

## CONCENTRATION OF ORANGE JUICE BY USING POLYMERIC DEHYDRATION TO PROTECT FLAVOR COMPOUNDS

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### ABSTRACT

This article is an attempt to protect the main flavor compounds in concentrated orange juice by using polymeric dehydration techniques (sodium polyacrylate), instead of the traditional which causes a remarkable degradation in these compounds. The physiochemical and microbial properties of juice were monitored throughout the concentration processes. Polymeric dehydration was used at different conditions to concentrate orange juice and comparing with traditionally heat treatment. Total soluble solid (TSS), ascorbic acid, acidity, pH, viscosity and tannins have been affected by various levels according to concentration technique and period of storage. The microbial content had never developed even throughout the storage for six months, because 100 ppm sodium benzoate was added to the fresh juice immediately after squeezing. The main flavor compounds in fresh orange juice have been monitored throughout the various concentration processes to evaluate their abilities for maintaining the flavor compounds of concentrated juice.

**Key words:** aroma retaining, physiochemical properties, proposal technique, Total soluble solid,

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### INTRODUCTION

Citrus fruits are the most economically relevant and extensively grown fruits in the world and are important source of secondary metabolites for nutrition, health, and industrial applications (O'Neil *et al* 2011; Al-Snafi, 2016; Rodríguez *et al*, 2017). Orange juice is the most popular juice because it has aroma, attractive flavor and color, as well as health benefits (Ozturk & Kuscü 2019; Marcillo-Parra *et al*, 2021; Rashid & Al-Atrushy, 2023; Amala Dev & Sonia Mol, 2023). Orange flavor is perhaps widely recognized and accepted in the food and beverage industry around the world (Mall *et al*, 2018; Al-Aubadi & Hashim, 2022). The flavor compounds of many fruits, such as oranges, cantaloupes, tangerines, and lemons, are widely used to improve many food products (Sontakke *et al*, 2023; Al-Janabi & Abd, 2024). The flavor of fresh orange juice is due to complex combination of a large number of volatile

compounds such as, esters, aldehydes, alcohols, ketones, and terpenes (Farahmandfar *et al*, 2020; Putnik *et al*, 2019). Odors and flavors are the major determinants of fruit quality, but these traits are often genetically complex and difficult to score (Galili *et al*, 2020). Storage time, temperature and microbial contamination had a significant effect on the flavor of fruit juice (Perez-Cacho & Rouseff, 2008; Al-Snafi, 2016). New innovative technologies are being developed to concentrate juices to improve their quality and microbiological safety. Replacing thermal processing with non-thermal processing is a trend in food processing science due to the thermal properties of antioxidant compounds, vitamins, natural pigments, and taste and aroma compounds (Li *et al*, 2017; Putnik *et al*, 2019). The aroma index is an important characteristic of citrus juice, which indicates that quality can be judged by changes in these compounds (Amala Dev & Sonia Mol, 2023).

Many of the technologies used globally come into play in improving the quality of juices. These technologies include the rotary evaporator, osmotic pressure concentration, reverse osmosis, freezing, steam distillation (SD) and microwave-assisted steam distillation (MASD) and use of ultrafiltration (Assawarachan & Noomhorm, 2011; Hameed, 2013; Suryanti, *et al*, 2023). Aroma change is one of the most critical issues in citrus juice during processing and storage, which implies that the disappearance of most aroma-active compounds and the formation of off-flavor compounds in citrus juice eventually led to the formation of citrus juice off-flavor including cooked, greasy, earthy, musty, plastic, pungent, medical odor (Ferrer *et al*, 2022). Cold concentration techniques maintain a high percentage of terpenes and sesquiterpenoids (Putnik *et al*, 2019; Campelo *et al*, 2020). In comparison, off-flavor has a remarkable negative impact on the pleasant aroma quality of citrus juice. Therefore, molecular sensory science has raised great interest in unraveling the off-flavor compounds and their formation pathway in citrus juice. A better understanding of the off-flavor compounds in orange, mandarin, and grapefruit juice, will control the production of off-flavor compounds in the processing and storage of citrus juice. Off-flavor compounds were found in thermal, storage, light, oxygen, and other factors-induced (fruit maturity, package, diseases, centrifugal pretreatment for cloudy orange juice debittering process) citrus juices (Jia *et al*, 2024). Applying certain concentration and preservation techniques can help improve the aroma and mitigate unwanted flavors of pasteurized orange juice. Many chemical reactions that occur without the use of heat have positive changes in the volatile profile of orange juice. Concentration and cold preservation techniques increased the concentration of terpenoid and aldehyde compounds that give orange juice its fresh properties, and reduced the concentration of off-flavor compounds by 61% (Alves Filho *et al*, 2019; Rodrigues & Fernandes, 2022). They are promising techniques that have unique new advantages compared to traditional methods of concentration (Alves

