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Lentil Flour in Gluten-Free Crackers

Insights on performance and quality optimization.

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TABLE OF CONTENTS

Study Objective

Lentil flour offers a compelling opportunity to enhance gluten-free crackers by naturally boosting protein, dietary fibre, and the sustainability profile. As interest grows in nutritious, plant-forward snacks, lentil ingredients provide a way to elevate a staple, high-volume category.

This report presents findings from a study investigating lentil flour performace in gluten-free cracker applications, highlighting the influence of raw material selection, formulation, and process optimization in maximizing cracker quality.

The Collaboration

This study was conducted through an NSERC Applied Research and Development grant and represents a collaboration between Pulse Canada and the Prairie Research Kitchen Technology Access Centre.

Why Crackers?

The cracker category is both large and fast-moving. According to Euromonitor, global cracker sales hit $31 billion USD in 2024, with North America and Western Europe accounting for over half of the total. Euromonitor forecasts a CAGR of 3% for both regions over the next 5 years, underscoring the opportunity for lentil flour inclusion in a major and staple end-use segment.

Lentil Flour Characteristics

Four lentil flours were sourced from different commercial suppliers to capture typical ingredient variability. Differences in lentil variety, growing conditions, milling type, and milling parameters can all influence their physicochemical properties.

KEY OBSERVATIONS

- Dough stickiness and surface tack increased with higher inclusion levels, based on chef observations.
- Higher lentil flour levels helped to mask the gritty texture associated with the rice flour in the gluten-free control blend.
- Process optimization (described in later sections) improved handling and sensory performance for all red lentil flours.
- The green lentil flour presented some challenges—even after optimization—particularly with hydration, dough handling, and sensory attributes. For this reason, it was not selected for further development.

	Dehulled Red Lentil Flour (Supplier 1)	Dehulled Red Lentil Flour (Supplier 2)	Heat-Treated Red Lentil Flour	Whole Green Lentil Flour
Particle Size	96% through 300 µm screen	100% through 841 µm screen	96% through 300 µm screen	100% through 841 µm screen
Optimal Inclusion Rate	Could optimize for >50% inclusion	Could optimize for >50% inclusion	Maximum 50% inclusion	Maximum 20% inclusion
Dough Handling	• Good workability after optimization	• Good workability after optimization • Sticky film on dough surface	• Preferred dough handling, lower mix time requirement • Firm dough	• Challenging hydration and handling
Sensory Notes	• Preferred flavour • Mild bean aroma post-bake • Lowest rated appearance • Less gritty • Softest texture	• Good flavour • Strong bean aroma pre-bake • Dark, some uneven colouring •Firmest texture	• Least preferred flavour • Even colour post-bake • Preferred appearance • Tender texture with "soft snap"	• Strong vegetal flavour and odor • Brown-grey in colour • Some grittiness • Snappy, but crumbly
Further Development?	**YES**	**YES**	**YES**	**NO**

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Cracker Formulations

CONTROL FORMULATION

Ingredients: 156g Bob's Gluten Free 1:1 Baking Flour (sweet white rice flour, whole grain brown rice flour, potato starch, whole grain sorghum flour, tapioca flour, xantham gum), 80g water, 50g vegetable shortening, 10.3g white granulated sugar, 6.75g baking powder, 1.75g xantham gum, 1.15g baking soda, 1g salt, 0.8g cream of tartar.

LENTIL FLOUR FORMULATION

50% of the Bob's Gluten Free 1:1 Baking Flour was substitued for each red lentil flour. All other ingredients remained consistent for all lentil crackers.

COOKING METHOD (ALL CRACKERS):

- Mix dry ingredients in Robot Coupe R 301 Ultra Series D and pulse until blended (~10 times)
- Add fat, run until mixture forms "wet sand"/"crumb" texture (~8-10 sec)
- Continue running, slowly incorporate water until dough has come together
- Rest dough for 18-30h at 4°C in plastic wrap to hydrate
- Roll dough to 1-3 mm thickness, cut into 3 cm x 4 cm squares
- Bake for 35 min at 149°C in Rationel Oven

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PROCESS OPTIMIZATIONS

A series of optimizations were performed across the lentil flour crackers to improve final quality characteristics.

