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Valorization of apple bagasse using sustainable technologies and encapsulation

Marina Roldan-Muñoz, Concepción Sánchez-Moreno, Begoña de Ancos

Department of Characterization, Quality and Safety, Institute of Food Science, Technology and Nutrition (ICTAN-CSIC), Madrid, Spain.

INTRODUCTION & AIM

The apple juice industry worldwide generates millions of tons of **bagasse as a by-product**. The valorization of bagasse as a source of extract rich in phenolic compounds with antioxidant and anti-inflammatory properties has been studied using sustainable technologies such as ultrasound-assisted extraction (UAE), high-pressure processing (HPP), and encapsulation for their protection.

The aim of this study was to evaluate the characteristics of **encapsulated** of **phenolic compounds (TPC)** obtained from **bagasse** of two different apple varieties, **Golden Delicious (GD)** and **Granny Smith (GS)** using sustainable technologies (**HPP and UAE**), and three different encapsulation materials, maltodextrin (MD), arabic gum (GA), or a mix of MD–GA (1:1.5).

METHODS

GD GS

Golden-Delicious bagasse (BGD)

Granny-Smith bagasse (BGS)

High-pressure processing (HPP)

BGS at 200 MPA/25 ºC/5 min

BGD at 400 MPa/25 ºC/5 min

Iso-Lab System, Model FPG7100:9/2C (Stansted Fluid Power LTD) Equipment at ICTAN-CSIC

HPP-bagasses dried (6 g)

Ultrasound-assisted extraction (UAE)

Amplitude 42 µm/20 min

Solvent: Ethanol /water (50:50)

500 Watts-20 kHz

Probe tipe 19 mm

TPC Extract

Encapsulation by Lyophilization

3 Encapsulation material

- Maltodextrin (MD)
- Arabic gum (GA)
- Mix (MD-GA) (1:1.5)

8% in H_2O Forming solution

Lyo

6 TPC-Encapsulated

MD–GD and MD–GS

GA–GD and GA–GS

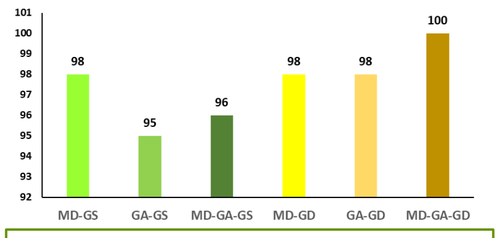
MD+GA–GD and MD+GA–GS

Encapsulated Characterization[1,2]

- Encapsulation yield
- Humidity and Hygroscopicity
- Release of TPC (H_2O, MeOH)
- Release of TPC during *in vitro* gastrointestinal digestión (GID)[3]
- TPC by Folin-Ciocalteu[4]
- Efficiency
- Efficacy

RESULTS & DISCUSSION

Encapsulation Yield (%)



The yield of the encapsulation was a bit higher in BGD-encapsulated (98-100%) than in BGS-encapsulated (95-96%) samples.

Humidity and Hygroscopicity

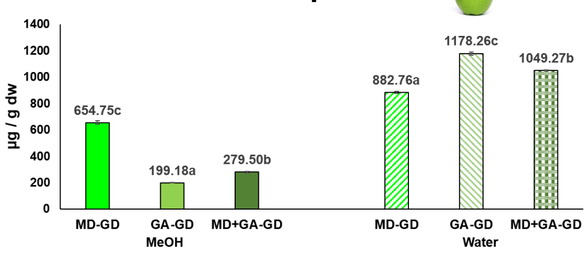
Encapsulated	Humidity (water content) mg/100 g dw	Hygroscopicity (water absorbed) mg/100 g dw
MD-GS	9.89 ± 0.05cA	25.17 ± 0.51aA
GA-GS	8.65 ± 0.15bA	34.00 ± 1.70bA
MD+GA-GS	8.40 ± 0.01aA	33.49 ± 1.48bA
MD-GD	10.19 ± 2.03abA	30.48 ± 0.78aB
GA-GD	9.51 ± 0.05aB	39.31 ± 1.09cB
MD+GA-GD	11.01 ± 0.03bB	33.32 ± 0.23bA

Different lowercase letters (a-c) indicate statistically significant differences ($p < 0.05$) between the encapsulation materials for the same apple bagasse (GD or GS). Different capital letters (A-C) indicate statistically significant differences ($p < 0.05$) between apple bagasse (BGS and BGD) for the same encapsulation materials (MD, GA or MD+GA)

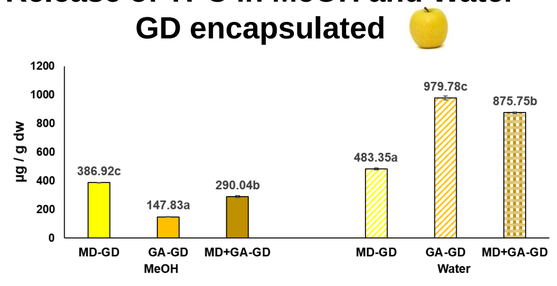
Encapsulated from BGS showed a humidity and hygroscopicity medium value (8.98 and 30.87 mg/100 g dw, respectively) lower than the encapsulated from BGD (10.23 and 34.34 mg/100 mg, respectively). In general, GA-encapsulated samples (GA-GS and GA-GD) showed higher hygroscopicity than MD- and MD–GA-encapsulated samples.