Filho *et al*, 2019; Rodrigues, & Fernandes, 2022). The nutritional quality of many juices is improved through cold processing. Some studies have shown that the antioxidant capacity, total phenolics content, and vitamin C content increased after cold processing and that this technology can be used to produce more nutritious foods with better bio accessibility of nutrients (Alves Filho, *et al*, 2016; Almeida, *et al*, 2017; Ekezie *et al*, 2017; Pankaj *et al*, 2017). The study of cold processing on sensory quality (aroma and flavor) still relies on sensory evaluations conducted mostly with untrained panelists giving a hedonic score on whether they like or dislike the smell, color and flavor of foods. In-depth studies on the chemical nature of odor and taste changes during non-thermal processing are rare. In this study, proposal concentration processes have been suggested to retain the main flavor compounds in concentrated orange juice and their changes during storage.

#### MATERIALS AND METHODS

**Preparation of fresh orange juice:** 10 kg of ripe orange known as navel oranges, (*Citrus sinensis*) fruits were washed, dried and squeezed by laboratory juicer. The juice was sieved to get rid of pulp and seeds, the yield is about 58.51%. 100 ppm sodium benzoate was added as preservative. The fresh juice was stored at freezing conditions.

**Determination of some orange juice properties:** Total Soluble solids (TSS) were determined using a manual refractometer. Ascorbic acid was estimated using 2,6-dichlorophenol indophenol as described in (Pegg & Eitenmiller, 2017). Total acidity was determined as citric acid in fresh juice as described in (AOAC, 2016). The pH was monitored using a portable pH meter, a Chinese pH device (5231 Crison, Model GLP22, Crison Instruments S.A.) with an accuracy of  $\pm 0.05$  units (Sadler & Murphy, 2010). Viscosity was determined using a viscometer (FUNGILAB instrument model ALPHA series 101034). Tannins was determined by titration method against permanganate solution by using indigo carmine as indicator (AOAC, 2016).

**Identification the main flavor compounds by GC/MS:** The flavor compounds in aforementioned juice were measured by GC-MASS after extraction by dichloromethane  $\text{CH}_2\text{Cl}_2$  (Solís-Solís *et al*, 2007).

**Liquid-Liquid Extraction (LLE):** Di chloromethane, which was the most suitable solvent for isolating of volatile compounds in fruits and vegetables (Kelebek & Selli 2011). The extraction method was performed by a method modified from a previously published procedure (Aubert *et al*, 2005). In a bottle, 10 mL of fruits juice and 20  $\mu\text{l}$  of n-octan as surrogate standard (IS) with 1.5 mL of  $\text{CH}_2\text{Cl}_2$  were vigorously shaken for 5 min using a Vortex mixer in order to extract the free volatile fraction. The mixture was centrifuged at 4000 rpm for 5 min (this extraction was done twice). With some modifications regarding concentrated juices. Watery phase was removed and the organic phase ( $\text{CH}_2\text{Cl}_2$  + volatile compounds) was adjusted from 1 ml to 0.1 ml in a dry flow of nitrogen and then injected (1  $\mu\text{l}$  of extract) in a GC/MS system (Solís-Solís *et al*, 2007).

