Torre Canne (Brindisi, Italy)

October 16-18, 2024

P30

Impact of stabilizers on ice cream's aroma release

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Summary: *This study explores how various stabilizers influence ice cream's aroma release of vegan and dairy bases recipes. The effect of twelve stabilizer blends was investigated by PTR-MS headspace, revealing significant differences in aroma release. The findings aim to enhance ice cream formulations for an optimal sensory experience*

Keywords: *Food hydrocolloids, PTR-MS, Headspace*

Introduction

Ice cream's physical and sensory attributes are influenced by its microstructural components, including the ice phase, air phase, and fat phase. To enhance these attributes and maintain stability through shelf life and temperature fluctuations, stabilizers such as hydrocolloids are used.[1] This ingredient adds viscosity to the unfrozen portion of water, preventing water migration within the product, enhancing gel structure, and delaying ice crystal formation. Collectively, these effects contribute to a smoother texture and improved stability.[2]
Polysaccharides, while often showing smaller interactions with volatiles, can still affect the dynamic headspace concentration due to their gel properties, which slow the mass transfer of volatiles from the food phase into the headspace.[3] Dynamic studies have shown that increasing the gel strength of biopolymers, as indicated by the strength of interactions (such as hydrogen bonds, covalent bonds, and hydrophobic interactions) correlates with decreased sensory intensity and volatile release. For instance, research by Carr *et al*.[4] demonstrated that different biopolymers affected volatile release differently as stronger gels result in decreased sensory perception. Additionally, it has been observed that thickened solutions of similar viscosity, but with different thickening agents, do not induce the same flavor release, highlighting the specific interactions between stabilizers and aroma compounds.[5]
This intricate balance between enhancing texture and preserving flavor release is a key focus of ongoing research, aiming to optimize ice cream formulations for sensory appeal.[6-9] This study employs an array of different stabilizer combinations to explore the synergy and rheological behavior of the stabilizers. Answering how stabilizer blends impact ice cream aroma release and influence rheological properties would be a key improvement for product developers.

Material and Methods

<u>*Ice cream samples*</u>

The dairy and vegan ice cream ingredients were added sequentially based on their solubility temperature, starting from dry ingredients to oils, with the temperature controlled up to 70°C using a liquid-kitchen thermometer. The tested recipes were similar in terms of macronutrients (fat, sugar and protein contents) with varying blends of stabilizer reported in table 1. The recipes included vegetable fat, vegetable oil, sugar, glucose syrup, skimmed milk powder, mono- and diglycerides, water, and stabilizers, all provided by Sorermartec internal suppliers.
The ice cream recipes were prepared in phases: Control, phase 0, phase 1, phase 2, and phase 3 (Table 1). After preparation, the mixture underwent homogenization followed by a rapid decrease in temperature to 10°C by ice bath. The mixture was then aged for at least 24 hours. Following the aging period, two flavors (milk and peach-type) of known composition, including flavoring substances from categories such as lactones, esters, terpenes, carboxylic acids, aldehydes, alcohols, and ketones, were incorporated at concentrations of 1% and 0.5% (*w/w*) to the ice cream liquid before blast chilling. The final product was prepared using a benchtop ice cream machine set to a 30-minute program. Subsequently, the ice cream underwent a hardening step, remaining at -19°C for at least 5 days before the headspace measurements were taken.

<u>*PTR-MS analysis and Data Analysis*</u>

Samples were weighed (1.5- 1.7 grams) and placed into 20 mL vials for Proton Transfer Reaction Mass Spectrometry (PTR-MS) headspace measurements. The vials were frozen overnight to ensure headspace equilibration and the frozen state of the ice cream.

Table 1. *Summary of stabilizer blend type*

Sample group		Information	
Blends			
a)	Blank	a)	Empty Frozen headspace vials
b)	Control	b)	Recipe without stabilizer
c)	Phase 0	c)	Best on literature: Guar, LBG, carrageenan kappa
d)	Phase 1	d)	Singular stabilizer: Alginate, LBG, xanthan, guar
e)	Phase 2	e)	Alginate+xanthan, alginate+Guar, xanthan+guar
f)	Phase 3	f)	(Alginate + carrageenan kappa) with xanthan or guar or LBG

The ice cream samples containing milk and peach volatile compounds were analyzed using PTR-MS at two-time points: time one (frozen dessert at 4°C) and time twenty (melted ice cream at 30°C to simulate consumption). With ionization conditions set to drift tube temperature of 110°C, pressure of 2.80 mbar, and voltage of 628 V, E/N ratio of 128 Townsend. The PTR-MS data were processed with in-house software from the Sensory Quality Unit at Fondazione Edmund Mach. Peak identification was performed using an in-house library and literature research. The ANOVA analysis was done to determine which sample signals (*m/z*) were significantly ($p < 0.05$) higher than those detected from the blanks, the outcome was the peak selection of 66/215 *m/z* for the vegan base and 114/240 *m/z* for the dairy base. Principal Component Analysis (PCA) was performed on all samples using the selected peaks (*m/z*) concentration, to highlight differences between samples formulated with different blends of stabilizers.

