Lupin Seed Protein Extract Can Enrich the Physical Properties of Cookies Prepared with Alternative Flours

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INTRODUCTION:

Cookies and crackers have become one of the most popularly consumed snacks due to their low manufacturing cost, availability, high nutrient density, long shelf-life and potential to be supplemented with a wide variety of nutraceuticals [1,2]. Legume seeds are food ingredients with high nutritional quality and a low glycemic index when compared to cereal grains [3]. Moreover, legume proteins in the form of flour or concentrate constitute a good supplement for cereal-based foods, because legume and cereal proteins are complementary in their essential amino acids compositions [4,5]. In particular, white lupin (*Lupinus albus*) seeds have received attention as a source of bioactive proteins [6] and have been used as an additive to food products, in order to improve their functional and nutritional properties [5,7].

For these properties, some researchers used *L. albus* to develop bakery products, such as bread [8], cookies [9] and pasta [7], and the ingestion of lupin-containing foods has been associated with the prevention of diabetes by the hypoglycemic effect, cardiovascular disease, and more recently, digestive tract diseases [6,7,10].

In the available literature, the major studies on lupin-containing foods have been made with flours prepared from the whole seed, therefore containing fat, oligosaccharides, protein and fiber. In addition, there are few or no studies comparing the incorporation of lupin extract (LE) in wheat alternatives such as spelt, kamut, oat and gluten-free (rice and buckwheat) flours. In this sense, the main goal of this study was to evaluate the impact of the addition of LE in the physical properties of sweet cookies prepared with flours (containing or not gluten) of different origins.

METHODS:

- The impact on the physical properties of the dough and cookies was evaluated for the different systems: .
    - Rheological measurements of dough were conducted using a controlled strain rheometer (Haake, Mars III, Thermo Fisher Scientific, Karlsruhe, Germany) at a constant temperature (25.0 °C ± 0.1 °C), controlled by a Peltier system.
    - Instrumental texture analysis of dough and cookies was conducted in a TA.XTplus (StableMicro Systems, Godalming, UK) texturometer. Texture measurements were performed at 20 °C ± 1 °C in a temperature-controlled room.
    - Cookie samples were analyzed for water activity (aw). This was determined using a thermohygrometer (HygroPalm HP23-AW, Rotronic AG, Bassersdorf, Switzerland) at 20 °C ± 3 °C.
    - The color of the cookie samples was measured using a Minolta CR-400 (Japan) colorimeter. The results were expressed in terms of L*, lightness; a*, redness to greenness, and b*, yellowness to blueness, according to the CIELab system.

RESULTS:

1. Physical Properties of the Dough

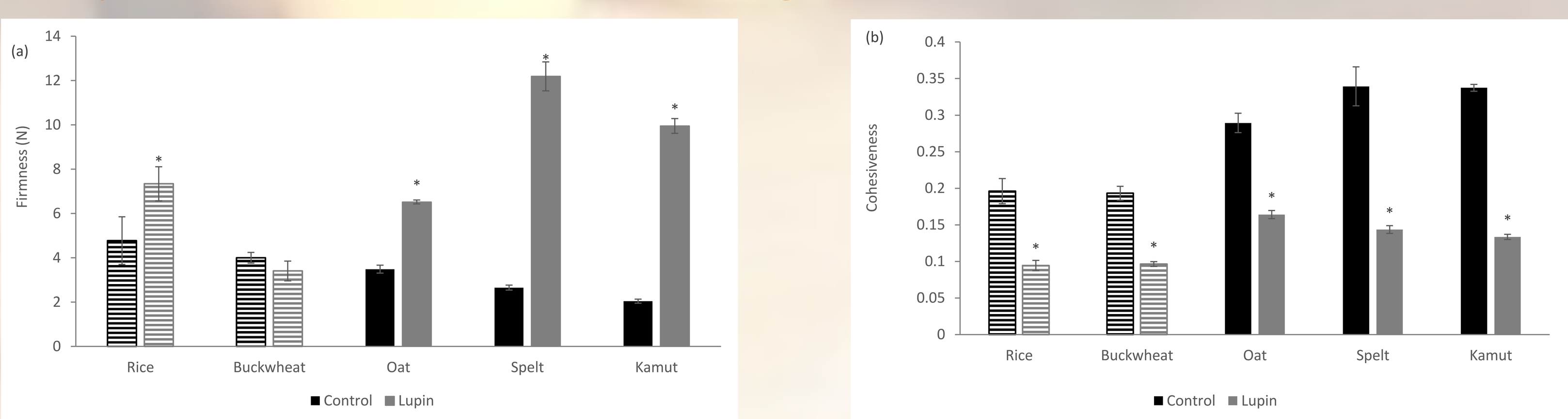

Figure 1. Texture parameters of control and lupin-enriched cookies prepared from five different flours. Solid bars represent the gluten-containing flours (oat, spelt and kamut) and the striped bars represent the gluten-free flours (rice and buckwheat): (a) the firmness; and (b) the cohesiveness. * represents $p < 0.05$ when compared with the corresponding control cookie.

