EFFECT OF EXTRUSION CONDITIONS ON THE PHYSICOCHEMICAL CHARACTERISTICS OF HIGH MOISTURE MEAT ANALOGUES FROM PEA PROTEIN ISOLATE

Clara Barnés-Calle, Grau Matas, Pere Gou and Elena Fulladosa*

Food Quality and Technology program. Institute of Agrifood Research and Technology (IRTA), Monells, Spain

*Corresponding author email: elena.fulladosa@irta.cat

I. INTRODUCTION

High moisture extrusion technology is gaining attention in the plant-based food industry for the obtention of muscle meat-like textures. However, physicochemical characteristics of high moisture extrudates (HME) are highly influenced by process conditions. The aim of this study was to evaluate the effect of extrusion process parameters on texture and moisture content of HME obtained from pea protein isolate. Response-surface models that enable the definition of the optimal extrusion conditions to achieve meat-like textures were also developed.

II. MATERIALS AND METHODS

HME samples were elaborated using pea protein isolate (PISANE^{TM} M9, Cosucra, Belgium) and a laboratory-scale twin-screw extruder (Process 11, Thermo Fisher Scientific Inc., Waltham, MA, USA). Chicken breast samples cooked at 75 ºC were used as reference samples. Effect of the extrusion conditions HME was explored using a central composite design varying three factors: barrel temperature, screw speed and the ratio of water feed rate (WFR) to powder feed rate (PFR). Sixteen conditions (described in Table 1) were performed in triplicate, including two central points. Moisture content was determined by drying the samples at 103 ± 2 ºC until constant weight. Textural properties were measured performing a shear test (TA.HDplusC, Stable Micro Systems Ltd., UK). Samples were cut transversally to the direction of the extrudate flow (or muscle fiber in chicken samples) using a Warner-Bratzler set with rectangular slot blade. Shear force, area and gradient (related to hardness/firmness and deformability [1]) were recorded. Data were analysed using a response surface regression using (JMP 16 software, NC, USA) and ANOVA and Tukey tests to show which treatments were significatively different to the chicken breast samples (XLSTAT v2020.1 1, Addinsoft, Paris, France).

III. RESULTS AND DISCUSSION

The moisture content of the HME samples increased with WFR/PFR ratio and was lower than reference values (cooked chicken breast) (Table 1). Some HME samples showed shear test textural properties not significantly different ($P \geq 0.05$) to reference samples, being HME-16 the most similar one.

Table 1. Mean of physicochemical properties of reference and HME samples elaborated using the different extrusion conditions defined in the experimental design (n=3).

	Extrusion conditions			**Moisture**	**Shear test textural properties**		
Sample	T [ºC]	Speed [rpm]	WFR/PFR	%	Force (N)	Area (N·mm)	Gradient (N/mm)
HME-1	116	844	1.50	62.3^{bc}	5.04^{c}	15.5^{e}	2.54^{de}
HME-2	116	456	1.50	61.6^{cd}	5.58^{bc}	19.5^{e}	2.87^{de}
HME-3	116	844	1.00	52.8^{g}	6.91^{bc}	18.5^{e}	5.94^{ab}
HME-4	116	456	1.00	52.1^{gh}	7.50^{bc}	20.8^{e}	5.86^{ab}
HME-5 (C)	138	650	1.20	57.0^{f}	8.75^{bc}	33.0^{e}	4.10^{bcde}
HME-6	138	650	0.90	49.6^{i}	11.15^{b}	33.3^{e}	7.26^{a}
HME-7 (C)	138	650	1.20	56.7^{f}	8.16^{bc}	33.0^{e}	4.08^{bcde}

