Influence of carnauba wax concentration on the physicochemical properties of olive oil organogels

University of Minho
School of Engineering
CENTRE OF BIOLOGICAL ENGINEERING

Silva, P.[1], Fasolin. L.[1], Martins, A.[1,2], Vicente, A. A.[1]

1. CEB - Centre of Biological Engineering, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
2. INL - International Iberian Nanotechnology Laboratory, Av. Mestre José Veiga s/n, 4715-330 Braga, Portugal

Email: pedro.silva@ceb.uminho.pt

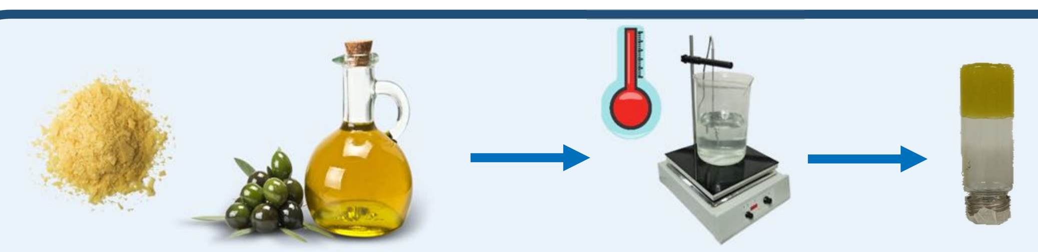
IUFoST 2018 INDIA
OCTOBER 23 - 27

Abstract

Edible oils have potential health benefits when compared to saturated and/or trans fats typically used in food products. In order to widen their use as spreadable products, structuring these oils is a requirement. Thus, the aim of this work consisted in the development of an olive-oil organogel, foreseeing its application in the food industry. Olive-oil was used for the production of the organogels, with carnauba wax (CW) as organogelator (1% to 6% (w/w)), solubilized under magnetic stirring (90 °C) and cooled to room temperature. Systems were evaluated regarding oxidation (PV), textural, rheological (flow curves; non-isothermal oscillatory sweeps) and thermal properties. Olive-oil and commercial butter were used as controls. An increase in CW concentration increased the textural parameters. Compared to values of commercial butter, organogels values were lower, indicating a less structured organogel (highest values: firmness of 3.79 N and 10.29 N for organogel and butter respectively; spreadability of 3.17 N/sec and 10.15 N/sec for organogel and butter respectively). Thixotropy, initial viscosity, onset temperature, enthalpy, also showed an increase with increasingly higher CW concentrations. Melting point of organogels was determined and compared with calorimetric analysis. Similar trends were found: an increase in concentration increased the melting point; Regarding oxidative stability (63 days of storage, room temperature, exposed to light), results showed that, while an increase exists, it is within expected values (maximum PV, 1.10 meqO2/kg at 63 days), and all organogel samples were below the PV of olive oil (maximum PV of 1.47 meqO2/kg, at 63 days). Results show that varying gelator concentration, physicochemical properties can be easily changed and tailored, possibly creating a wide range of products. Thus, an industrial application can be easily projected, since olive oil is a healthier alternative to other spreadable products.

Methods

Sample Preparation

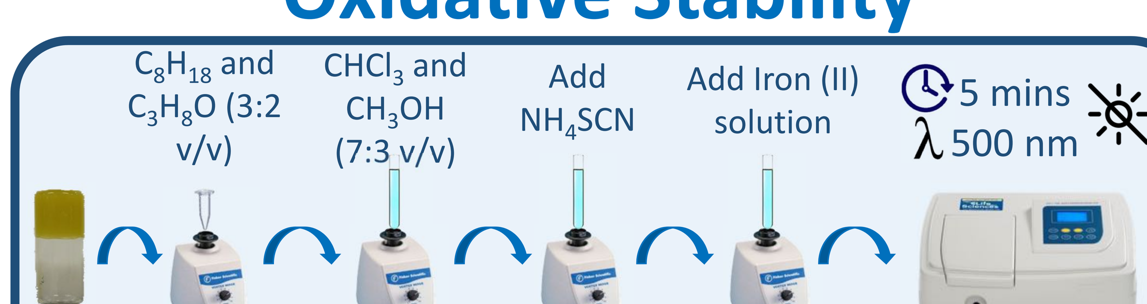


Solubilize carnauba wax (1 % up to 6 % (w/w)) in virgin olive oil at 90 °C during 30 min to ensure full solubilization

