Microcapsules formed by polyphenols contained in Blackberry and starch from Gros Michel banana and modified with octenyl succinic anhydride as wall material by spray drying: Production and bioaccessibility.

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ABSTRACT

Banana starch Gros michel can be used industrially by modifying them to improve their functional properties. Modified starches have been widely used in the food industry as an encapsulating material in spray drying. The objective of this work was to determine the operating conditions of spray drying and to determine the bioavailability and release of microcapsules formed by blackberry and OSA-modified starch extracted from Gros michel bananas. Starches were extracted, modified, and characterized physicochemically. To determine the drying conditions, two experimental designs were carried out to determine the number of solids in the feed and to determine the drying operation variables, respectively. Subsequently, an in vitro digestion was performed to determine the release kinetics and bioavailability of the phenolic compounds contained in the microcapsules formed. The modified starches showed a structural alteration that allowed them to change some functional properties such as viscosity and gelatinization onset temperature. The maximum concentration of solids from blackberry was 8%. The feeding solution must be made up of 47.75% blackberry concentrate, 5% starch, 1.8% maltodextrin, and 40.93% water and subject it to spray drying using 129 ° C, 75 ° C as the outlet air temperature, and 27850.9 rpm atomizer disk speed. It was possible to determine that the phenol with the highest intestinal bioavailability was gallic acid with 42.3% at 120 minutes of digestion and the rest of the components had their maximum bioavailability values in the gastric phase, in turn between 15 and 30 minutes of intestinal digestion occurred the release of 50% of the content of phenols that passed from the stomach to the intestine.

INTRODUCTION

- At present, chemically modified starches have aroused scientific interest due to their functional properties, which make them a novel material for the food industry.
- Several authors have reported the use of commercial modified starches in spray drying as wall material for the encapsulation of bioactive compounds.
- There are no scientific reports that evidence the use of modified starches from banana used as wall material in in spray drying, in turn, there is no scientific information available on how these starches release bioactive compounds in the intestine, nor on how is its bioaccessibility

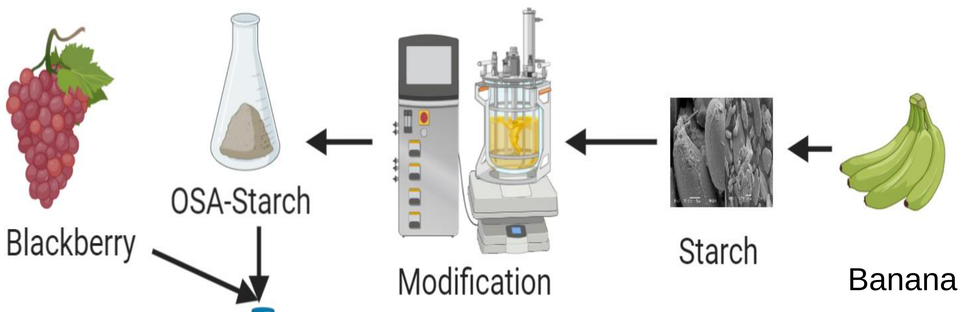
HYPOTHESIS

OSA starch from Gros michel banana could be used to produce microcapsules by spray drying preserving their bioactive compounds to release them in the small intestine later to make them bioaccessible

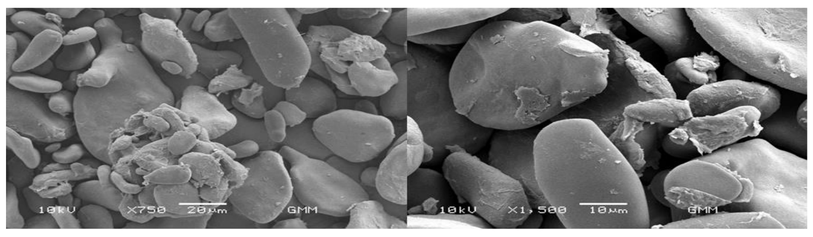
OBJECTIVE

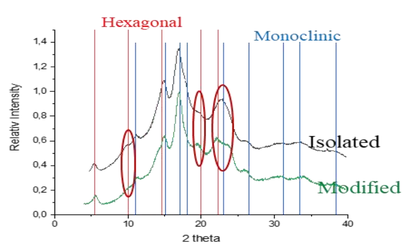
To obtain and characterize the OSA modified starch from Gros michel banana, determine the optimal conditions for spray drying of a solution formed by blackberry and OSA starch, and determine the bioaccessibility, permeability, release and storage stability of the microcapsules