Results

Different stabilizer blends exhibited distinct impacts on aroma release, particularly when flavor was added. Unflavored samples clustered together, whereas flavored samples differentiated based on the stabilizer used showing a clear impact of the stabilizer's type/combination. Notably, dairy ice cream without stabilizers (NSF) showed the highest release of peach flavor volatiles, tentatively identified as linalool (*m/z* 155.14), hexenyl acetate (*m/z* 143.12), and isoamyl acetate (*m/z* 131.12). This indicates that the absence of stabilizers enhances the release of certain aroma compounds confirming the idea that a stronger matrix may have a negative impact.

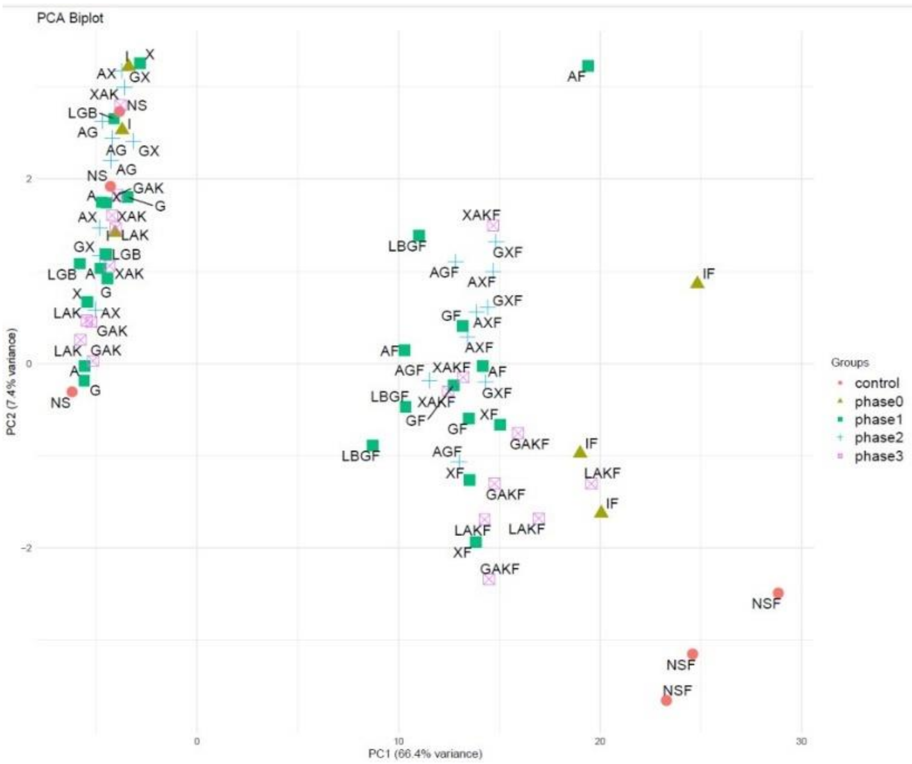

Figure 1. *Dairy Ice cream peach flavored and unflavored recipes measured at minute 20. Colors and shapes mean different groups of stabilizer blends. I: Guar +Locust Bean + Carrageenan kappa, A: Alginate, LBG: Locust bean gum, X: Xanthan, G: Guar, K: Carrageenan kappa, NS: No stabilizer, F: for flavor added*

However, this effect is clear only on dairy ice cream, whereas vegan ice cream samples containing a blend of alginate and carrageenan with locust bean gum and xanthan showed the highest release of milk flavor volatiles, tentatively identified as decanoic acid (*m/z* 173.15) and ethyl lactate (*m/z* 119.08). This research contributes to the broader understanding of the interactions between stabilizers and volatile compounds, in which significant difference were observed within the phases attributed, with the complex blend of three stabilizers having overall a higher release of aroma compounds.

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