The thermal characteristics of coffee and cocoa powders prepared by freeze-drying process

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Introduction

Coffee and cocoa are considered to be one of the most common brews consumed in the world due to their unique taste and aroma. In recent years, numerous scientific references have been established the potential health benefits on the human body and the health-promoting properties of both plant materials. Most of all, researchers focus their attention on antioxidant and anti-inflammatory properties, fatigue reduction, supporting weight management, preventing cardiovascular disease or protecting against neurodegenerative disorders (Alzheimer's disease or Parkinson's disease). Positive health effects of coffee and cocoa are associated with the bioactive compounds such as meteloxanthines (mainly theobromine and caffeine), polyphenolic compounds (phenolic acids, flavonoids) and melanoidins. Recently, an increasing pace of life, work and education with long-term, intense concentration is pushing up the demand for convenient, functional and natural food products that reduce sleepiness and stimulate the nervous system. In addition, there is a growing awareness of consumers regarding the connection between diet and health, as well as the need to take care of ones health using natural methods. The growing functional food market and the expectations of consumers require a constant creation of novel recipes for valuable products.

The aim of this research was to evaluate thermal properties of cocoa and coffee freeze-dried powders.

Materials and methods

Brazilian medium roasted Arabica coffee beans

Raw organic cocoa

Milling and mixing powders in different ratios

Preparation of extracts: brewing, evaporation, freezing

Freeze-drying process

Freeze-dried coffee and cocoa powders

Evaluation of thermal behaviour of prepared powder formulations

Glass transition temperature (T_g) by using DSC Q200

Thermogravimetric analysis (TGA) in oxygen (O_2) and nitrogen (N_2) atmosphere

Measurement of water activity (a_w)

Results and discussion

Tab 1. Overview of thermograimetric analysis parameters for different cocoa and coffee lyophilisates variants (**I**-100% coffee, **II**-100% cocoa, **III**-5% cocoa and 95% coffee, **IV**-20% cocoa and 80% coffee, **V**-60% cocoa and 40% coffee)

Variant of samples	Atmosphere	I mass loss [%]	I temperature range [°C]	II mass loss [%]	II temperature range [°C]	III mass loss [%]	III temperature range [°C]	IV mass loss [%]	IV temperature range [°C]
I	Nitrogen	$4,08^{ab*} \pm 0,09$	50-114	$58,75^{a} \pm 0,01$	114-400	$8,80^{a} \pm 0,08$	400-540	$4,89^{a} \pm 0,02$	540-700
II		$4,81^{a} \pm 0,03$	50-114	$58,50^{a} \pm 0,11$	114-400	$8,77^{a} \pm 0,57$	400-540	$5,57^{a} \pm 0,17$	540-700
III		$3,26^{ab} \pm 0,42$	50-114	$56,42^{a} \pm 8,90$	114-411	$8,18^{a} \pm 1,21$	411-586	$3,13^{b} \pm 0,79$	586-700
IV		$4,83^{a} \pm 0,04$	50-114	$75,46^{b} \pm 0,07$	114-400	$11,41^{b} \pm 0,06$	400-586	$3,75^{ab} \pm 0,03$	586-700
V		$4,14^{ab} \pm 0,38$	50-114	$60,43^{ab} \pm 3,97$	114-400	$8,63^{a} \pm 0,74$	400-560	$4,37^{ab} \pm 0,46$	560-700
I	Oxygen	$3,60^{a*} \pm 0,01$	50-114	$53,77^{a} \pm 0,03$	114-370	$38,07^{a} \pm 0,05$	370-500	$1,28^{c} \pm 0,03$	500-700
II		$3,60^{a} \pm 0,00$	50-114	$51,20^{b} \pm 1,02$	114-370	$22,08^{d} \pm 0,77$	370-465	$2,07^{a} \pm 0,03$	465-700
III		$2,90^{c} \pm 0,03$	50-114	$46,74^{c} \pm 0,17$	114-370	$32,51^{b} \pm 0,17$	370-475	$0,72^{e} \pm 0,03$	475-700
IV		$2,81^{c} \pm 0,03$	50-114	$45,69^{c} \pm 0,39$	114-370	$33,60^{b} \pm 0,19$	370-480	$0,91^{d} \pm 0,03$	480-700
V		$3,24^{b} \pm 0,03$	50-114	$45,96^{c} \pm 0,14$	114-370	$30,51^{c} \pm 0,21$	370-480	$1,50^{b} \pm 0,05$	480-700

Tab 2. Onset, midpoint, endpoint of the glass transition temperature determined in different cocoa and coffee lyophilisates variants (**I**-100% coffee, **II**-100% cocoa, **III**-5% cocoa and 95% coffee, **IV**-20% cocoa and 80% coffee, **V**-60% cocoa and 40% coffee)