**GC/ MS Conditions:** Analytical Column: Agilent HP-5ms Ultra lenite. injection volume 1 $\mu\text{l}$  Pressure 11.933 psi GC inlet temperature: 250 $^\circ\text{C}$  Aux heaters temperature 300  $^\circ\text{C}$  Injector Temperature: 250 $^\circ\text{C}$  Temperature Ramp 1 60  $^\circ\text{C}$  to 180  $^\circ\text{C}$  7  $^\circ\text{C}/\text{min}$  Ramp 4 280  $^\circ\text{C}$  hold to 3 min.

**Statistical analysis:** Statistical Analysis System, User's Guide. Statistical Version 9.6<sup>th</sup> ed. SAS. Inc. Cary. N.C. USA (SAS. 2018).

## RESULTS AND DISCUSSION

**Determination of physical and chemical indexes:** Some physicochemical properties of fresh and concentrated orange juice utilizing conventional temperature and polymeric dehydration technique using (sodium poly acrylate) are shown in Table (1). The physicochemical properties, pH, total acidity, vitamin C, viscosity, and tannin, all showed significant variations. The degradation of vitamin C was taken as indicator to the efficiency of polymeric dehydration comparing with traditional one. In general, the traditional method to concentrate orange juice (using high temperature) was harm as compared to polymeric dehydration method. These results are associated with what was Abd-Allah, *et al*, (2019) found in the concentration of tomato juice, as they stated that the increase in all physicochemical parameters proportional with juice concentration (Abd-Allah, *et al*, 2019; Bellot *et al*, 2023).

**The Effect of concentration technique on Flavor Compounds:** The flavor compounds were grouped into seven main chemical classes; including, terpenes, alcohols, aldehydes, esters, ketone and two types of heterocyclic aromatic compounds. Other derivatives included hydrocarbons, alkyl halides, carboxylic acids, and their derivatives. Fifty flavor compounds were detected in fresh orange juice. According to the peak areas the main flavor compounds are show in Table (2). Perestrillo *et al* (2019) identified 98 flavor compounds in fresh orange juice, including terpenoids, esters,

**Table 1. Physical and chemical parameters of fresh and concentrated orange juice using polymeric dehydration and conventional heat treatment techniques has been detected by GC/MASS.**

Orange Juice	TSS	pH	TA	Vit C mg\100ml	Viscosity	%Tannins mg\100g	%destroying Vit C
Fresh 25 $^\circ\text{C}$	11.50	3.701	0.743	56.055	0.213	280.37	-----
Polymer 2.5g/kg	12.50	3.683	0.804	64.02	0.258	350.0	16.49
Polymer 5g/kg	16.50	3.660	1.060	79.00	0.309	402.3	16.69
Polymer 7.5g/kg	20.05	3.636	1.288	93.06	0.351	470.0	16.90
Temp 60 $^\circ\text{C}$	56	2.873	3.605	73.329	11.031	1365.3	77.81
Temp 80 $^\circ\text{C}$	57	2.854	3.649	38.023	11.74	1424	91.94
Temp 100 $^\circ\text{C}$	57	2.833	3.673	10.864	12.48	1436.4	96.23
LSD	8.17 *	0.734 *	1.05 *	8.94 *	3.26 *	38.72 *	11.43 *

\*( $P \leq 0.05$ ).

