AN OBERVATION OF PROCESSING AND FLAVANONE CONTENT IN 100% ORANGE JUICE

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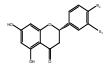
ABSTRACT

Flavanones are a flavonoid subclass common to citrus fruits. Flavonoids including flavanones may be of benefit to human health through their radical scavenging and antioxidative properties. Orange juice is the foremost food that provides flavanones in the diet. The predominant flavanones in pure orange juice are hesperetin and naringenin glycosides. Globally, the total consumption of pure orange juice out of all orange juice products such as fruit juice, nectar, and juice drinks was 40% in 2011. The goal of this study was to examine the effects of pasteurization and concentration on hesperetin and naringenin content in 100% juice made from sweet oranges (*Citrus sinensis L.*).
Studies from different countries that analyzed pure orange juices processed using different methods were collected through a scientific literature search. Analytical values for hesperetin and naringenin contents in these juices were compared to examine processing effects. Three processing techniques (e.g. domestically-squeezed, pasteurized-not-from-concentrate, and pasteurized-made-from-concentrate) and flavanone content in 100% sweet orange juice were compared. Twenty studies originating from the U.S., EU and Brazil where researchers analyzed flavanones in 100% orange juice (*Citrus sinensis L.*) were retrieved. Results for hesperetin weighted mean values in 100% orange juice pasteurized-made-from-concentrate, pasteurized-not-from-concentrate and domestically-squeezed were 17.17±12.50, 10.92±7.86, and 11.04±8.18 mg/100g respectively. For naringenin values were 3.01±0.98,2.12±1.32 and 3.52±4.97 mg/100g respectively. Concentration may have a significant positive correlation with hesperetin content, whereas there was no significant change in hesperetin content observed after pasteurization. Concentration may have a significant positive correlation with naringenin content, whereas pasteurization may have a negative correlation with naringenin content in orange juice. Knowing the process that conserves most of the flavanones in orange juice is valuable. These processing techniques have implications when determining appropriate dietary sources of flavonoid compounds in available foods and beverages.

INTRODUCTION

Citric flavanones are a subclass of flavonoids with polyphenolic structures, see Figure 1 (USDA, 2011). They are secondary plant metabolites that play a role in plant defense mechanisms. In commercial citrus species like oranges flavanones tend to be similar in the flavedo and albedo tissues with slightly higher concentrations in the leaf, see Figure 2 (USDA, 1998). Clinical trials and epidemiological studies show the consumption of flavanones like hesperetin and naringenin glycosides may lead to health promoting effects. In human clinical trials and random crossover studies hesperetin glycosides have been shown to have significant cardio-protective effects (Garg et al., 2001, Morand et al., 2011, Manthey et al., 2001). Naringenin may slow down the progression of bone loss by reducing human osteoclast cells and subsequent bone resorption (La et al., 2009). The quantity of sweet orange (*Citrus sinensis L.)* and its processed products consumed make it among the most popular fruits in the world lending to its economical and nutritional value (Liu et al., 2012). In 2010-2011 the world produced 3.3 billion gallons of orange juice where Brazil produced the most at 62% of the world production followed by United States (27%), Mexico (4%), European Union's 27 member states (3%) and "Other" (3 %) (USITC, 2007). Almost 80% of orange juice consumed in the U.S. is from domestic sources especially from Florida with remaining imported mostly of Brazilian origin (Liu et al., 2012). The main cultivars for orange juice manufacturing in Brazil include: Hamlin, Pera Rio, Natal, and Valencia. On the other hand, top U.S. orange juice manufacturers use Hamlin, Valencia or Pineapple sweet cultivars depending on the season (Tropicana.com). Navel cultivars may be mixed into orange juice mixtures to produce the desired color and flavor (Johnson, 2001). The goal of this study was to see if there may be an effect of pasteurization and concentration on hesperetin and naringenin content in 100% juice made from sweet oranges (*Citrus sinensis L.*). Various orange juice production processes are shown in Figure 3 including the three products that are the focus of this research: non-pasteurized-not-from-concentrate orange juice (NP-NFC) or domestically squeezed juice, pasteurized-not-from-concentrate (P-NFC), and pasteurized-made-from-concentrate (P-MFC).



Flavanone	R_1	R_2
Eriodictyol	OH	OH
Hesperetin	OMe	OH
Naringenin	OH	H

Figure 1. Flavanone Aglycone Structure and citrus flavonoids with respective functional group or R-group (USDA, 2011).

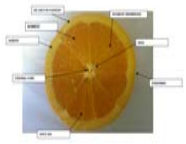


Figure 2. A cross section of a navel sweet orange (*Citrus sinensis L.*).

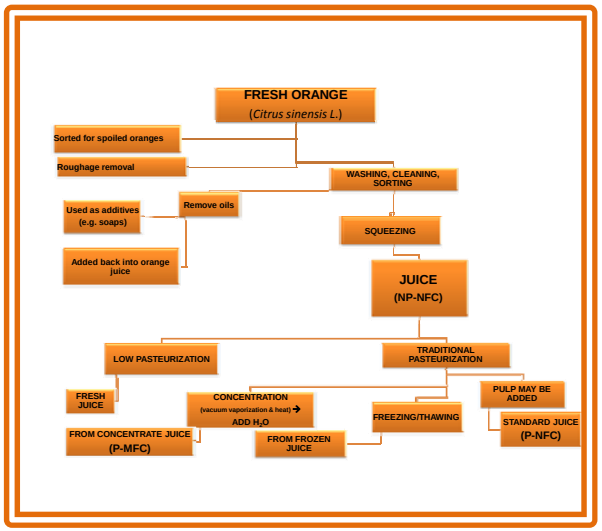


Figure 3. Orange Juice Production: Modified from Gil-Izquierdo, A., et al. (2002). "Effect of processing techniques at industrial scale on orange juice antioxidant and beneficial health compounds." J. Agric. Food Chem. **50(18): 5107-5114.**

METHODS

1. Literature search: a literature search on the effect of pasteurization and concentration on the flavanone content in 100% orange juice (*Citrus sinensis L.*) was carried out.