Thermal Analysis

Heating and cooling ramps from 5 to 90 °C with a 10 °C/min rate; Under nitrogen atmosphere

Oxidative Stability

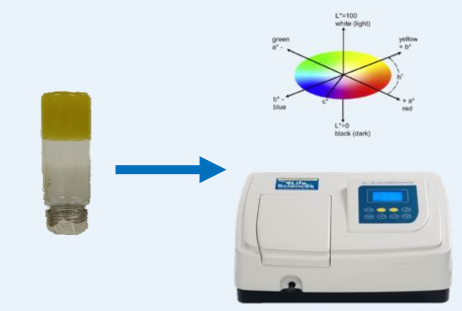


Physical assessments

Morphology

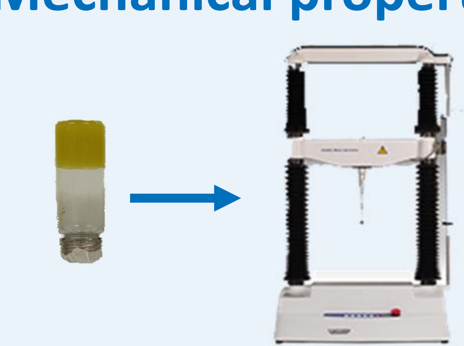
Phase contrast microscopy

Color Assessment



Transmittance Spectrum; Transform to CIELAB data

Mechanical properties



TTC Spreadability Rig (HDP/SR) probe;
Test speed: 3 mm/s;
Post-Test speed: 10 mm/s

Rheology Analysis

Flow curves at 25 °C (0.1 to 300 s^{-1}), up-down-up step program;
Cooling and heating ramps between 90 °C and 5 °C at 10 °C/min, 1 Hz

Introduction

Natural vegetable oils are known to have several benefits in comparison to saturated and/or trans fats. However, these saturated and/or trans fats are generally used in food products as texture modifiers due to their physical properties while healthier edible oils are generally found in a liquid state, therefore limiting its applicability; Therefore, modulating the physicochemical properties by conferring structure to edible oils without changing lipid profile and chemical composition could overcome this lack of structure and allow a greater range of applications

The aim of this work was to develop an olive oil organogel, observing how different concentrations of organogelator impacted its characteristics. In order to do so organogels were characterized regarding morphology, physicochemical, thermal, textural and rheological properties. This work can be seen as a possible step in developing an olive oil organogel, foreseeing its application in the food industry.

Results

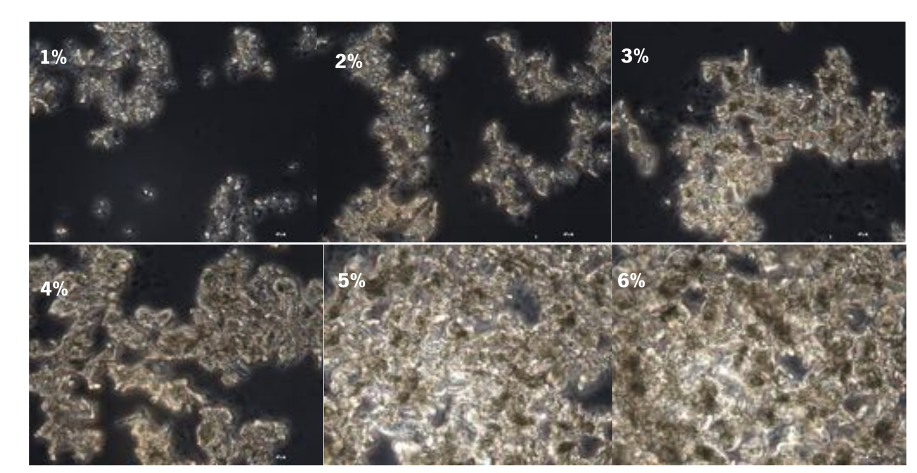


Figure 1. Phase contrast micrographs for all carnauba wax-virgin olive oil organogel samples, after organogelation

