

COLD PLASMA TREATMENT AS A NON-THERMAL STRATEGY TO ENHANCE CHICKPEA FLOUR FOR PLANT-BASED FOODS

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INTRODUCTION

Plasma is a medium of free positive and negative particles that is overall electrically neutral. Non-thermal plasma has emerged as a sustainable technology in food processing, with potential to improve quality and microbial safety. As starch is a major food component, there is growing interest in using plasma to tailor its functionality through interactions with reactive species [1].

OBJETIVE

- ① To assess the effect of short cold plasma treatments (5-sec and 10-sec) on the thermal, structural, and rheological properties of chickpea flour.
- ② To evaluate the potential of cold plasma as a green, non-thermal modification method for plant-based applications.

METHODOLOGY

Plasma treatment: Chickpea flour was treated using the Blown Arc™ cold plasma system under two conditions: 5 seconds (continuous exposure) and 10 seconds (pulsed exposure). For the pulsed treatment, plasma was applied for 5 seconds on, followed by 5 seconds off, with the plasma probe kept in the same position (4 cm from the sample) during the off period. The sample-to-source distance remained constant at 4 cm for both treatments.

Thermal properties: Differential Scanning Calorimetry (DSC) was used to measure gelatinization temperatures (onset, peak, and endset).

Structural analysis: Fourier Transform Infrared Spectroscopy (FTIR) (ATR mode) was employed to assess short-range molecular order, using band ratios (1047/1022 and 1022/995 cm⁻¹).

Rheological behavior: Performed under temperature sweep conditions using a controlled-strain rheometer, evaluating elastic (G') and viscous (G'') moduli during heating.



RESULTS

Rheological behavior:

- Both G' and G'' increased above ~95 °C, consistent with starch gelatinization (Figure 1).
- 5-sec plasma treatment decreased G' and G'' (weaker gel formation).
- 10-sec plasma treatment increased G' and G'' (stronger gel formation) [2].

