Processed Foods Research Unit - Grape Research

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BACKGROUND

Raisins are an important agricultural product with 317,515 tons produced in the US in 2007/08. About 95% of California raisins are produced from Thompson Seedless grapes, followed by Fiesta (3%) and Black Corinth grapes (1.5%). Recently introduced cultivars are being planted with 2225 and 713 acres of Selma Pete and DOVine, respectively. With the development of new cultivars, comes the chance to improve health benefits.

When drying grapes into raisins oxidative browning normally occurs and causes the darkening of raisins during drying and storage. The cause of darkening is mainly due to Polyphenol oxidase (PPO) enzyme. Pretreating grapes to lessen enzymatic and nonenzymatic browning reactions has been shown to increase the concentrations of certain phenolics (Fig. 1).

In order to lighten the dark color and also prevent enzymatic reactions, grapes are treated with sulphur dioxide during drying or after drying. It is also possible to use blanching prior to the drying to inactivate the enzymes to prevent the undesirable color changes. Blanching can be achieved by using steam or water which may cause nutrient loss and generate wastewater. It is needed to develop a dry-blanching method for grapes, which can perform simultaneous blanching and partial dehydration.

Infrared (IR) energy is a form of electromagnetic energy and is transmitted as a wave, which penetrates the food, and is then converted to heat. IR seems promising to heat the skin of grapes in order to inactivate PPO and also dissolve the waxy layer to accelerate the drying rate.

ACCOMPLISHMENTS

• We have already determined the antioxidant activity and total and individual phenolic composition of different raisin grape cultivars and selections.

• Furthermore, we have already found a novel way to inactivate the enzyme in order to produce Golden Raisins with decreased drying time.

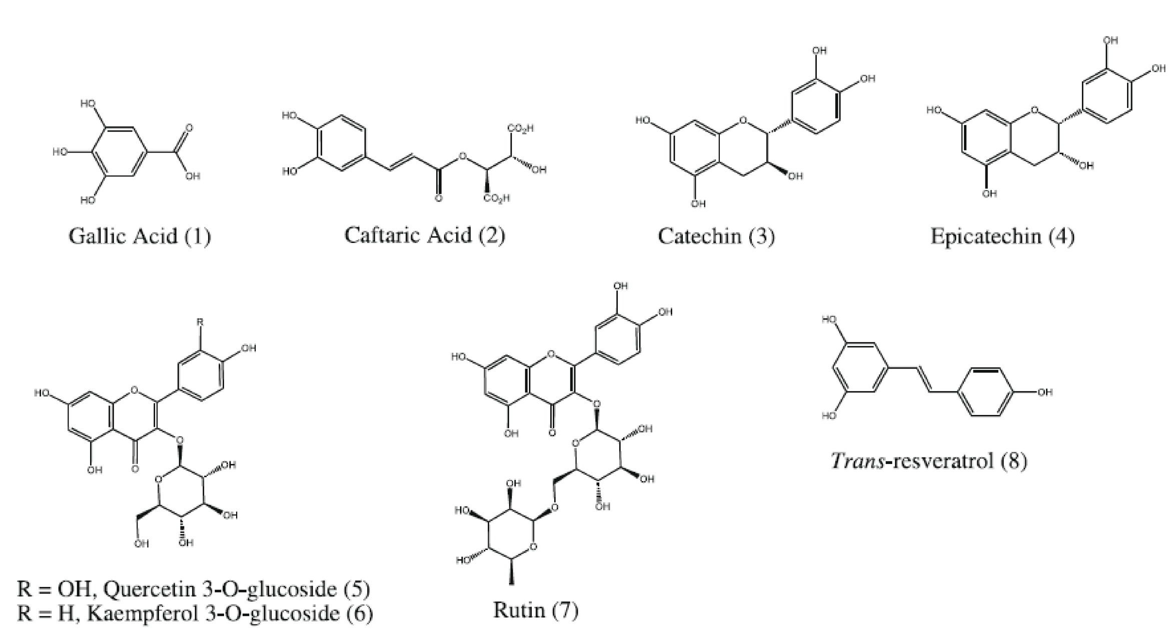

Figure 1. Chemical structures of phenolics

MATERIALS AND METHODS

Antioxidant Activity and Phenolic Content

Grape varieties: The fresh fruit for this study was harvested from the raisin cultivars and selections on August 18–20, 2008, except for Thompson Seedless which was harvested on September 11, 2008. Sugar levels ranged from 20.7° to 30.4° Brix at harvest.