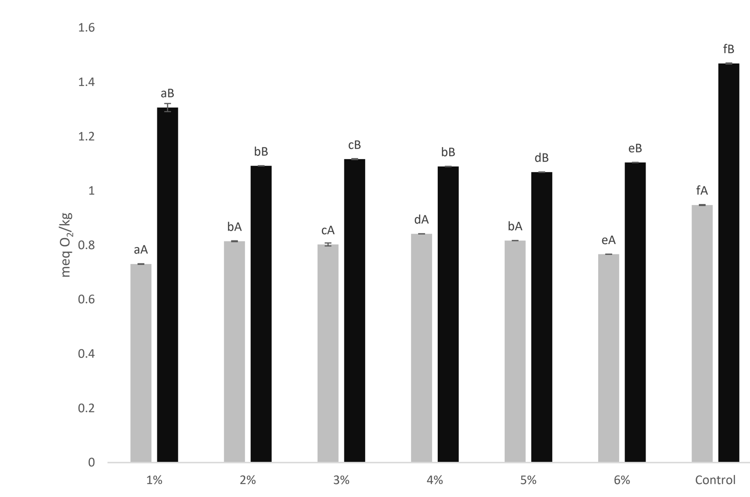


Figure 2. Peroxide values of carnauba-virgin olive oil organogels. Different small letters indicate statistical differences between different concentration, while different capital letters indicate statistical differences between different time assessments (p<0.05); T0=0; T1=63 days.

Table 1. Color differences between final and initial assessments

Sample	$\Delta E^*ab_{(T1-T0)}$
1%	4.058
2%	2.630
3%	4.785
4%	5.057
5%	4.903
6%	5.155
Control	53.964

Table 2. Color differences between sequential concentrations for the initial (T0) and final (T1) assessments

Sample	T0	T1
$\Delta E^*ab_{(2\%-1\%)}$	11.775	9.399
$\Delta E^*ab_{(3\%-2\%)}$	3.172	4.481
$\Delta E^*ab_{(4\%-3\%)}$	4.912	5.874
$\Delta E^*ab_{(5\%-4\%)}$	1.955	1.492
$\Delta E^*ab_{(6\%-5\%)}$	3.239	4.197

Table 3. Thermal properties of the carnauba wax-virgin olive oil organogels. Different small letters for the same property represent significant differences

	Melting			Crystallization		
Sample	Peak (T_m °C)	ΔH_m (J/g)	Onset (T_m °C)	Peak (T_c °C)	ΔH_c (J/g)	Onset (T_c °C)
1%	70.77	0.97	65.24	42.06	-1.07	44.65
2%	72.09	0.98	66.17	42.63	-1.08	46.03
3%	73.64	2.31	67.92	47.58	-2.72	50.18
4%	74.73	4.79	68.95	50.32	-4.83	53.92
5%	75.28	9.87	69.12	53.05	-8.54	58.78
6%	76.72	8.96	68.63	54.38	-8.43	58.52
Control	85.39	144.70	82.25	75.74	-136.27	78.89

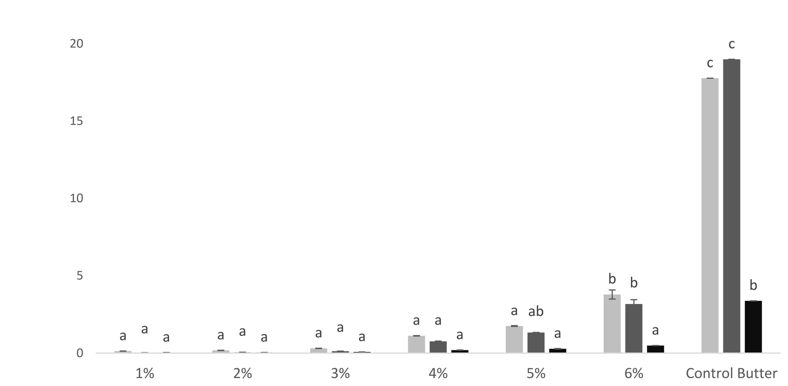


Figure 3. Mechanical properties of candelilla-virgin olive oil organogels. Different small letters for the same property represent significant differences. Firmness (N); Spreadability (N.s); Adhesiveness (N.s) (in modulus).