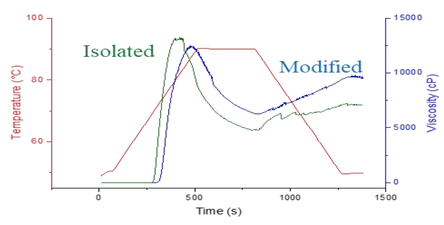
MATERIALS AND METHODS

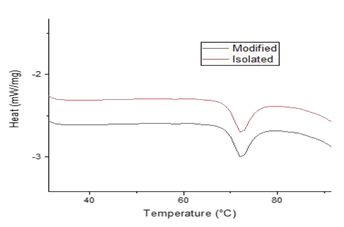


RESULTS









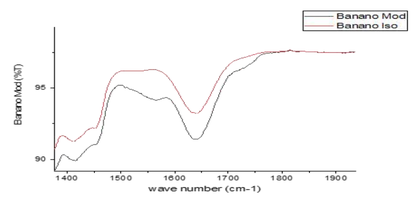


Figure 1. Results of the physical analyzes carried out on the banana starch modified with OSA. Micrographs obtained by SEM, XR diffractogram, viscoamylogram, Thermogram obtained by DSC and FTIR spectrum.

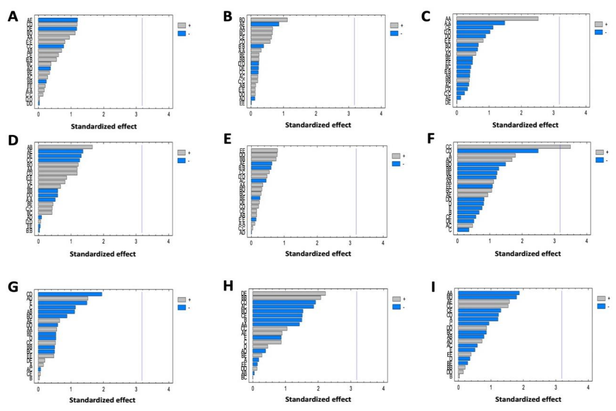


Figure 2. Pareto charts for the response variables analyzed in the experimental design of the spray drying process using OSA-modified banana starch. (A) aw; (B) D10; (C) D50; (D) Humidity; (E) hygroscopicity; (F) Solubility; (G) viscosity; (H) wettability; (I) Yield (%).

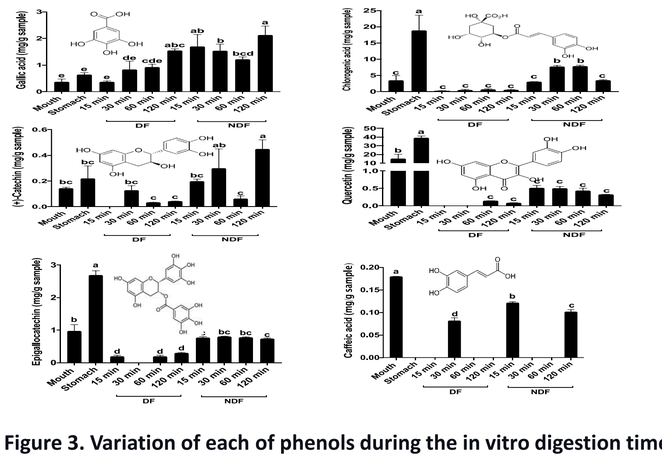
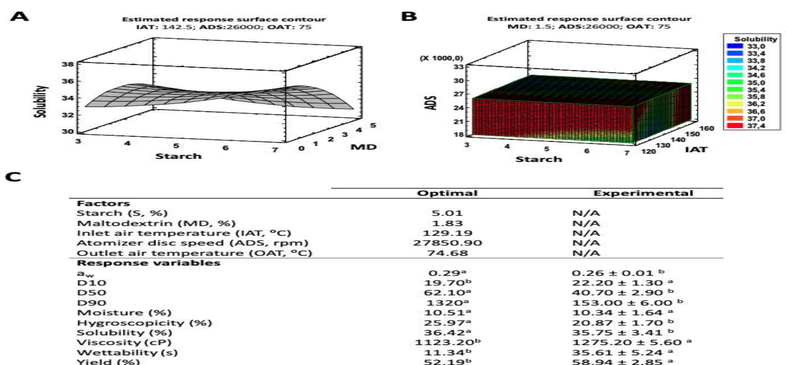


Figure 3. Variation of each of phenols during the in vitro digestion time

Table 1. Results from the statistical optimization of all the involved variables during the spray-drying process