\*TSS= Total Soluble Solid, \*T. A= Total Acidity alcohols, carbonyl compounds, carboxylic acids, phenols and furanic compound. Most of those compounds were found in navel oranges

(our sample). Liu *et al*, (2024) identified 84 volatile compounds in blood orange. Table 2, shows that, orange juice's taste ingredients are primarily composed of terpenes, specifically

limonene, eremophylene, and  $\beta$ -myrcene. The degradation percentage of terpenes as taste chemicals was directly correlated with temperature, as the table illustrates. Polymeric dehydration caused less deterioration than the traditional method of concentrating orange juice (high temperature at ambient conditions). The results illustrate that the polymeric dehydration method maintain the major flavor compounds, these results were agreed with what was found by (Elss *et al*, 2007). The limonene may convert during the heat treatment to  $\alpha$ -terpinol and  $\alpha$ - pinene, while the eremophylene may change to nootkatone depending on oxygen content and this was a negative contribution in orange juice quality (Darıcı & Cabaroglu, 2022). In this study, beside limonene and  $\alpha$ - terpinol other monoterpenes such as,  $\alpha$ -pinene,  $\beta$ - myrcene, isocitral and citral were also detected in orange juice during high temperature conventional method comparing with polymeric dehydration. Table (2) illustrates disappearing of some terpenes by using high temperature

treatments throughout the presence of monoterpenes isomers and hydrocarbon terpenes which was agreed with (Sadecka *et al*, 2014). The study also refers to disappearing of citral and iso citral when high temperature was used. When oxygen and high temperature were available the oxidation of terpenes was taken a place, so the concentration of orange juice using polymeric dehydration is safer for flavor compounds as mentioned by (Kumar *et al*, 2023). The previous papers refer to the effect of high temperature degree on flavor compounds, that it caused a series of chemical alterations, which in turn, lead to lose many aromatic compounds (such as terpenes, aldehydes and esters) and production anew abnormal flavour compounds which were affected negatively on the acceptance of the consumers (Jiménez-Sánchez *et al*, 2017). Although, the sesquiterpenes (such as cubenene and selinadiene) were more sensitive to light and temperature, but it gave low degradation percentage by using polymeric

**Table 2. percentages of flavor compounds (terpenes) in fresh orange juice and reconstituted concentrate using polymeric dehydration techniques has been detected by GC/MASS**

flavour Compounds	Fresh % of total	Polymer 2.5g/kg	Polymer 5g/kg	Polymer 7.5g/kg	Temp 60° C	Temp 80° C	Temp 100° C	LSD
Limonene	63.955	28.91	30.69	31.55	15.10	8.49	2.98	6.59 *
Eremophylene Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylethenyl)-, [1S-(1 $\alpha$ ,7 $\alpha$ ,8 $\alpha$ )]-	9.152	6.89	8.43	8.74	4.83	3.87	2.65	2.04 *
Beta-Myrcene	1.434	0.80	0.93	1.38	0.38	ND	ND	0.784 *
4,11-selinadiene 2-Isopropenyl-4a,8-dimethyl-1,2,3,4,4a,5,6,7-octahydro naphthalene.	0.793	0.71	0.74	0.82	0.34	0.25	0.22	0.272 *
Cubenene naphthalene, 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-.								
(E)-Iso citral.								
Citral.	0.604	0.43	0.44	0.47	ND	ND	ND	0.233 *
$\alpha$ – pinene	0.488	0.41	0.46	0.48	0.67	0.70	0.81	0.205 *
(-)-beta-Elemene Cyclohexane, 1 ethenyl-1-methyl-2,4-bis(1-methylethenyl)-, [1S (1 $\alpha$ .,2 beta.,4beta.)] .	0.413	0.33	0.39	0.41	0.17	0.11	ND	0.219 *
7-epi-alpha-selinene (2S,4aR,8aR)-4a,8-dimethyl-2-(prop-1-en-2-yl)-1,2,3,4,4a,5,6,8a-octahydronaphthalene.	0.395	0.35	0.35	0.38	0.30	0.28	0.25	0.159NS
(-)- alpha -Panasinsen 2,2,4a,8-tetramethyl-1,2a,3,4,5,6-hexahydrocyclobutafijindene .								
Aromadendrene (-)-Allo-Aromadendrene.								
4aH-Eudesmane Naphthalene, decahydro-1,4a-dimethyl-7-(1-methylethyl)-, [1S-(1 $\alpha$ ,4 $\alpha$ ,7 $\alpha$ ,8 $\beta$ )]-	0.329	0.27	0.30	0.32	0.19	0.14	0.11	0.172 *
Cedrene-V6 .								