Total Soluble Phenolics (TSP): The Folin–Ciocalteau method for the colourimetric estimation of total polyphenols was adapted following the suggestions of different publications.

HPLC Analysis: A Waters HPLC System equipped with a Model 2695 Separations Module coupled to a Waters Model 996 diode array detector (190–500 nm) (Milford, MA) was used. Instrument control and data acquisition were accomplished using Masslynx (Version 4.0). Respective chromatograms are shown in Fig 2.

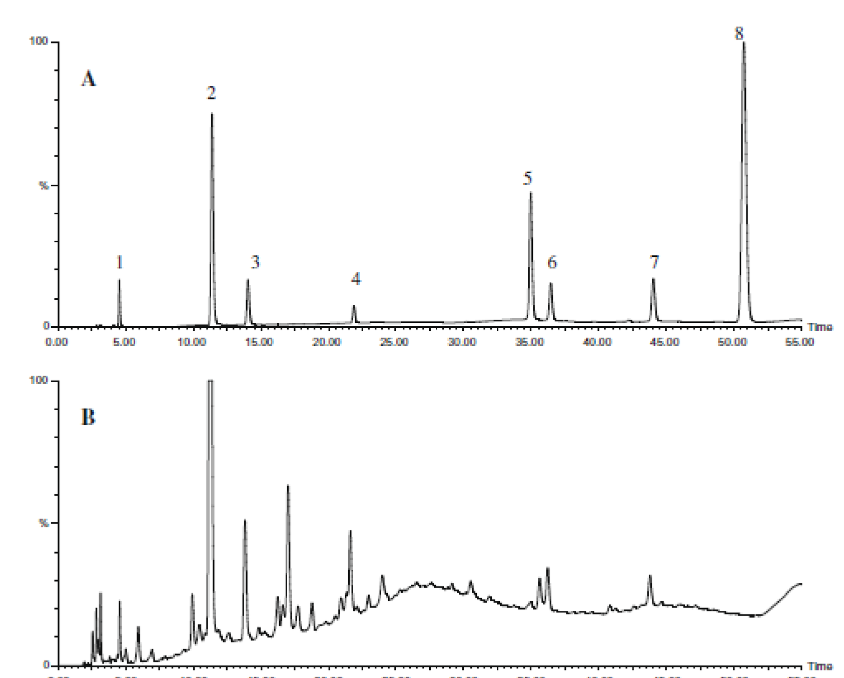

Figure 2. Chromatograms obtained for standards (A) and two different grape samples – (B) A-95-27,

Infrared Dry-Blanching for Golden Raisins

Grape varieties: The drying of grapes into raisins were studied with the Thompson Seedless grapes.

Infrared Dry-blanching : Grapes were put onto the tray of a pilot scale catalytic infrared equipment (Fig. 3) with double-sided heating (Catalytic Industrial Group Inc., Independence, KS). The IR equipment was operated at high IR intensity corresponding to 3 inch-water pressure of natural gas supply. During dry-blanching, the near surface and center temperature of grapes reached to 88° and 57°C, respectively.

Hot Air Drying: We selected 40°, 50° and 60°C as the safe hot air drying temperature for grapes.