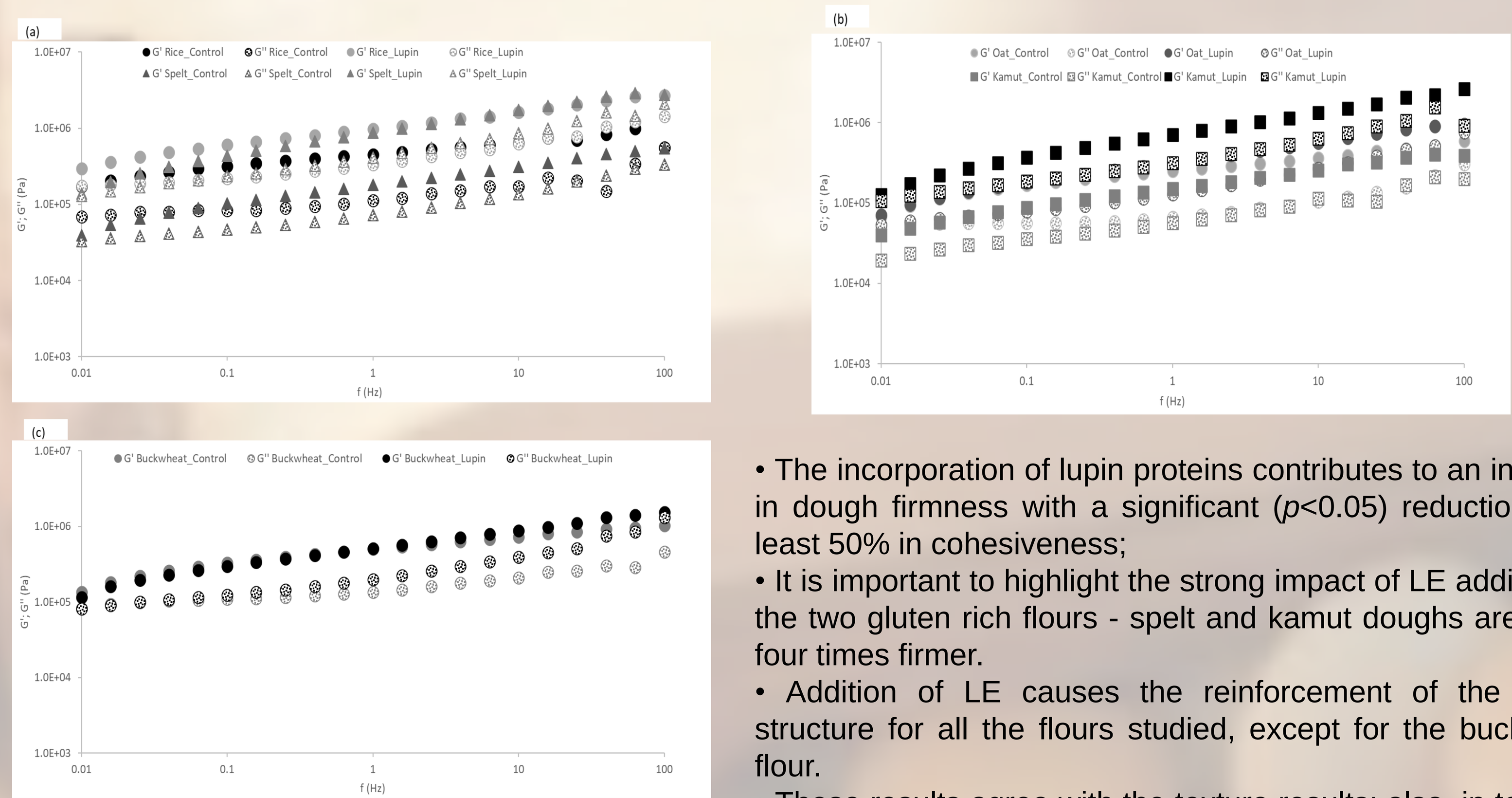

Figure 2 . Mechanical spectra of the control and the lupin-enriched doughs prepared with five different flours: (a) rice and spelt; (b) oat and kamut; and (c) buckwheat. Solid symbols represent G' (elastic modulus) and the dotted symbols represent G" (viscous modulus).