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Mixing Speed

Three mixing speeds were evaluated across two mixing systems

- **Low Shear**: a Globle Mixer SP5 at speed 2
- **Medium Shear:** a Globle Mixer SP5 at speed 5
- **High Shear:** a Robot Coupe R 302 Ultra

KEY OBSERVATIONS

- Reducing mixing speed reduced beany flavour, improved dough handling and improved the sensory properties of crackers formulated with lentil flour.
- The effects on flavour were thought to be the result of slower oxidation, as its breakdown products are associated with off-flavours in pulses. In contrast, high-shear mixing may promote these reactions through added heat and air incorporation.
- There were no notable differences between low and medium shear mixing conditions.

Medium shear mixing for 1:45 – 2:30 minutes, dependent on flour type, was applied as the final mixing condition.

Low to Medium Shear	High Shear
Longer, gentler mixing time	Accelerated mixing time
More uniform hydration	Uneven hydration and fat dispersion. Required kneading by hand before hydration.
Easier to handle	Gritty, brittle, crumbly dough but workable
Improved texture and taste (reduced beany flavour and odour)	Strong vegetal aroma
Facilitates higher inclusion rates	Lower inclusion rates

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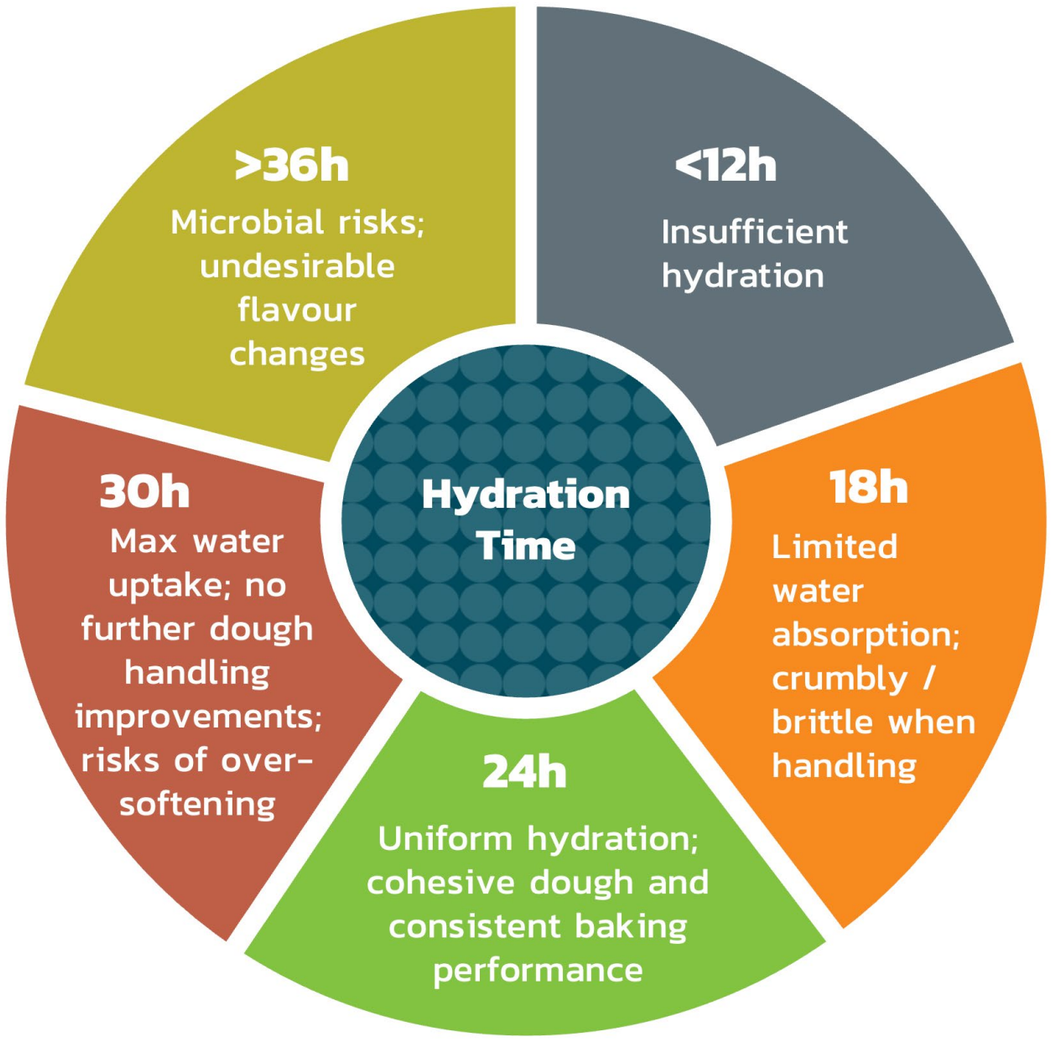
Dough Hydration Time