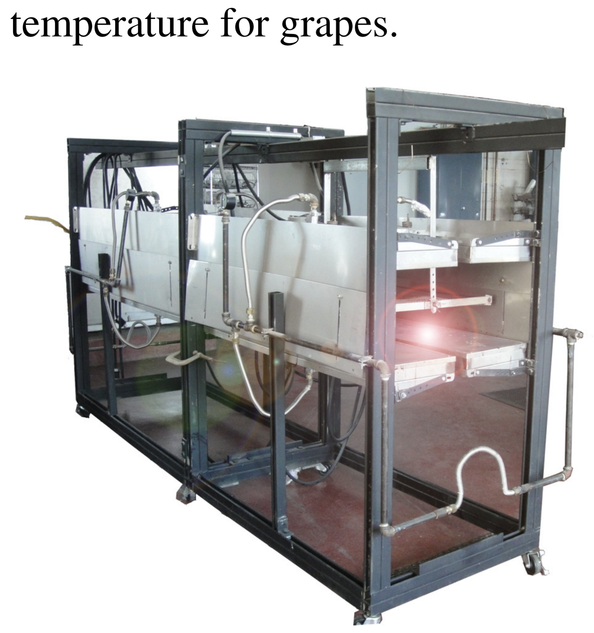

Figure 3. Infrared heating equipment, USDA-ARS-WRRC

RESULTS

The total soluble phenolic content (TSP) and antioxidant capacity (AO) of different raisin cultivars are shown in Table 1. It is seen that among the several varieties, A95-27 has significantly higher TSP and AO content.

Table 1. Total soluble phenolic (TSP) content and antioxidant (AO) capacity

	TSP (mg gallic acid/100 g DW[a])	AO (μmol Trolox/g DW[a])
Controls		
Trolox[b]	33525 ± 2409	–
BHT[b]	51682 ± 5832	1.6 ± 0.5
Ascorbic acid[b]	–	7.4 ± 2.1
Varieties		
Diamond Muscat	387.7 ± 6.5	7.7 ± 0.9
DOVine	375.8 ± 8.1	8.9 ± 0.6
Fiesta	442.4 ± 13.9	15.1 ± 0.4
Selma Pete	423.8 ± 19.0	13.1 ± 1.1
Summer Muscat	393.2 ± 6.7	10.7 ± 0.4
A50-33	435.1 ± 50.9	15.1 ± 1.3
A50-39	316.3 ± 11.4	8.3 ± 0.8
A56-66	507.6 ± 28.3	29.4 ± 3.1
A95-15	594.2 ± 25.6	34.1 ± 0.6
A95-27	1141.3 ± 141.0	60.9 ± 1.3
B53-122	370.7 ± 2.9	8.5 ± 0.6
B58-41	413.3 ± 8.7	14.3 ± 1.0
B64-108	401.7 ± 28.3	11.9 ± 1.2
C65-81	419.9 ± 9.2	9.9 ± 0.7
C90-100	364.6 ± 21.1	10.8 ± 1.3
Thompson Seedless	357.7 ± 5.5	9.3 ± 0.4

[a] Samples were analyzed as described in the experimental section and reported as average ($n = 3$) ± SD. Since controls were analyzed with each set of samples, their reported values represent the average ± SD across all experiments.
[b] Trolox (0.250 mg/ml), BHT (0.125 mg/ml) and ascorbic acid (0.05 mg/ml).

Sun-dried, dipped, and golden raisins produced from Thompson Seedless grapes contained 39.6, 45.2, and 84.3 mg/kg, respectively, of trans-caftaric acid. Considerable variation in the concentration of individual phenolics in the samples was observed (Table 2).

Selections A56-66, A95-15, and A95-27 had much higher levels of catechin (86.5–209.1 μg/g DW) and epicatechin (126.5– 365.7 μg/g DW) than other grapes. Experimental data suggest that catechins might prevent chronic diseases in humans. Catechin and epicatechin have been shown to be powerful inhibitors of in vitro human LDL oxidation.

Table 2. Content of phenolic compounds (μg/g DW ± SD) in berries of raisin grape cultivars and selections