C

Factors	Optimal	Experimental
Starch (S, %)	5.01	N/A
Maltodextrin (MD, %)	1.83	N/A
Inlet air temperature (IAT, °C)	129.19	N/A
Atomizer disc speed (ADS, rpm)	27850.90	N/A
Outlet air temperature (OAT, °C)	74.68	N/A
Response variables		
a_w	0.29[a]	0.26 ± 0.01 [b]
D10	19.70[b]	22.20 ± 1.30 [a]
D50	62.10[a]	40.70 ± 2.90 [b]
D90	1320[a]	153.00 ± 6.00 [b]
Moisture (%)	10.51[a]	10.34 ± 1.64 [a]
Hygroscopicity (%)	25.97[a]	20.87 ± 1.70 [b]
Solubility (%)	36.42[a]	35.75 ± 3.41 [b]
Viscosity (cP)	1123.20[b]	1275.20 ± 5.60 [a]
Wettability (s)	11.34[b]	35.61 ± 5.24 [a]
Yield (%)	52.19[b]	58.94 ± 2.85 [a]
TP (mg GAE/g)*	1701.45 ± 5.36 [a]	909.6 ± 3.6 [b]
AOX (DPPH)*	196.84 ± 4.25 [a]	88.33 ± 0.07 [b]
EE (%)	N/A	53.4

Table 2. Results of the bioaccessibility and permeability

Compuesto	Bioaccesibilidad %						Permeabilidad aparente (cm/s)			
	Boca	**estomag**	**15**	**30**	**60**	**120**	**900**	**1800**	**3600**	**7200**
Fenoles	5,41	6,33	0,31	0,39	0,27	0,08	0,000141918	8,8868E-05	3,1149E-05	4,35433E-06
Acido gallico	7,4	16,0	6,9	20,9	22,9	42,3	0,001243699	0,00188776	0,00103271	0,000954983
Acido clorogénico	7,89	45,12	2,05	2,37	2,79	2,17	0,000130948	7,5729E-05	4,457E-05	1,73545E-05
Catequina	6,85	8,47	0,40	6,45	1,21	1,61	1,57768E-06	1,2621E-05	1,183E-06	7,8881E-07
Quercetina	20,32	51,25	0,00	0,00	0,05	0,04	0	0	1,577E-06	5,9161E-07
Epigalocatequina	20,91	59,27	4,74	0,00	4,96	6,68	3,4709E-05	0	9,017E-06	6,1152E-06
Acido cafeico	3,4	0,0	0,0	1,4	0,0	0,0	0	5,5219E-06	0	0

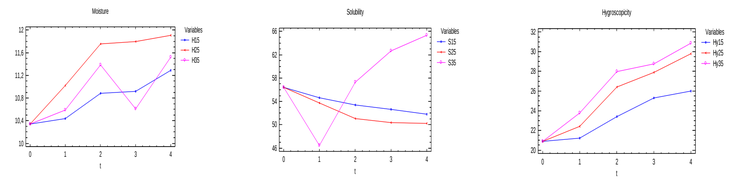


Table 3. Values of the constants and coefficients for each of the equations evaluated in the release kinetics of phenolic compounds.

Model	Constant	Values
Zero order	Ko	0.00671
	Qo	0.18518
	R^2	**92.02430**
First order	Ko	0.00635
	Qo	0.20647
	R^2	**79.88714**
Korsmeyer - Peppas	K	0.05592
	n	0.59894
	R^2	**97.39575**
Higuchi	K	0.09287
	R^2	**97.92373**
Weibull	β	0.88087
	τ	0.02096
	R^2	**97.30596**

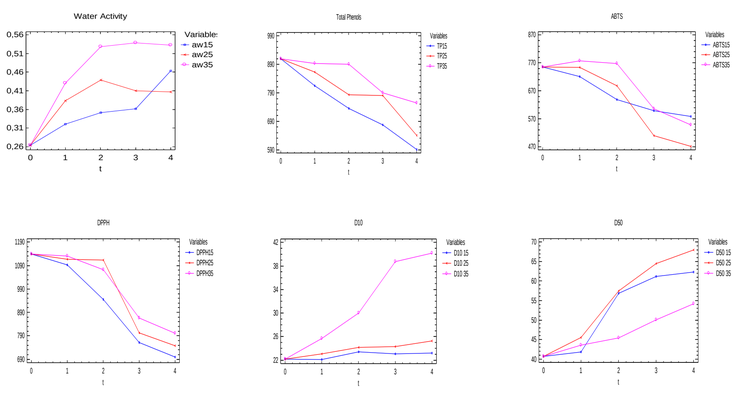


Figure. 4. Graphics of degradation kinetics during storage

CONCLUSION

- The chemical modification with octenyl succinic anhydride produced morphological and microstructural changes on the native starches of Gros Michel banana, which could be evidenced in the functional changes of each of them, especially in the maximum viscosity which decreased in both cases and the decrease of the gelatinization initiation temperature.
- The modified starches from the varieties mentioned above, used as wall material in spray drying, showed good performance in terms of the final product obtained.
- It was possible to demonstrate that the phenolic compounds and their antioxidant activity could be preserved by 50% during the storage period.
- It was evidenced that the powders formed starch from banana had higher percentages of release and bioaccessibility,. The above is due to the low solubility and the particle size, with which the microcapsules or aggregates can travel throughout the gastrointestinal tract without generating strong interactions with aqueous fluids and being able to release bioactive compounds in the small intestine.

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