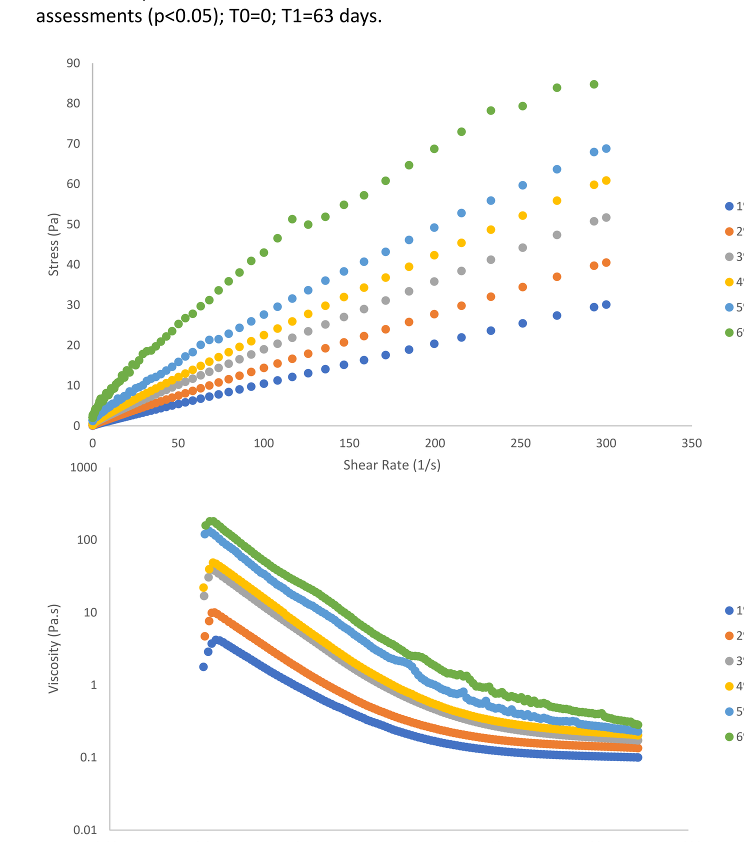


Figure 4. Viscosity (bottom) and stress (top) results for all carnauba wax-virgin olive oil organogel samples .

Table 4. Melting and crystallization points obtained from non-isothermal oscillation rheology of all carnauba wax-virgin olive oil organogel samples. Different small letters represent significant differences

Sample	Melting Point (°C)	Crystallization point (°C)
1%	N.D.	N.D.
2%	30.328	11.171
3%	62.373	27.436
4%	73.617	42.935
5%	76.729	48.671
6%	78.153	50.757

Table 5. Thixotropy and Initial Viscosity (0.05 s^{-1}) of all carnauba wax-virgin olive oil organogel samples. Different small letters represent significant differences

Sample	Thixotropy (Pa/s)	Initial Viscosity (1/s)
1%	427.51	12.78
2%	1263.72	132.20
3%	2324.33	345.07
4%	3443.54	1095.64
5%	6237.67	2510.25
6%	12219.23	4328.86

Conclusions

- Peroxide values were well below both the values of the control samples and the legal limits;
- Comparing DSC results and non-isothermal rheology it was possible to see a clear tendency between melting and crystallization peaks; It is clearly seen that an increase in gelator concentration increases initial viscosity and thixotropy and thus creates a stronger 3D network in the organogel. This data and conclusions are supported by the textural results.
- These results show that by varying the gelator concentration it is possible to modulate organogels characteristics to target a specific application in the food industry, as a possible replacement or healthier alternative for currently used spreadable products.

FCT Fundação para a Ciência e a Tecnologia — COMPETE 2020 — PORTUGAL 2020 — NORTE 2020 — UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

This study was supported by FCT under the scope of the strategic funding of UID/BIO/04469/2013 unit and COMPETE 2020 (POCI-01-0145-FEDER-006684) and BioTecNorte operation (NORTE-01-0145-FEDER-000004) funded by the European Regional Development Fund under the scope of Norte2020 - Programa Operacional Regional do Norte.