LWT - Food Science and Technology 60 (2015) 593–597

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Porous starch for flavor delivery in a tomato-based food application

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ARTICLE INFO

Article history:
Received 29 January 2013
Received in revised form
17 September 2014
Accepted 18 September 2014
Available online 7 October 2014

Keywords:
Plating
Ranking test
Flavor shelf life
Sensory–chemical correlation

Chemical compounds studied in this article:
Ethyl Butyrate (PubChem CID: 7762)
α-Pinene (PubChem CID: 6654)
Camphene (PubChem CID: 6616)
Myrcene (PubChem CID: 31253)
α-Terpinene (PubChem CID: 7462)
γ-Terpinene (PubChem CID: 7461)
p-Cymene (PubChem CID: 7463)
β-Ocymene (PubChem CID: 5281553)
Estragol (PubChem CID: 8815)
β-Ionone (PubChem CID: 638014)

ABSTRACT

The aim of this study was to evaluate the performance of porous starch, a newly proposed flavor carrier, in a simulated real industrial application. A liquid tomato flavor was plated onto porous starch, as well as onto maltodextrin, and also spray dried, being the latter the most common flavor encapsulation technique used by the food flavor industry. The three flavor systems were added into a tomato sauce that was subjected to sterilization and ambient storage to verify flavor resistance to sterilization and shelf life, measured by sensory and chemical analyses. The three flavor systems showed a similar flavor content after sterilization and similar behavior during shelf-life. Both sensory and chemical analyses confirmed that the polarity of the solvent used to carry the flavor molecules onto porous starch is a key factor in determining flavor retention over time.

1. Introduction

Flavors are widely used in the food industry to improve the sensory attributes of food products that have lost the original flavor of the raw materials during the production processes, especially when heat is involved. Flavors are generally liquid blends of molecules in solvents and are often liable to damage when exposed to heat, air, humidity and other factors (Salzer, 2007). For this reason, liquid flavors are generally converted to powder form to gain a longer stability over time and an easier handling, storage and dosage (Gharsallaoui, Roudaut, Chambin, Voilley, & Saurel, 2007).

Different techniques are currently used by the food industry for the conversion of liquid flavors into powder flavors. A liquid flavor may be dispersed onto a bulk powder carrier, such as salt or maltodextrin (Salzer, 2007), a technique which allows only a low amount of liquid in the mixture and often requires the use of anti-caking agents (such as silicon dioxide). Liquid flavors may also be mixed with carriers and spray dried to obtain a fine free-flowing powder where the flavor is in the microencapsulated form (Madene, Jacquot, Scher, & Desobry, 2006). A spray dried flavor can have a flavor load of 200 g/kg or more, depending on the carrier used. Microencapsulation protects the liquid flavor from the outside environment thus prolonging its shelf life, whereas a simple blended flavor is not protected from oxygen, air, moisture and heat (Salzer, 2007).

The food industry's continuous search for new and innovative means for flavor delivery has recently brought attention to the use of porous starch. Porous starch is a native corn starch that is modified to obtain a porous “sponge-like” structure with a large surface to volume ratio, and it is believed to be able to host flavor molecules and solvents inside its porous structure with a simple plating procedure (Glenn et al., 2010; Zeller, Saleeb, & Ludescher, 1999). The advantages of using porous starch would be mainly

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http://dx.doi.org/10.1016/j.lwt.2014.09.047
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the lower production costs (simple plating rather than spray drying) and the high liquid to powder ratio achievable (even higher than in spray drying). Previous studies have shown porous starch's capability of encapsulating various substances allowing a high load of the liquid flavor (Belingheri, Curti, Ferrillo, & Vittadini, 2012; Glenn et al., 2010). It has also been shown that porous starch effectively shields plated oil from light, and, moreover, since no heat is involved in the plating procedure, there is no induced initial oxidation of the carried oil as is found in spray dried products (Belingheri, Giussani, Rodriguez-Estrada, Ferrillo, & Vittadini, 2015). It is however not clear if the porous starch behaves like other more conventional bulking agents, and if its porous nature protects the flavor just as a microencapsulating structure would. To the best of the authors' knowledge, there is no study present in literature that shows the performance of porous starch in a real food application, compared to the techniques currently in use for liquid flavor conversion to powder. Such information would support the flavor industry in the use of this new substrate for carrying flavors.

The present study aimed, therefore, at evaluating the performance of a flavor carried onto porous starch in comparison with flavor encapsulated by spray drying and a flavor blended onto a non-porous carrier (maltodextrin). A tomato flavor carried onto the three different carriers was applied into a tomato sauce and the effect of heat (i.e. sterilization) and storage (up to six months) on flavor stability was evaluated to simulate a practical industrial application.