Sample	Gallic acid	Caftaric acid	Catechin	Epicatechin	Rutin	Quercetin 3-*O*-glucoside	Kaempferol 3-*O*-glucoside	*trans*-Resveratrol
Diamond Muscat	nd	202.7 ± 18.5	12.2 ± 1.7	nd	1.3 ± 0.5	13.8 ± 1.8	8.0[a] ± 2.1	nd
DOVine	nd	272.8 ± 8.8	1.8[a] ± 0.5	nd	3.7 ± 0.5	67.0 ± 7.6	10.3 ± 0.1	nd
Fiesta	nd	598.7 ± 73.8	12.2 ± 4.7	4.5[a] ± 1.2	1.6 ± 0.8	7.4[a] ± 3.9	nd	nd
Selma Pete	nd	305.8 ± 12.4	4.3 ± 0.5	nd	0.8 ± 0.1	19.7 ± 0.9	nd	nd
Summer Muscat	nd	339.1 ± 17.9	14.1 ± 1.0	1.1[a] ± 0.5	3.7 ± 0.9	14.3 ± 0.8	nd	nd
A50-33	nd	192.2 ± 8.9	19.9 ± 2.9	8.2 ± 0.9	4.5 ± 0.5	41.2 ± 2.8	10.6 ± 2.3	nd
A50-39	nd	180.1 ± 22.7	19.2 ± 1.5	14.9 ± 0.4	2.7 ± 0.5	62.2 ± 2.7	5.6[a] ± 0.8	nd
A56-66	nd	261.7 ± 9.0	86.5 ± 5.4	175.5 ± 11.0	1.6 ± 0.8	25.8 ± 5.4	7.7[a] ± 1.7	nd
A95-15	6.9 ± 1.2	153.5 ± 11.4	132.0 ± 20.3	126.5 ± 14.7	3.2 ± 0.1	30.5 ± 2.6	8.7[a] ± 0.8	nd
A95-27	24.5 ± 1.6	590.4 ± 30.1	209.1 ± 24.1	365.7 ± 28.1	0.8 ± 0.1	22.1 ± 0.5	14.1 ± 1.2	nd
B53-122	nd	417.8 ± 42.3	3.2[a] ± 0.8	nd	1.3 ± 0.5	19.1 ± 0.8	nd	0.8[a] ± 0.1
B58-41	nd	204.4 ± 2.7	8.2 ± 0.5	15.7 ± 2.3	3.2 ± 0.1	69.3 ± 5.0	10.4 ± 0.8	nd
B64-108	nd	374.2 ± 16.1	9.8 ± 0.5	1.6[a] ± 1.4	1.6 ± 0.1	8.0[a] ± 0.1	nd	nd
C65-81	nd	244.1 ± 52.9	8.2 ± 2.0	nd	0.8 ± 0.1	21.5 ± 0.9	2.1[a] ± 0.5	nd
C90-100	nd	204.5 ± 22.0	12.7 ± 0.1	66.4 ± 1.5	nd	37.5 ± 0.8	nd	nd
Thompson Seedless	nd	183.0 ± 6.3	9.0 ± 0.9	6.4[a] ± 0.1	nd	8.8 ± 0.8	nd	nd

nd, not detectable.
[a] Estimated, raw absorbance values <LOQ.

Due to its waxy nature grape skin poses as a resistance to moisture transfer and decreases the drying rate significantly. Infrared dry-blanching alters the skin of the grapes by dissolving the waxy layer due to applied heat. Grapes, which were infrared blanched, depending on the temperature of hot air, dried into raisins in 9 to 20 hours (Fig 4-b); whereas in all of the air temperatures drying of untreated grapes took from almost 40 hours to 215 hours (Fig 4-a).