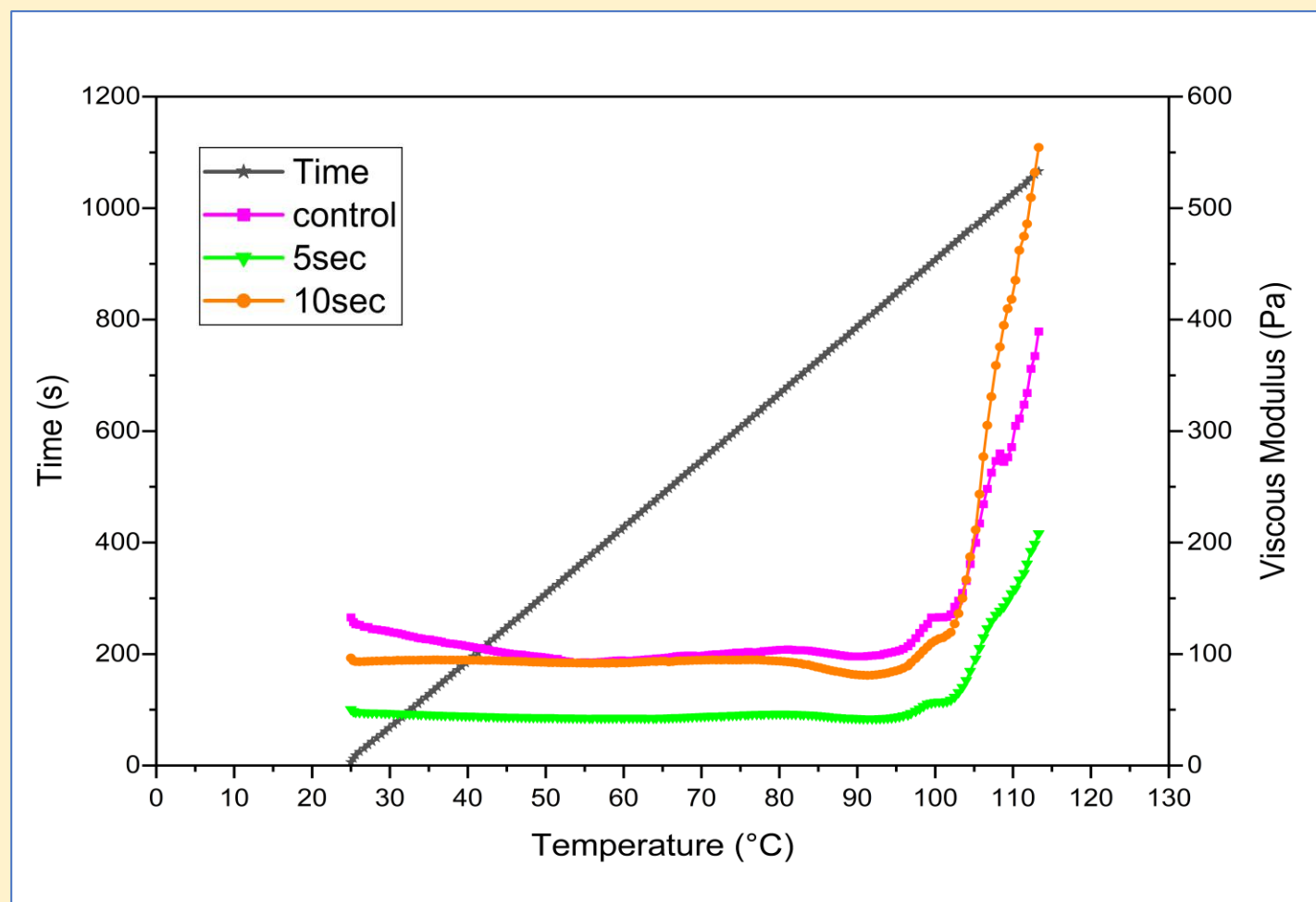
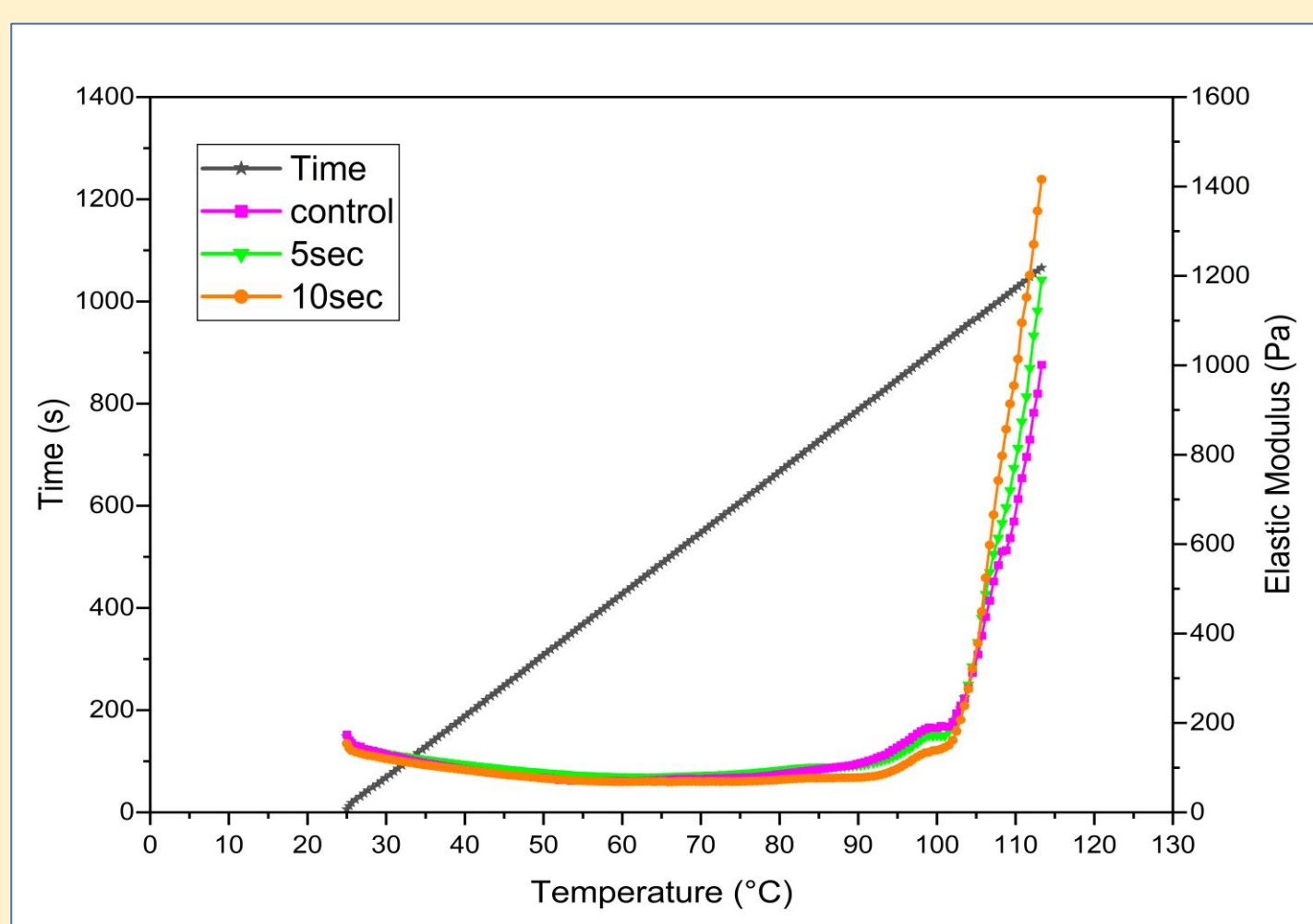