The high water-binding capacity of the protein and fibre fractions in lentil flour has a direct impact on dough structure, machinability, and final cracker texture. Optimizing hydration time was therefore essential to achieving consistent dough performance.

KEY OBSERVATIONS

- Lentil flour requires sufficient time for proteins and starches to fully hydrate, contributing to improved dough cohesiveness.
- Hydration times shorter than 24 hours resulted in insufficient water absorption, producing doughs that were crumbly or brittle during handling.
- Hydration times of 30 hours or more did not yield additional handling benefits and introduced risks of over-softening, undesirable flavour development, or microbial growth.

A 24-hour hydration period at 4°C was selected as the optimal processing condition.



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Cracker Thickness

Cracker sheet thickness impacted both the texture and flavour of lentil flour crackers, though effects were not consistent across flour type.

TRENDS NOTED

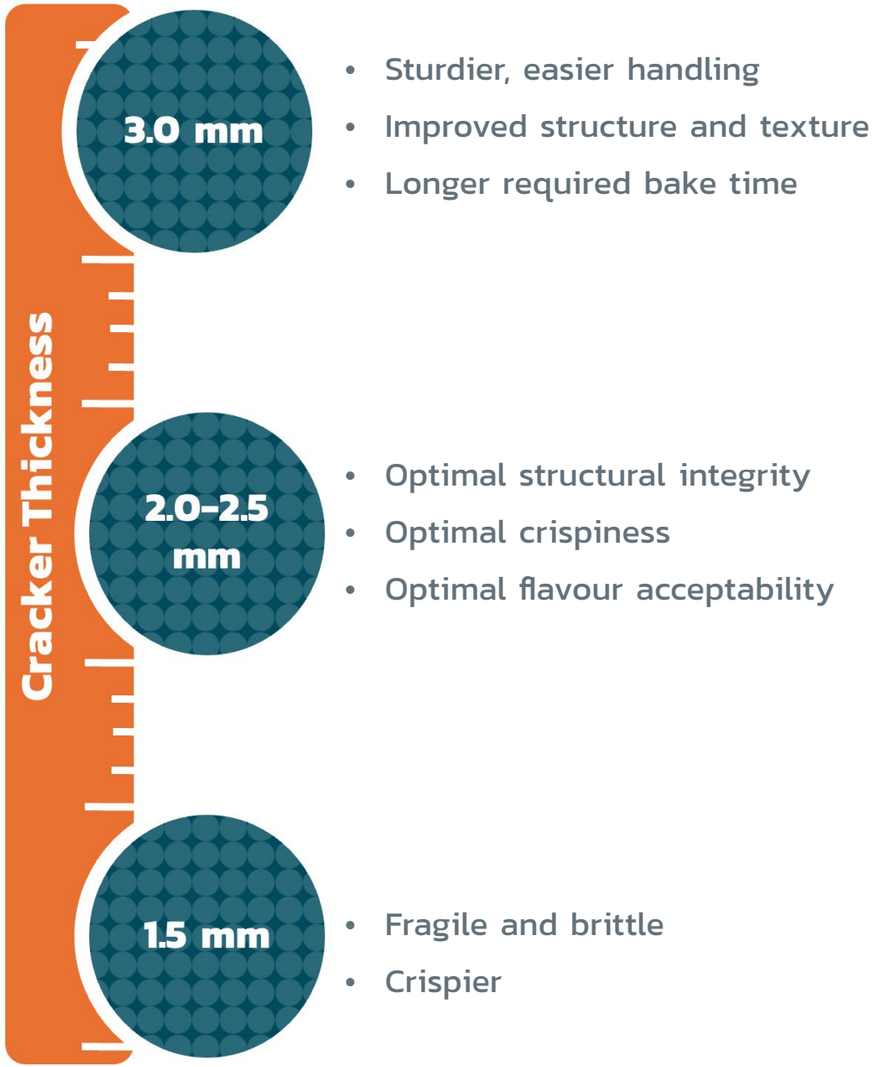
Thicker crackers tended towards:

- Stronger beany odours
- Greater sturdiness and improved structure
- Easier handling
- Longer required bake times

Thinner crackers tended towards:

- Slightly bitter perception
- Increased crispiness
- Higher fragility and brittleness
- Shorter required bake times

A thickness of 2.0 – 2.5 mm was identified as optimal. Bake times of 42, 28 and 40 minutes for dehulled red lentil flour (supplier 1), dehulled red lentil flour (supplier 2) and heat-treated flour were chosen, respectively.



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PERFORMANCE OF FINAL FORMULATIONS

Optimized lentil flour crackers were evaluated across nutrition, colour, moisture, texture and other sensory attributes.

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Nutritional Profiles

Estimated Nutrition Facts tables were generated using Genesis R&D for the optimized cracker formulations containing 50% lentil flour. These were compared on a per-serving basis to a retail benchmark product, **Mary's Organic Real Thin Crackers (Sea Salt)**, selected for its similar ingredient profile, appearance, and texture.

Lower Calories and Carbohydrates

Lentil flour inclusion reduced overall calories and total carbohydrate content relative to the retail control.

Higher Protein

Protein increased from 1 g per serving in the retail control to up to 3 g per 30 gram serving in lentil flour crackers.

Increased Potassium

All lentil flour formulations demonstrated elevated potassium levels—consistent with the mineral profile of pulses.

Comparable Fibre

Total dietary fibre remained relatively similar across lentil flour formulations and the control cracker.