Variant of samples	Glass Transition temperature (T_g)		
	$T_{g\ onset}$ [°C]	$T_{g\ midpoint}$ [°C]	$T_{g\ endpoint}$ [°C]
I	$41,98^{a*} \pm 0,04$	$49,78^{a} \pm 0,66$	$57,58^{a} \pm 1,27$
II	$43,09^{a} \pm 0,65$	$54,33^{b} \pm 0,85$	$63,77^{b} \pm 1,78$
III	$41,46^{a} \pm 1,01$	$47,42^{a} \pm 0,18$	$53,38^{a} \pm 0,66$
IV	$50,91^{b} \pm 1,23$	$59,74^{c} \pm 1,07$	$68,60^{c} \pm 0,95$
V	$42,89^{a} \pm 0,18$	$48,13^{a} \pm 0,03$	$53,37^{a} \pm 0,13$

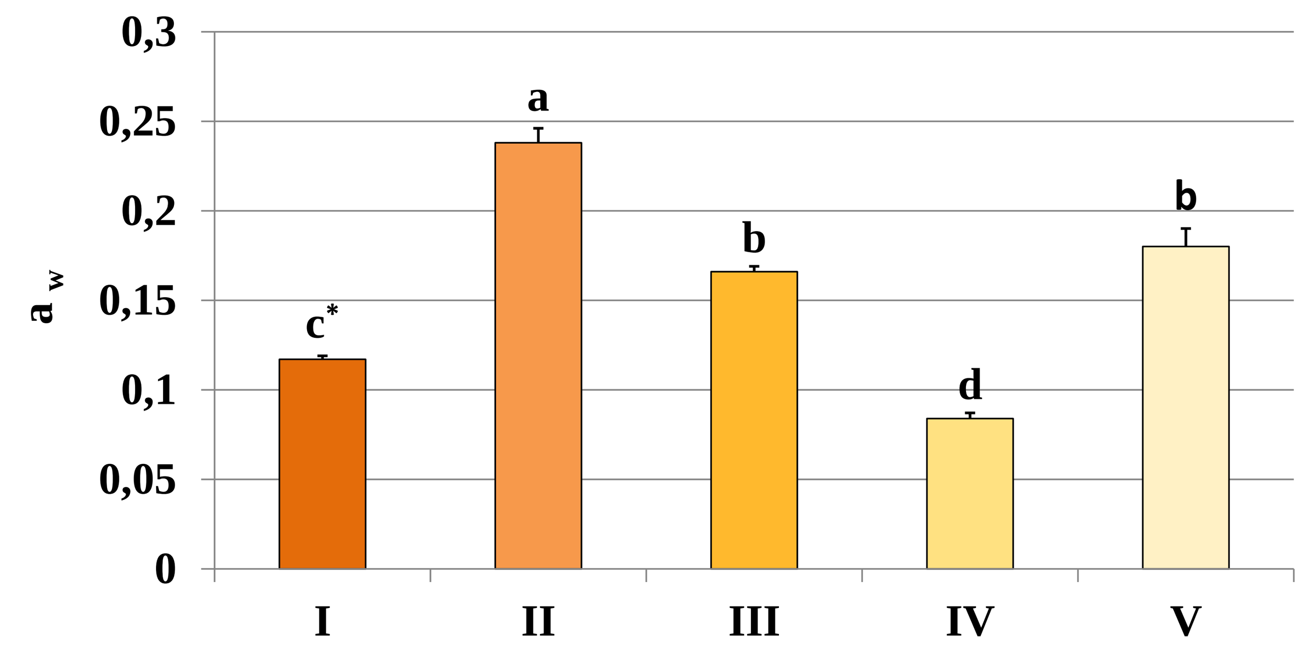

Fig 1. Water activity (a_w) of freeze-dried powders variants (**I**-100% coffee, **II**-100% cocoa, **III**-5% cocoa and 95% coffee, **IV**-20% cocoa and 80% coffee, **V**-60% cocoa and 40% coffee)

*** Different lower cases indicate that the samples are considered significantly different (α = 0.05)**

Conclusions

- The increase in the value of water activity determined in obtained freeze-dried powders fromulations was not directly proportional to the increased cocoa addition.
- The glass transition temperature of the tested powders depended on the value of water activity.
- In the oxygen atmosphere, the thermal decomposition of the freeze-dried powders was faster compared to the thermogravimetric analyzes of the samples carried out in the nitrogen atmosphere.
- Freeze-dried coffee powder with 20% cocoa addition could potentially be considered as a promising powder material in terms of thermal stability. This variant of obtained cocoa and coffee lyophilisates was characterized by the lowest water activity and the highest glass transition temperature.