Technological potential of plant extracts for inhibiting hydroxymethylfurfural formation in bovine serum albumin and glucose model systems

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Introduction

Non-enzymatic browning reactions (such as the Maillard reaction) modify the physicochemical, functional and organoleptic characteristics of foods, nutraceuticals and cosmetics.
Pleasant flavor and color are developed, but in recent years, international organizations (IARC, FAO) have identified compounds that are generated in foods as potentially toxic and/or carcinogenic.

Some of them are furfural and heterocyclic compounds (furans, pyrroles and pyridines) and acrylamide (Jin et al., 2013).

They were detected in variable concentrations depending on the severity of the heat treatment or storage conditions.

Oxidative reactions are involved in the evolution of the Maillard reaction.

Inhibiting oxidative reactions may inhibit the formation of Maillard intermediates.
Objective

To investigate natural sources of inhibitors for Maillard reaction.

Hydroxymethylfurfural (HMF) was employed as a chemical marker of the antiglycant effect.
Materials and Methods

The effectiveness of selected herbs and spices extracts, from the families Piperaceae and Lamiaceae, was evaluated to mitigate HMF formation in model systems containing bovine serum albumin (BSA) and glucose, treated at 55, 70, 80 and 90 °C.
Extraction

Ultrasound-assisted extracts of thyme and peppers were prepared in β-cyclodextrin (BCD) (5 mM and 15 mM), and water-ethanol (1:1) in a solid-liquid ratio (1:3). After centrifugation for 20 min at 10,000 rpm, the supernatant was collected and freeze-dried.

- Water
- Water-ethanol (1:1)
- β-CD solution

Green pepper
White pepper
Black pepper
Pink pepper
Jamaican pepper
Thyme

Ultrasound
5 - 6 min
0.5 cycles
100 % amplitud

Centrifuged
30 min
4 °C
10,000 rpm

Freeze-drying
20 % (p/p) Tr
β-cyclodextrin-water in combination with ultrasound was optimized through response surface methodology (RSM) for optimizing the extraction of biomolecules with antiradical and reducing activity. RSM provides a reduced number of experimental steps through statistical tools (Yolmeh & Jafari, 2017).

Characterization

- Total polyphenols: (Folin-Ciocalteau)
- Antioxidant activity: 2,2-diphenyl-1-picrylhydrazyl radical (DPPH•)
- Reducing power: Ferric reducing/antioxidant power (FRAP)

Response surface plots for the total polyphenolic content

Green pepper extracts

ultrasonication for 5 min

β-CD conc. = 15 mM

Extraction T = 41 °C
Response surface plots for the antioxidant activity (DPPH•)

Green pepper extracts

ultrasonication for 5 min

β-CD conc. = 15 mM

Extraction T = 41 °C
Response surface plots for the reducing power (FRAP)

Green pepper extracts

ultrasonication for 5 min

Extraction T = 41 °C

β-CD conc. = 15 mM
The optimum extraction conditions were reached at:

15 mM β-cyclodextrin concentration
5 min sonication
Temperature 41 °C.

TPC was 24.9 mg GAE/mL.
The anti-radical activities were 3.1 mg GAE/mL and 0.45 mg GAE/mL for DPPH• assay and FRAP method respectively.

GAE: gallic acid equivalent
Effect of extracts on HMF development (55°C)
Effect of extracts on HMF development (70 °C)
Arrhenius plots

(d) Control
Con β-CD
+ Black pepper

(d) Control
Con β-CD
+ Green pepper

(d) Control
Con β-CD
+ White pepper

(d) Control
Con β-CD
+ Thyme
Effect of Green pepper extract on HMF development at 70, 80 and 90 °C
Correlation of HMF production with total polyphenols (TPC) and antioxidant capacity (DPPH) at 55 °C in BSA-Glucose model systems

Thy : Thyme
JP: Jamaican pepper
GP: Green pepper
BP: Black pepper
WP: White pepper
Conclusions

The extracts of thyme and green, black, white and Jamaican peppers in β-CD solutions modified the kinetics of HMF formation, without affecting its dependence on temperature.

Thyme and Jamaican pepper extracts were able to exert the inhibitory effect over the entire temperature range studied while green pepper exerted inhibitory effects at the lower studied temperatures.
Conclusions

The polyphenols content correlated with the antiglycemic activity, which indicates that the oxidative pathways that lead to the formation of brown products have an important influence, in addition to the traditional pathway of intermediaries generation through the rearrangement of Amadori.

The obtained results contribute to improve food safety and to mitigate the generation of undesirable intermediaries in the thermal processing of foods, expanding the technological applications of natural products.
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