Colour Analysis

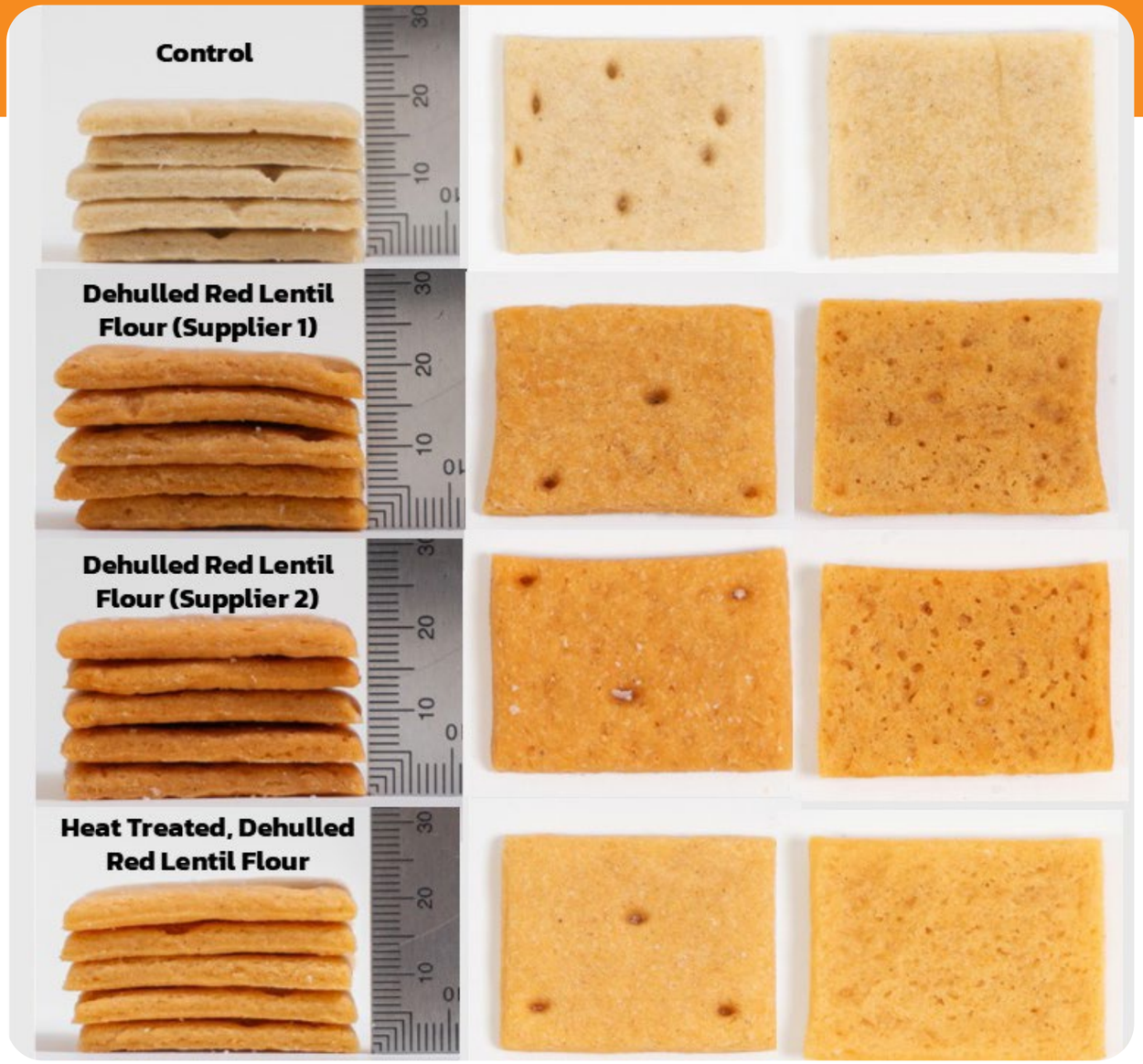
KEY OBSERVATIONS

Colour

- Lentil flour crackers were darker overall, with elevated a* (redness) and b* (yellowness) values compared to the control.
- Raw lentil flours generated the most pronounced colour changes.
- Heat-treated lentil flour produced lighter crackers, likely due to enzyme inactivation in addition to partial protein denaturation and gelatinization of starch. These changes could limit the formation of free amino groups and reducing sugar substrates or enzymatically formed precursors which accelerate browning reactions (Maillard reaction).

Likeability

- The control and crackers made with raw red lentil flours were rated “like slightly”, with no significant differences among them.
- Crackers made with heat-treated lentil flour achieved the highest appearance ratings, averaging “like very much” and were preferred by panellists.



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Instrumental Colour Analysis

All samples were cooled following baking for 1h at room temperature before storage in plastic bags for 24h prior to analysis in duplicate. Colour analysis was determined using CR-10 Plus Minolta Color Reader. Letters within rows indicate significant ($p<0.05$) differences between cracker types according to Tukey HSD test.

	Attribute	Control	Dehulled Red Lentil Flour (Supplier 1)	Dehulled Red Lentil Flour (Supplier 2)	Heat Treated, Dehulled Red Lentil Flour
Top Colour[1]	L*	66.2 ± 0.3b	56.7 ± 2.3a	56.9 ± 0.2a	65.0 ± 0.1b
	a*	7.2 ± 0.4a	20.3 ± 0.2b	21.2 ± 0.7c	18.9 ± 0.1b
	b*	26.5 ± 0.4a	37.4 ± 0.4b	36.1 ± 0.4b	39.2 ± 0.0b
Bottom Colour[1]	L*	62.4 ± 0.7b	55.1 ± 2.1a	54.5 ± 1.1a	59.9 ± 2.2a
	a*	13.4 ± 0.7a	19.9 ± 0.4b	20.1 ± 1.4b	17.5 ± 0.3b
	b*	33.8 ± 3.5	37.1 ± 0.4	36.7 ± 2.3	36.7 ± 0.5

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Moisture and Texture

Moisture and water activity of lentil crackers were all significantly lower than the control, likely attributed to differences in initial flour moisture content and the high-water holding capacity of lentil flour. Instrumental texture measurements indicated that lentil flour crackers fracture with slightly less energy than the control, but this difference was not perceptible to consumers.