\* (P $\leq$ 0.05).

Significant, NS= non-significant

dehydration method comparing with the traditional method (high temperature open system). The study shows that the degradation of such compounds like (-)- $\beta$ -elemene, epi- $\alpha$ -selinene, (-)- $\alpha$ -panasinsen and aromadendrene were less affected by using polymeric dehydration comparing with traditional method. The degradation percentages of (-)-allo-aromadendrene, 4 $\alpha$ H-eudesmane and cedrene-V6 was less when polymeric dehydration was used comparing with high temperature open system (conventional method). Table (3) shows that the decomposition rates of some alkane compounds, such as hexadecane, heptadecane, and heneicosane, were higher using the traditional method of orange juice concentration compared to polymeric dehydration, which indicates the superiority of the polymeric dehydration method in

preserving these compounds. The decrease in these compounds in the traditional method compared to fresh orange juice is due to the conversion of some of them into alkyl halides or their other derivatives by bonding with some organic compounds. Heneicosane, tetracosane and pentacosane were records high degradation percentages at high temperature treatment which was associated what was found by (Perez-Cacho, & Rouseff, 2008). In general, using polymeric dehydration technique to concentrate orange juice caused less damage in flavor compounds comparing with the traditional one. The disappearance of 10-methylnonadecane, Nonane, 1-iodo and 4-methyl-tetradecane when using polymeric dehydration may be due to the effect of moisture loss, low pH level, as well as exposure to light, which leads to its association

**Table 3. Percentages of flavor compounds (Alkane and Halide alkyl) in fresh orange juice and reconstituted concentrate using polymeric dehydration techniques have been detected by GC/ MASS.**

flavour Compounds	Fresh % of total	Polymer 2.5g/kg	Polymer 5g/kg	Polymer 7.5g/kg	Temp 60° C	Temp 80° C	Temp 100° C	LSD
Heneicosane, Heptadecane, Hexadecane	2.050	1.02	1.29	1.93	0.44	0.44	0.41	0.544 *
Heneicosane, Tetracosane, Pentacosane	1.355	0.91	1.12	1.18	0.42	0.39	0.32	0.437 *
Octadecane.	1.121	0.66	0.73	0.75	ND	ND	ND	0.304 *
10-Methylnonadecane	0.745	ND	ND	ND	ND	ND	ND	0.275 *
Nonadecane.	0.714	0.41	0.46	0.55	ND	ND	ND	0.219 *
3-Ethyl-3-methylheptane	0.596	0.57	0.58	0.57	ND	ND	ND	0.205 *
5-methyl-5-propylnonan	0.571	0.51	0.57	0.48	ND	ND	ND	0.218 *
Nonan, 1-iodo	0.427	0.32	0.39	ND	ND	ND	ND	0.225 *
Tetradecane, 4-methyl-Pentacosane	0.410	0.31	0.33	0.35	0.19	0.17	0.12	0.214 *
Octadecane, 3-ethyl-5-(2-ethylbutyl)	0.369	0.30	0.30	0.31	ND	ND	ND	0.163 *
Tritetracontane, Hexacosane	0.362	0.32	0.34	0.37	ND	ND	ND	0.182 *
Heneicosane, 11-(1 ethylpropyl)-Hentriacontane	0.300	0.33	0.40	0.41	ND	ND	ND	0.109 *
Eicosane, Heneicosane	0.293	0.33	0.37	0.44	0.28	0.25	0.16	0.219 *
2-Bromotetradecane	0.260	0.40	0.48	0.37	0.095	0.055	0.043	0.103 *
Tetradecane	0.259	0.38	0.43	0.44	ND	ND	ND	0.134 *
Hexadecane	0.259	0.38	0.43	0.44	ND	ND	ND	0.134 *
Octacosane	0.259	0.38	0.43	0.44	ND	ND	ND	0.134 *
Hentriacontane	0.259	0.38	0.43	0.44	ND	ND	ND	0.134 *
Decane, 4-ethyl	0.241	0.34	0.33	0.28	0.20	0.17	0.13	0.178 *