2. Data collection and selection criteria: analytical hesperetin and naringenin glycoside values for orange juice that was either non-pasteurized-not-from-concentrate, pasteurized-made-from-concentrate, or pasteurized-not-from-concentrate were collected. See Table 1 for selection criteria.

Table 1. Inclusion and exclusion criteria

Inclusion Factors	Exclusion Factors
• Hesperetin and naringenin values collected from articles with valid analytical methods. • Orange juice from one of three processes o Non-pasteurized, not from concentrate (a.k.a. domestically squeezed juice) o Pasteurized, not from concentrate o Pasteurized, made from concentrate • Juice from cultivars common to the U.S. food supply (e.g. Valencia, Hamlin, Pera, Navel) • Top selling retail 100% sweet orange juices in U.S. (e.g. Tropicana, Minute Maid, etc.) • Traditional processing and analytical techniques • HPLC flavanone quantification method	• Blood sweet orange cultivars • Blond sweet orange cultivars rare in the U.S. food supply • Experimental processing or analytical techniques rather than traditional processes or analytical techniques

3. Statistical analysis: SAS Version 9.3 (SAS Institute, Cary, NC, USA) was used to describe analytical values obtained from the literature search and observe significant differences in the values for pasteurization and concentration.

RESULTS

❑ Twenty studies originating from the U.S., EU and Brazil where researchers analyzed flavanones in 100% orange juice (*Citrus sinensis L.*) were retrieved. Summary statistics for hesperetin and naringenin content in each orange juice treatment are in Table 2 and Figure 4.

❑Concentration may have a significant positive correlation with hesperetin and naringenin content, whereas pasteurization may have a negative correlation with naringenin content in orange juice as shown in Table 3 and Table 4.

Table 2. Summary statistics for flavanone content in three orange juice treatments (mean, SD, min, max, and range are in mg/100g)

NON PASTEURIZED – NOT FROM CONCENTRATE (NP-NFC)							
Flavanone Aglycone	**Weighted Mean**	**SD**	**Min**	**Max**	**Range**	**No. of data points**	**Number of Publications**
Hesperetin	11.04	8.18	2.46	25.40	22.94	47	13
Naringenin	3.52	4.97	0.20	12.93	12.73	47	
PASTEURIZED – NOT FROM CONCENTRATE (P-NFC)							
Flavanone Aglycone	**Weighted Mean**	**SD**	**Min**	**Max**	**Range**	**No. of data points**	**Number of Publications**
Hesperetin	10.92	7.86	1.32	20.25	18.92	32	7
Naringenin	2.12	1.35	0.24	3.70	3.46	33	
PASTEURIZED – MADE FROM CONCENTRATE (P-MFC)							
Flavanone Aglycone	**Weighted Mean**	**SD**	**Min**	**Max**	**Range**	**No. of data points**	**Number of Publications**
Hesperetin	17.17	12.50	0.53	32.42	18.92	31	8
Naringenin	3.01	0.98	0.902	4.38	3.48	30	

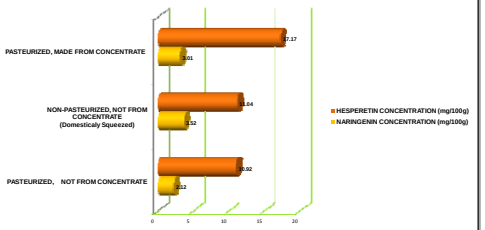


Figure 4: Mean hesperetin and naringenin content in orange juice made from three different processes

Table 3. Change in hesperetin content with concentration and pasteurization

CONCENTRATION	
Orange Juice Process	**Hesperetin (mg/100g)**
P-NFC	10.92a*
P-MFC	17.17b
PASTEURIZATION	
Orange Juice Process	**Hesperetin (mg/100g)**
NP-NFC	11.04a
P-NFC	10.92a

*Different letters are significantly different (p<0.05)

Table 4. Change in naringenin content with concentration and pasteurization

CONCENTRATION	
Orange Juice Process	**Naringenin (mg/100g)**
P-NFC	2.12b*
P-MFC	3.01a
PASTEURIZATION	
Orange Juice Process	**Naringenin (mg/100g)**
NP-NFC	3.52a
P-NFC	2.12b

*Different letters are significantly different (p<0.05)

CONCLUSION

❑Knowing the process that conserves most of the flavanones in orange juice is valuable. Flavanones may be cardio and osteo protective in humans, so these orange juice processing techniques have implications when determining appropriate dietary sources of these compounds in available foods and beverages.

❑More paired comparison studies are needed comparing flavanone content in 100% sweet orange juice that is traditionally pasteurized not from concentrate to pasteurized made from concentrate.

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