KEY OBSERVATIONS

- Moisture content and water activity were consistently lower in crackers made with lentil flour.
- The heat-treated lentil flour showed the largest reduction in water activity, likely due to partial protein denaturation, which exposes hydrophilic binding sites and pre-gelatinized starch, which retains water more effectively. These properties could contribute to improved product stability and shelf-life potential.
- The control cracker required more total work (energy) to break compared with lentil flour samples.
- Despite instrumental differences, sensory panelists reported no significant differences in overall liking of mouthfeel.

Attribute	Control	Dehulled Red Lentil Flour (Supplier 1)	Dehulled Red Lentil Flour (Supplier 2)	Heat Treated, Dehulled Red Lentil Flour
Moisture[1] (%)	7.6 ± 0.1c	3.5 ± 0.2a	5.7 ± 0.2b	3.2 ± 0.0a
Water Activity[2]	0.60 ± 0.02c	0.28 ± 0.00b	0.44 ± 0.01b	0.19 ± 0.01a
Hardness[3] (g)	478 ± 16	346 ± 109	597 ± 66	357 ± 172
Deformation at Hardness[3] (mm)	0.72 ± 0.22	0.30 ± 0.01	0.41 ± 0.06	0.27 ± 0.02
Tota Work Done[3] (mJ)	3.4 ± 0.2b	1.2 ± 0.4a	2.6 ± 0.1a	1.4 ± 0.8a

1 Moisture content determined using Mettler Toledo HE73 moisture analyzer following grinding; 2 Water activity was determined usiing a Rotronic Hygrolab C1 digital water activity meter following grinding; 3 Texture properties were measured using a Brookfield CTX texture analyzer (50 kg load cell) fitted with a three-point bend assembly, following Millar et al. (2017)** with minor modifications. Measurements were collected in compression mode to a distance of 5.0 mm (trigger load: 5 g; test speed: 0.5 mm/s; filter: 0.95) and recording using Texture Pro V1.0 Building 10 software. Hardness = peak force require to fracture the sample, Deformation at Hardness = the distance the sample deforms at the point of maximum forces, Total Work Done = the area under the force-determination curve, which represents the total energy required to break the sample. **Millar, K. A., Barry-Ryan, C., Burke, R., Hussey, K., McCarthy, S., & Gallagher, E. (2017).. https://doi.org/10.1111/ijfs.13388.

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Sensory Analysis

Flavour

Despite being often described as bitter, both **untreated lentil flours rated higher in flavour liking than the control**.

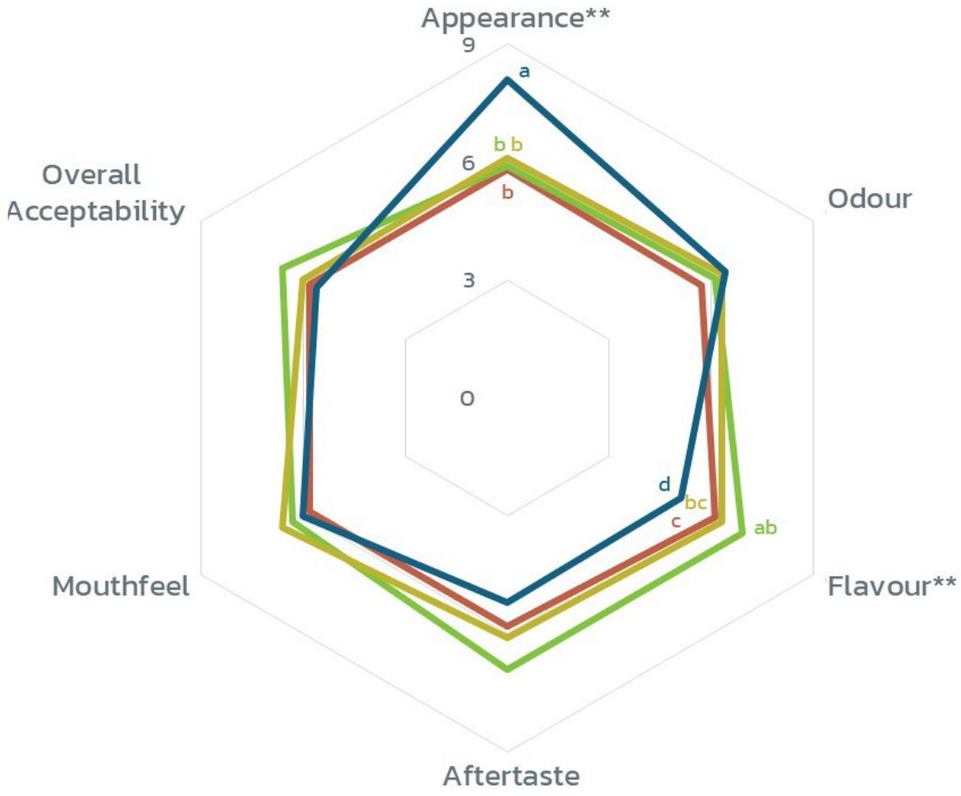
Although thermal treatment typically improves pulse flavour, the heat-treated lentil flour unexpectedly received the lowest flavour liking scores. "Bitter" was noted for both untreated flours, but not for the heat treated flour. This suggests that the heat treatment successfully reduced lipid-oxidation–related bitterness but introduced or intensified other undesirable volatiles that negatively influenced the flavour rating.