- The incorporation of lupin proteins contributes to an increase in dough firmness with a significant ($p<0.05$) reduction of at least 50% in cohesiveness;
- It is important to highlight the strong impact of LE addition on the two gluten rich flours - spelt and kamut doughs are about four times firmer.
- Addition of LE causes the reinforcement of the dough structure for all the flours studied, except for the buckwheat flour.
- These results agree with the texture results: also, in terms of firmness, the buckwheat flour formulation was the only one without significant differences ($p>0.05$) due to the addition of LE.

2. Physical Properties of Cookies

2.1 Dimensions of Cookies

Table 1. The dimensions of each cookie formulation with 10% (w/w) of lupin extract (LE). Values are the averages of ten cookies ± SD. * represents p < 0.05 and ** represents p < 0.001 when compared with the corresponding control cookie..

Cookie Formulation		Area (cm^2)	Thickness (mm)
Rice	Control	15.63 ± 0.06	2.55 ± 0.14
	LE	15.08 ± 0.12 **	2.94 ± 0.08 *
Buckwheat	Control	13.26 ± 0.11	2.62 ± 0.11
	LE	16.05 ± 0.16 **	3.14 ± 0.10 *
Oat	Control	15.61 ± 0.10	3.25 ± 0.34
	LE	15.44 ± 0.21	2.79 ± 0.12
Spelt	Control	13.00 ± 0.03	3.57 ± 0.10
	LE	15.94 ± 0.11 **	3.35 ± 0.28
Kamut	Control	15.30 ± 0.07	2.94 ± 0.20
	Lupin	16.69 ± 0.06 **	2.68 ± 0.16

- Spelt, kamut and buckwheat flours, the addition of LE increased the area in relation to the control.
- Rice flour cookies were the only ones with a significant ($p<0.001$) reduction in the cookie area.
- The presence of gluten does not seem to affect the cookie area and no direct relationship can be established with the expansion of the structure.
- Thickness: the two gluten-free flours (rice and buckwheat) showed a significant increase ($p<0.05$) in the LE-containing cookies, unlike the gluten flours, where it showed a generalized decrease