2. Materials and methods

2.1. Preparation of powder flavor systems

A concentrated liquid top note tomato flavor (Kerry Ingredients and Flavors, Italy) was appropriately diluted into Medium Chain Triglycerides (MCT, 99.7%, Nutrivis Srl), a standard solvent in the industry, to obtain a liquid flavor that would allow to obtain a final flavor load of 13 g/kg when converted to powder form with each of the three methods below:

- Spray drying: a slurry (solids concentration of 400 g/l) was made by mixing the carriers (Gum Arabic, Kerry Ingredients UK Ltd, and DE 20 potato maltodextrin, Brenntag SPA, at a 1:3 ratio) and the liquid flavor in water. The slurry was fed to a single stage spray dryer (APV, Italy; $T_{in} = 160$ °C; $T_{out} = 90$ °C) to obtain the flavor powder.
- Plating onto maltodextrin: the liquid flavor was blended onto DE 20 potato maltodextrin (Brenntag SPA) in a 2:1 powder to liquid ratio to obtain the flavor powder.
- Plating onto porous starch: the liquid flavor was blended onto porous starch (StarrierR®, Cargill) in a 1:1 powder to liquid ratio to obtain the flavor powder. Since previous studies have shown an influence of solvent on porous starch performance (Belingheri et al., 2012), the liquid flavor to be plated on porous starch was obtained also using propylene glycol (99.8%, Univar SPA) or triacetin (99.0%, Chemical SPA) as solvent alternatives to MCT to dilute the top note tomato flavor.

A summary of the flavor systems obtained can be seen in Table 1.

2.2. Preparation of flavored tomato sauce

All powders had the same flavor fraction content and were thus equally dosed at 0.3 g/kg into an industrially prepared unflavored tomato sauce (Santa Rosa Classica sapore crudo, Italy). The sauce was heated to 50 °C, and the flavor was then added and stirred until complete dispersion. Sauces containing the spray dried flavor, the flavor plated onto maltodextrin and the flavor plated onto porous starch were labeled SD, PM and PPS respectively. For the flavor plated onto porous starch, the subscripts PG, TA and MCT were used to identify the solvent present in the flavor, for propylene glycol (i.e. PPS_{PG}), triacetin (i.e. PPS_{TA}) and MCT (i.e. PPS_{MCT}), respectively (see Table 1).

Table 1
Summary of evaluated samples.

Sample	Sample description
SD	Spray dried tomato flavor
SDst	Sterilized spray dried tomato flavor
PM	Tomato flavor plated onto maltodextrin
PMst	Sterilized tomato flavor plated onto maltodextrin
PPS_{PG}	Tomato flavor plated on porous starch with propylene glycol as solvent
PPS_{TA}	Tomato flavor plated on porous starch with triacetin as solvent
PPS_{MCT}	Tomato flavor plated on porous starch with medium chain triglycerides as solvent
PPSst	Sterilized tomato flavor plated on porous starch with propylene glycol as solvent

2.3. Preparation of sterilized flavored tomato sauce

The sauces flavored with SD, PM and PPS_{PG} were weighed (250 g) into retortable glass jars (250 ml; Quattro Stagioni, Bormioli Rocco, Italy) and sterilized in a retort (Levati Food Tech, Parma, Italy) using the temperature cycle outlined in Table 2. Sterilized sauces were stored at room temperature for two days prior to tasting. The sterilized sauces containing the three flavors SD, PM and PPS_{PG} were identified with the codes SDst, PMst and PPSst, respectively (see Table 1).

2.4. Flavor shelf life

The powder flavors were allowed to age at ambient storage conditions in High Density Poly Ethylene, non hermetically sealed containers (Con Plax New Pac SPA, Bergamo, Italy) at room temperature (22 ± 2 °C) in the dark. After three and six months from production they were once again used to flavor the tomato sauce and were subjected to sensory and chemical analysis as the fresh and sterilized sauces had been.

2.5. Sensory analysis

Tests were carried out in sensory analysis booths (designed according to ISO methodology 8589:2007). Each booth was equipped with a computer for data registration and a red light was used to minimize visual influences on the results. Panelists had water and unsalted crackers at their disposal to clean their mouths in between samples. The following tests were performed in separate sessions:

Table 2
Operational temperature cycle of the retort.

Stage	Temperature
Start	0 °C
Ramp 1	Heat to 80 °C; hold 5 min
Ramp 2	Heat to 120 °C; hold for 30 min
Ramp 3	Cool to 95 °C; hold for 15 min
Ramp 4	Cool to 60 °C; hold for 15 min
Finish	Cool to 30 °C