\* (P $\leq$ 0.05).

\* Significant, NS= non-significant

with other organic compounds. (Perestrelo *et al*, 2019). Light can cause Stryker to decompose methionine, which in turn may combine with alkyl halides, allyl sulfur, or other organic compounds to produce the flavor of sunlight (Grant-Preece *et al*, 2017). Table (4) shows the percentages of some carboxylic acids and esters in fresh orange juice and reconstituted concentrated which prepared by polymeric dehydration and traditional methods. At high temperature degree, such as 100 °C, an increase was observed in carboxylic

acid percentage, this may be due to the hydrolysis or oxidation of some compounds (such as esters and aldehydes) under the conditions of the experiment (Perez-Cacho & Rouseff, 2008; Jiménez-Sánchez *et al*, 2017). On the other hand, the decomposition of ascorbic acid and the oxidation of fatty acids by the sun can cause chemical interactions with many flavor compounds, leading to the appearance of unnatural flavors (Conrad *et al*, 2005; Cheng *et al*, 2021).

**Table 4. The percentages of flavor compounds (Carboxylic acid and esters) in fresh orange juice and reconstituted concentrate using polymeric dehydration techniques have been detected by GC/MASS.**

The flavour Compounds	Fresh % of total	Polymer 2.5g/kg	Polymer 5g/kg	Polymer 7.5g/kg	Temp 60° C	Temp 80° C	Temp 100° C	LSD
n-Hexadecenoic acid, Pentadecanoic acid	1.819	1.72	1.77	1.95	1.47	1.52	1.88	0.303 *
1,2-Dipalmitine: Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester.	1.256	1.71	1.75	1.65	ND	ND	ND	0.548 *
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester.								
Phthalic acid, 3-methylbutyl nona decyl ester.								
Phthalic acid, 4,4-dimethylpent-2-yl octadecyl ester	0.579	0.34	0.37	0.37	ND	ND	ND	0.218 *
Phthalic acid, hexyl tridecyl ester.								
9-Hexadecenoic acid, methyl ester, (Z)	0.569	0.49	0.51	0.50	ND	ND	ND	0.226 *
Methyl palmitate Hexadecenoic acid, methyl ester	0.453	0.40	0.71	1.12	ND	ND	ND	0.197 *
Hexanoic acid, 3-hydroxy-, ethyl ester.								
Butane dioic acid, hydroxy-, diethyl ester.	0.439	0.55	0.58	0.62	ND	ND	ND	0.189 *
Sulfurous acid, hexyl octyl ester.	0.427	0.33	0.75	0.63	ND	ND	ND	0.196 *
Methyl petroselinate 6-Octadecenoic acid, methyl ester, (Z)-.	0.318	0.48	0.53	0.41	ND	ND	ND	0.156 *

\* (P<0.05).

