salt level	MTBITC	Water
	Loss (%)	Loss (%)
0%	15±2.5[a]	3±2.7
5%	22±5.2	46±3.2
15%	38±4.6	49±8.6
25%	47±5.8	54±3.8

[a] Mean±standard deviation ($n=9$ replicates/treatment).

4. Conclusions

The substantial loss of MTBITC that occurs in the commercially feasible methods of drying has considerable implications for the eating quality of processed radish that has been mechanically dried or salted. Processors need to be aware of losses during processing and to select either a white radish cultivar that will give the desired level of MTBITC in the end-product or select a milder drying protocol to better retain the flavour.

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