2. Physical Properties of Cookies

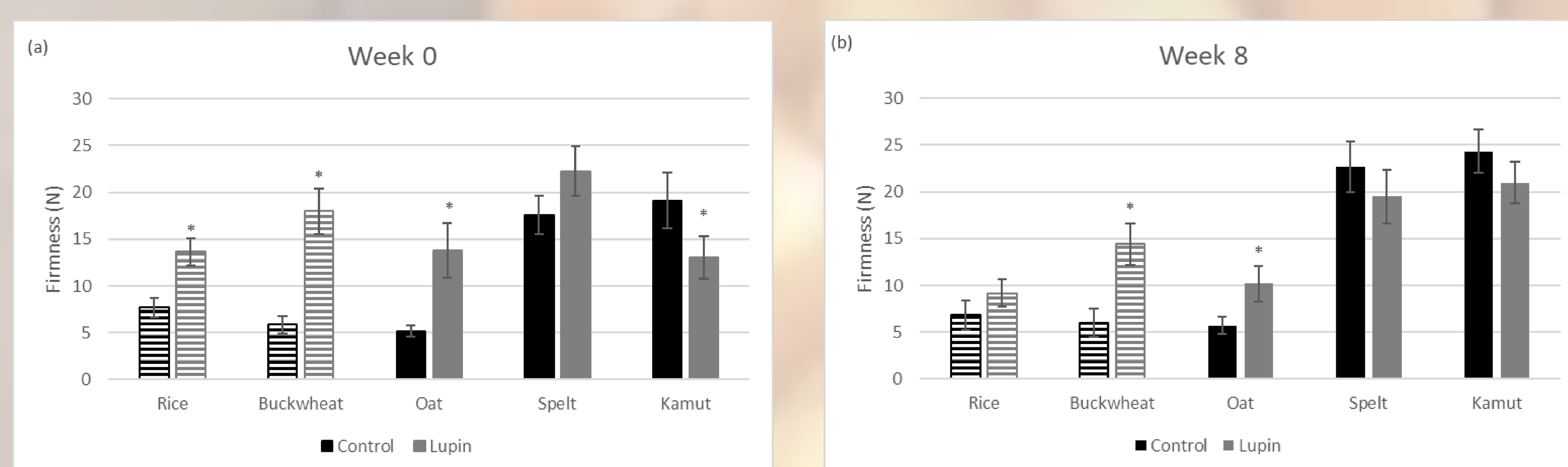

Figure 3. Firmness of the control and lupin-enriched cookies at week 0 (a) and week 8 (b). Solid bars represent the gluten-containing flours (oat, spelt and kamut) and the striped bars represent the gluten-free flours (rice and buckwheat). Values are the means of at least six experiments ± SD. * represents $p < 0.05$ when compared with the corresponding control cookie.

- Cookies prepared with the ancient grains and without LE (spelt and kamut) were firmer than the other control cookies and this observation remained valid after storage (eight weeks).
- The changes induced by the LE in the cookie structure differed over time, since at week 0 only the spelt flour had no significant difference ($p>0.05$) when compared to the control; however, after eight weeks, the spelt, kamut and rice flours showed no significant differences ($p>0.05$) when the cookie with LE and the control were compared.
- Oat and buckwheat flours were statistically different over time (eight weeks), meaning that the incorporation of lupin clearly modified the texture of the cookies, making them firmer.

Table 2. Values of ΔE*, L*, aw and the moisture content (H, % w/w) of the control and lupin-enriched cookies. Values are the means of at least three experiments ± SD, except ΔE* which is the difference between the control and lupin-enriched cookie colors. * represents $p < 0.05$ and ** represents $p < 0.001$ when compared with the corresponding control cookie.

		Rice	Buckwheat	Oat	Spelt		Kamut
ΔE*	**Week 0**		21.52	20.58	12.22	31.19	15.80
	Week 8		24.99	20.18	11.97	20.20	22.03
L*	Week 0	Control	80.40 ± 1.28	72.84 ± 0.81	71.27 ± 0.92	55.16 ± 3.04	73.43 ± 0.69
		Lupin	65.74 ± 2.73 **	56.78 ± 1.53 **	61.21 ± 1.47 **	64.68 ± 2.05 *	59.72 ± 1.11 **
	Week 8	Control	80.81 ± 1.06	69.37 ± 2.89	71.41 ± 0.97	78.43 ± 3.57	72.79 ± 1.70
		Lupin	62.10 ± 1.51 **	55.28 ± 3.02 *	63.11 ± 2.00 *	60.50 ± 2.21 *	53.41 ± 2.80 **
a_w	Week 0	Control	0.36 ± 0.02	0.21 ± 0.01	0.04 ± 0.02	0.09 ± 0.01	0.50 ± 0.03
		Lupin	0.59 ± 0.01 **	0.35 ± 0.01 **	0.09 ± 0.00 *	0.40 ± 0.02 **	0.39 ± 0.01 *
	Week 8	Control	0.17 ± 0.00	0.12 ± 0.01	0.12 ± 0.00	0.22 ± 0.00	0.15 ± 0.01
		Lupin	0.23 ± 0.01 **	0.37 ± 0.00**	0.33 ± 0.00 **	0.36 ± 0.00 **	0.35 ± 0.00 **
H (%)	Week 0	Control	3.42 ± 0.14	5.61 ± 0.61	1.04 ± 0.11	2.75 ± 0.22	1.97 ± 0.08
		Lupin	2.88 ± 0.11 *	3.88 ± 0.08 *	2.29 ± 0.16 **	4.33 ± 0.08 **	2.85 ± 0.06 **

- The ΔE* values obtained were always higher than 5 for both time periods studied (week 0 and week 8).
- These differences result mainly from a general decrease in the lightness parameter (L*) in all lupin-containing cookie samples, resulting in a golden-brown color.
- Moisture content values of cookies with and without LE are low (ranging from 1.04 to 5.61%), indicating a positive impact in terms of conservation.
- Most of the samples were shown to have an aw value of less than 0.5. which means that all cookie formulations (with and without LE) had a low percentage of free water for microbial proliferation, leading to a high stability product.

CONCLUSIONS:

Consumers are currently more cognizant about the environmental effects and nutritional benefits of foods. In this sense, lupin can be considered a suitable raw material for food production due to its nutritional and health-promoting properties.

Overall, our results show that the cookies prepared with flours with or without gluten can be produced successfully by replacing 10% of the flour with LE. Therefore, the inclusion of 10% (w/w) sweet lupin protein extract in formulations improves the nutritional value and quality of cookies.

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