\* Significant, NS= non-significant

Previous research has confirmed that these thermal treatments easily induced a series of chemical changes, which leads to the loss of many characteristic aroma-active compounds (mainly terpenes, aldehydes, and esters) and the production of new off-flavor compounds (mainly terpenes degradants, sulfur-containing compounds, phenols, acids, and others) (Table 4), subsequently, reducing the consumer acceptability (Jiménez-Sánchez *et al*, 2017; Perez-Cacho & Rouseff, 2008). As shown in Table 4, the polymeric dehydration technique was maintaining the content of many flavour

compounds comparing with the traditional method (high temperature) such as, Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester, 2-hydroxy-1-(hydroxymethyl) ethyl ester, 9-Hexadecenoic acid, methyl ester, Methyl palmitate hexadecenoic acid, methyl ester, and methyl petroselinate 6-Octadecenoic acid methyl ester. The decrease in the concentration of some of the main esterified aromatic compounds represent a significant loss in the aroma of orange juice after concentrated treatment, while the increase in the percentages of some carboxylic acids and

other esters indicates their varying reactive nature, and this is shown in Table 4. These results agreed to some extent with what was found (Mastello *et al*, 2015). Table (5) shows the percentages of aldehydes, alcohols, ketones and some amines and amides. Some of these compounds were disappear or interact with other organic compounds, especially, at high temperature degrees, which in turn, illustrate the highly sensitive of these compounds. The polymeric dehydration technique gave less degradation due to low temperature. The percentages of 2-piperidinone, N- [4-bromo- n- butyl] degradation by using polymeric dehydration was less that with conventional method, which explain the suitability of polymeric dehydration to maintain flavor compounds. 12-Methyl-E, E-2,13-octadecadien-1-ol compounds, the degradation effect was higher by using high temperature (traditional method) and free oxygen. The degradation of other aroma compounds (aldehydes and ketones) during processing and storage can also affect the aroma of juices (Mall *et al*, 2018). Sellami

*et al*, (2018) found that the reduced intensity of typical citrus-like odor of NFC (orange juice not from concentrate) during storage was correlated with a loss of the key aroma compounds. Among them, aldehydes were oxidized to 2-alkylthiazolidine-4-carboxylic acids by a reaction of saturated aldehydes (hexanal, octanal, nonanal, and decanal) with cysteine in the stored NFC orange juice. Similar results have also been reported in previous research (Bai *et al*, 2016). Mall *et al*, (2018) also found that the key aroma compound such as 1-penten-3-one was essential to the aroma of NFC orange juice, while it was degraded during storage. The heat treatment easily leads to chemical degradation and building up new adopted flavor compounds, which may badly affect the original flavor (Mastello *et al*, 2015; Welke *et al*, 2022). Many previous papers referred to the presence of d- carvone and  $\alpha$ -terpinol which derived from limonene dissociation throughout heat treatment under acidic conditions (Bi *et al*, 2020; Cheng *et al*, 2022; Welke *et al*, 2022).

**Table 5. The percentages of flavor compounds (alcohol, ketone, aldehyde and others) in fresh orange juice and reconstituted concentrate using polymeric dehydration technique have been detected by GC/MASS.**

The flavor Compound	Fresh % of total	Polymer 2.5g/kg	Polymer 5g/kg	Polymer 7.5g/kg	Temp 60° C	Temp 80° C	Temp 100° C	LSD
N-Methyl-3 piperidinecarboxamide.	1.464	0.68	1.03	1.11	ND	ND	ND	0.459 *
Octanal								
2-pyridinemethanamine	1.434	1.21	1.12	0.89	0.23	ND	ND	0.463 *
2-Piperidinone, N-[4-bromo-n-butyl]	1.429	0.93	0.75	0.44	0.38	0.36	0.23	0.502 *
1,3,2-Dioxaborolane, 4,4-dimethyl-5-oxo-,2-ethyl.	1.256	ND	ND	ND	ND	ND	ND	0.412 *
1,2-15,16-Diepoxyhexadecane.	0.793	ND	ND	ND	ND	ND	ND	0.290 *
12-Methyl-E, E-2,13-octadecadien-1-ol	0.760	0.77	0.85	0.86	0.23	0.20	0.17	0.263 *
1H-Tetrazole-1-ethanol, 5 amino-	0.555	ND	ND	ND	ND	ND	ND	0.217 *
1-Dodecanol, 2-octyl-2-Hexyl-1-decanol.	0.389	0.33	0.40	0.44	ND	ND	ND	0.178 *
Anethole	0.337	ND	ND	ND	ND	ND	ND	0.155 *
2-Dodecen-1-yl (-) succinic anhydride.	0.318	0.38	0.34	0.41	ND	ND	ND	0.164 *
Octadecanal								
3,5-di-terButyl-4-hydroxybenzaldehyde	0.280	ND	ND	ND	ND	ND	ND	0.178 *
1-Cyclohexene, 1,3,3-trimethyl-2-(1-methylbut-1-en-3-on-1-yl). Pyrido(4,3-d) pyrimidine-2,4(1H,3H)-dione, 1,3-dimethyl-	0.261	0.28	0.29	0.36	ND	ND	ND	0.166 *