Release of TPC in MeOH and Water GS encapsulated

Higher TPC concentration was released from GS-encapsualted than from GD-encapsulated



Release of TPC in MeOH and Water GD encapsulated

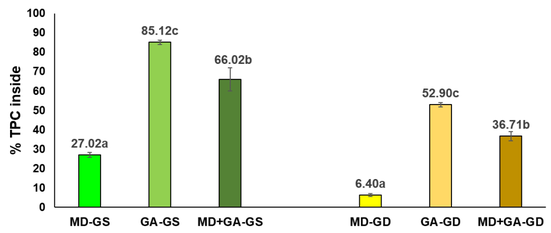


TPC in Water = TPC inside and outside (total) of microcapsules
TPC in MeOH = TPC outside of microcapsule
$TPC_{water} - TPC_{MeOH}$ = TPC inside microcapsules

Encapsulation Efficiency= %of TPC inside microcapsules compared to the total TPC (in and out) in the capsule

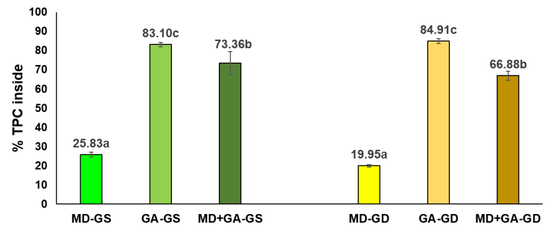
Encapsulation Efficacy = % of TPC in the forming solution that has been encapsulated (inside)

Encapsulation Efficacy



The maximum efficacy was found in GA-encapsulated samples (85%, GA-GS; 53% = GA-GD) compared to MD+GA and MD encapsulated.

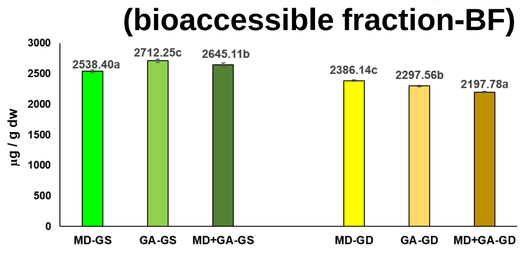
Encapsulation Efficiency



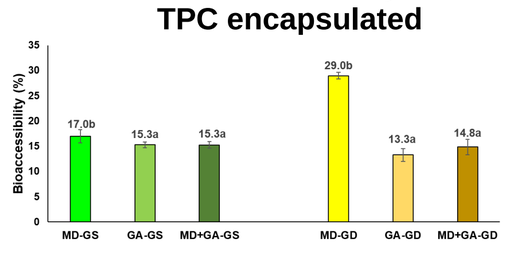
The efficiency was higher in GA-encapsulated (~84%) than in MD–GA- (~70%) and MD-encapsulated samples (~23%).

Release of TPC during GID (bioaccessible fraction-BF)

BF of encapsulated from GS bagasse showed higher TPC concentration than the BF of encapsulated from GD bagasse.



% Bioaccessibility of TPC encapsulated



The highest TPC bioaccessibility was found in MD-encapsulated samples (MD-GS = 17% and MD-GD = 29%).

CONCLUSION

Very high encapsulation yields were found with the three encapsulation materials, maltodextrin-MD, Arabic-gum-GA, and mix of MD-GA (1:1.5) and with the two bagasse studied, one from Golden Delicious (GD) and other from Granny Smith (GS) apples. The highest efficiency and efficacy of encapsulation of phenolic compounds were achieved with TPC-extract of Granny-Smith bagasse encapsulated with Arabic gum (GA). The highest TPC bioccessibility were found in the maltodextrin (MD) encapsulated. The characteristics of the encapsulated studied depended on the bagasse (apple variety) from which the TPC extract was obtained and the type of encapsulation material.

REFERENCES

[1]Jasso de Rodríguez et al. Ind. Crops Prod., 2019,138, 111444; [2] Oancea et al. LWT-Food Sci. Technol., 2018, 129-134.[3]Brodkorb et al. Nat. Protoc., 2019, 14, 991–1014 (INFOGEST). [4]Fernández-Jalao et al. J Food Eng, 2019, 213, 60-68.

ACKNOWLEDGEMENTS

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