Odour and Aftertaste

No significant differences were detected for odour or aftertaste among any crackers, suggesting sensory differences were driven largely by immediate flavour perception, not lingering notes.

Overall Acceptability

Overall acceptability scores did not differ significantly across treatments, including the control. Any flavour-related differences associated with certain flours did not meaningfully influence the overall eating experience.



Sensory evaluation was conducted using a structured 9-point hedonic test with nine trained participants Panelists assessed appearance, odour, flavour, aftertaste, mouthfeel and overall acceptability. Standardized evaluation protocols were followed, including palate cleansing and a descriptor reference library.

**Indicates significant differences ($p<0.05$) across cracker types according to Tukey HSD test.

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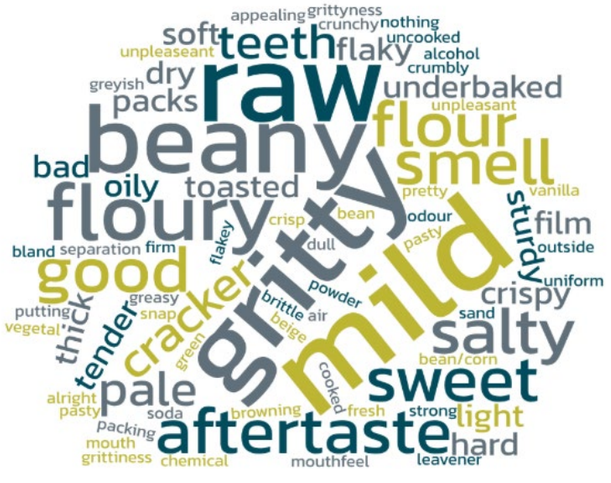
Sensory Analysis:
Panelist Descriptions

Dehulled Red Lentil Flour (Supplier 1)

Dehulled Red Lentil Flour (Supplier 2)

Heat Treated, Dehulled Red Lentil Flour



Control

CONCLUSIONS

This study demonstrates that lentil flour can be successfully incorporated into gluten-free crackers while delivering distinct visual appeal, improved nutritional attributes, and acceptable sensory performance.

Colour Advantage

Lentil flour adds a natural orange–red hue that enhances visual appeal.

Acceptable Flavour Profile

Despite some beany, vegetal, or bitter notes, flavour and overall liking remained in the neutral-to-slightly-liked range for all crackers, including the control. Warm, savoury flavours (e.g., tomato, paprika, cheese, BBQ) pair naturally with lentil flour's colour and may boost flavour liking further.

Improved Mouthfeel

Informal chef tasting noted reduced grittiness vs. rice-based controls, potentially improving sensory experience.

Ingredient Selection Matters

Cracker quality varied by flour type and supplier, highlighting the importance of ingredient screening.

Process Controls Improve Quality

- Slow mixing minimized off-flavours
- 24h dough hydration improved cohesion and baking performance
- 2.0–2.5 mm thickness optimized texture, integrity and flavour