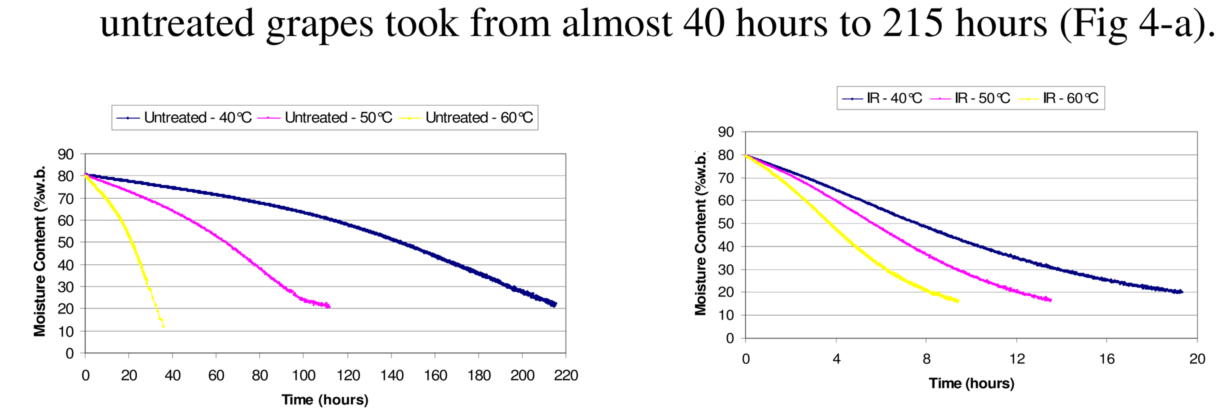

Figure 4. a) drying rate of untreated grapes **b)** Convective drying rate of dry-blanched grapes

It is seen from Fig. 5 that inactivation of PPO by dry-blanching prevented enzymatic browning reactions that took place during drying. Grapes that were stemmed and dry-blanched did not darken during drying.

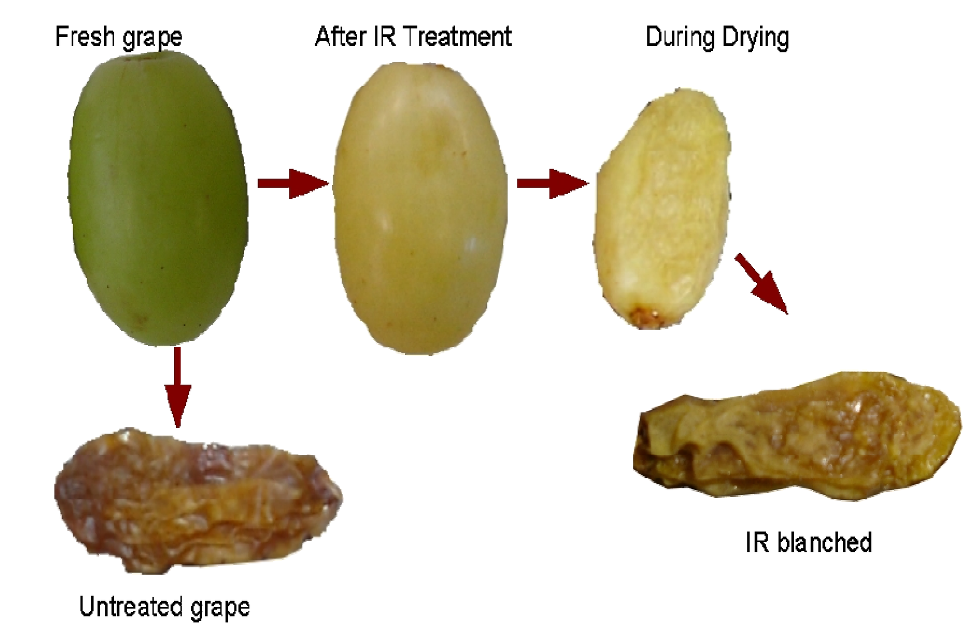

Figure 5. Untreated and dry-blanched grapes

CONCLUSIONS

• Different grape cultivars have significantly different phenolic contents.
• A56-66, A95-15, and A95-27 had much higher levels of catechin and epicatechin, a substance preventing chronic diseases in humans, than other grapes such as Thompson Seedless grapes.
• Pretreating grapes with infrared heat not only prevented browning reactions but also significantly accelerated drying rate which will result in considerable energy savings.
• Since enzymatic and nonenzymatic browning reactions lessen phenolic contents, pretreating grapes with infrared heat could increase the phenolic contents of raisins by inactivating Polyphenol oxidase enzyme.
• Selection of an appropriate grape variety, such as A 56-66, A95-15 and A95-27 and pretreating with infrared heat prior to drying could significantly increase phenolic contents of raisins.

ROAD MAP

It is clearly shown that different grape cultivars have significantly different phenolic contents and that the infrared heat has the potential to produce golden raisins, which has been shown to have significantly higher levels of trans-caftaric acid than the other raisins.

We believe that with our extensive experience with grapes, both on nutritional and chemical analysis and moreover with drying technologies, it seems promising to investigate the phenolic contents of different grape cultivars exposed to infrared heat. Thereby not only could a healthier product be introduced to market, but also considerable energy savings be achieved during drying.