HME-8	138	900	1.20	56.6^{f}	8.68^{bc}	35.2^{de}	4.18^{bcd}
HME-9	138	400	1.20	56.5^{f}	6.80^{bc}	27.4^{e}	3.83^{bcde}
HME-10	138	650	1.60	64.5^{b}	5.13^{c}	21.9^{e}	2.59^{de}
HME-11	110	650	1.20	57.6^{ef}	5.62^{bc}	17.8^{e}	3.49^{cde}
HME-12	159	456	1.50	60.0^{cde}	7.47^{bc}	42.1^{cde}	3.25^{de}
HME-13	159	844	1.50	59.5^{de}	7.64^{bc}	46.5^{cde}	2.95^{de}
HME-14	159	456	1.00	50.4^{ghi}	18.86^{a}	137.0^{b}	4.53^{bcd}
HME-15	159	844	1.00	49.6^{hi}	23.09^{a}	181.6^{a}	5.77^{abc}
HME-16	165	650	1.20	55.6^{f}	8.53^{bc}	75.5^{c}	1.97^{e}
Reference	(Cooked chicken breast)			69.5^{a}	9.90^{bc}	69.6^{cd}	2.84^{de}
	SEM			0.872	1.943	5.80	0.499
	P-value			<0.0001	<0.0001	<0.0001	<0.0001

^{abcde}Different letters in the same column indicate significant differences (P<0.05). (C) Indicates central points.

Response surface models showed that although the three variable factors had a significant influence on moisture content, only temperature and WFR/PFR ratio influenced textural parameters. Figure 1 shows the effect of WFR/PFR and barrel temperature on the predicted shear force (A), area (B) and gradient (C). According to the predictive model, the texture values showed by the reference samples (striped areas in Figure 1) can be achieved for the three textural parameters simultaneously only by applying barrel temperatures between 145-165 ºC and a WFR/PFR ratio between 1.4 and 1.2.

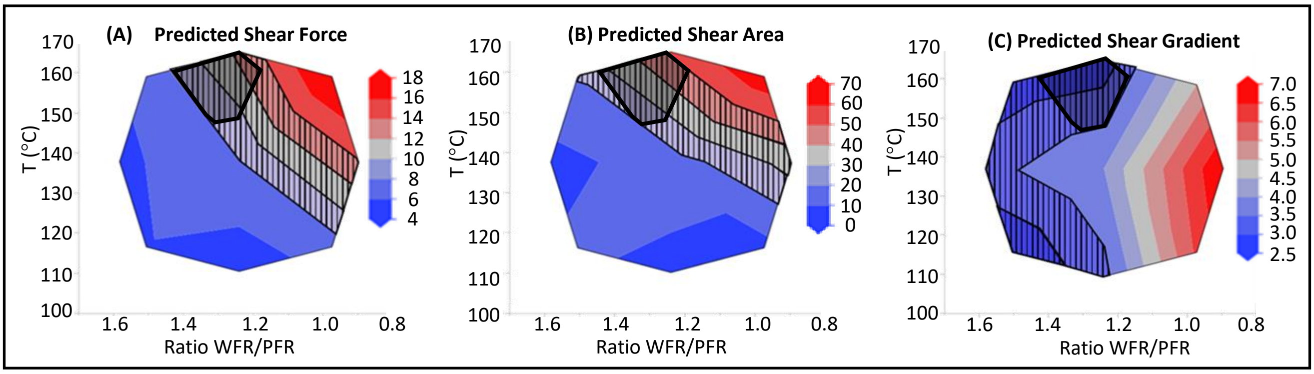

Figure 1. Contour plots fitted to shear force (A), shear area (B) and shear gradient (C) as a function of WFR/PFR ratio and barrel temperature. Striped areas correspond to chicken breast values for each parameter (reference), and darker areas indicate common reference areas for all parameters.

IV. CONCLUSION

Extrusion process parameters have a significant effect on the characteristics of the final product and textures similar to cooked chicken breast can be achieved. Future studies on the use of new formulations and application of subsequent processes to improve the texture are needed.

ACKNOWLEDGEMENTS

This work has been funded by CROPDIVA project (H2020-101000847), Sensanalog Project (PID2021-122285OR-I00) and CERCA programme. First author was supported by FPU fellowship (FPU20-04009).

REFERENCES

[1] Stable Micro Systems (2023). Texture Analysis and Materials Testing Terminology. https://www.stablemicrosystems.com/glossary.html