Figure 1. Pasting properties of plasma-treated chickpea flours. Up: Elastic modulus (G'); Down: Viscous modulus (G''). Purple line: control; green line: 5-sec treatment; orange line: 10-sec treatment.

FTIR Analysis:

- No visible spectral changes between control and treated samples.
- Band-ratio analysis showed only minor variations, suggesting no major change in short-range molecular order. (Table 1)

Thermal Properties (DSC):

- Plasma-treated flours exhibited higher onset, peak, and endset gelatinization temperatures, indicating greater thermal stability and delayed gelatinization [3]. (Table 1)

Table 1. Structural and thermal properties of control and modified flours.

Sample ID	FTIR		DSC		
	$\frac{1047}{1022}$	$\frac{1022}{995}$	T _o (°C)	T _p (°C)	T _c (°C)
Control	1.11 ± 0.01 ^a	1.06 ± 0.00 ^a	95.0 ± 0.4 ^a	101.9 ± 0.8 ^a	117.9 ± 2.5 ^a
5-sec	1.10 ± 0.00 ^a	1.05 ± 0.01 ^a	97.4 ± 0.6 ^b	102.4 ± 1.9 ^b	128.4 ± 0.3 ^b
10-sec	1.10 ± 0.00 ^a	1.05 ± 0.00 ^a	101.0 ± 1.1 ^c	103.6 ± 1.8 ^b	126.4 ± 2.5 ^b

(T_o: Onset Temperature, T_p: Peak Temperature, T_c: Conclusion Temperature)

CONCLUSION

Cold plasma, as a flour modification method:

- **Acts as a green, non-thermal technology** capable of tailoring functional properties without chemical additives.
- **Modifies** thermo-rheological behavior while **preserving structural integrity** of the flour.
- **Improves** thermal stability and gelation characteristics.
- **Offers potential** for enhancing functionality and sustainability in gluten-free and plant-based food systems.

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