\* (P<0.05).

\* Significant, NS= non-significant

## CONCLUSION

GC-MS has identified about 50 taste constituents in fresh orange juice. The main flavor components of concentrated and fresh orange juice include esters, monoterpenes, sesquiterpenes, and limonene. According to the study, the flavor constituents of fresh orange juice and orange juice condensed using a rotary vacuum evaporator and a conventional one differed significantly. In concentrated orange juice, new taste molecules have been found, particularly when high temperatures are applied. The paper also discusses how difficult it is to protect taste molecules against degrading factors.

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## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

## AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.

Author/s signature on Ethical Approval Statement.

Ethical Clearance and Animal welfare

Funds:

## AUTHOR'S CONTRIBUTION STATEMENT

Mohamed Subhi Khattab and Tariq Nasser Musa were responsible for designing the study. All experiments under study were conducted by Mohamed.S. Khattab. The simulation and discussion were conducted by Mohamed.S. Khattab. and Tariq N. Musa. They were responsible for expressing all the flavor compounds mentioned in the research. The data analysis was conducted by Mohamed S. Khattab using Agilent GC-MS analysis in the Ministry of Science and Technology with the assistance of BSc Hatem Al-Shuhail. All manuscripts and data were discussed with some specialists.

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## تركيز عصير البرتقال بأستعمال التجفيف البوليمري لحماية مركبات النكهة

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### المستخلص

أن البحث الحالي هو محاولة لحماية مركبات النكهة الرئيسية في عصير البرتقال المركز بأستعمال تقنية التجفيف البوليمري (صوديوم بولي أكريلات) بدلا من الطريقة التقليدية التي تسبب تحطم ملحوظ بتلك المركبات. تمت مراقبة الخواص الفيزيوكيميائية والميكروبية للعصير خلال عمليات التركيز. تم أستعمال تقنية التجفيف البوليمري تحت ظروف مختلفة لتركيز العصير ومقارنة ذلك بالطريقة التقليدية التي تستعمل فيها حرارة عالية. تمت مراقبة التغيرات في المواد الصلبة الذائبة الكلية، حامض الأسكوربيك، الحموضة، الرقم الهيدروجيني، اللزوجة، والتانينات بعد عملية التركيز إذ أنها تأثرت بمستويات مختلفة بحسب تقنية التركيز المستعملة. لم يتطور المحتوى الميكروبي خلال عمليات الخزن لمدة ستة أشهر بسبب إضافة 100 جزء بالمليون من مادة بنزوات الصوديوم كمادة حافظة بعد عملية العصر مباشرة. تمت مراقبة مركبات النكهة الرئيسية في عصير البرتقال الطازج خلال عمليات التركيز المختلفة للحكم على قابليتها في الحفاظ على مركبات النكهة في العصير المركز.

**الكلمات المفتاحية:** المواد الصلبة الكلية الذائبة، التقنية المقترحة، الخواص الفيزيوكيميائية، الاحتفاظ بالرائحة.

\* جزء من أطروحة دكتوراة للباحث الأول.