Texture, sensory property, and marketability of lentil-enriched crackers made from Montana-grown wheat and lentils

S. Li & W-Y. Kuo

Sustainable Food Systems, Montana State University, Bozeman, MT

Contact Information:
lisharon96@gmail.com
wanyuan.kuo@montana.edu

ABSTRACT

Lentils *(Lens culinaris)* are rich in protein, fiber, folic acid and iron and are environmentally sustainable as they require less water and nitrogen fertilizers compared to major cereal crops. This study aims to evaluate the texture, sensory, and marketability of lentil-enriched crackers to promote value-added agriculture in Montana, a leading lentil producer. Lentil-enriched crackers were formulated using local Montana wheat flour and red Petite Crimson lentils. Variables of the cracker formulations included different lentil to wheat flour weight ratios (0/100, 50/50, 100/0) and pre-roasting times of the lentil flours (0- 10 minutes at 350 degrees Fahrenheit) before mixing into the dough. The texture of the crackers was evaluated using a texture analyzer. The crackers with or without the labels of "Made-in-Montana" or "Low-Carbon-Footprint" were evaluated by a consumer sensory panel using a nine-point hedonic scale. Quantitative descriptive analysis (QDA) were used to profile the sensory properties of the crackers. Texture analysis revealed increase in lentil to wheat ratios from 0/100 to 100/0 increased the hardness, stiffness, toughness, and crunchiness of the crackers, and the increase in time of lentil pre-roasting from 5 to 10 minutes reduced the hardness, stiffness, and toughness ($P < 0.05$). The consumer test revealed that increase in lentil to wheat ratios from 0/100 to 100/0 increased the liking of the crackers ($P < 0.05$), and pre-roasting of lentils did not cause any difference. Labeling claims did not impact the score of crackers. QDA revealed that the lentil-enriched crackers are described by beany aroma and aroma-by-mouth, umami taste and aftertaste, and crunchy texture. This study can provide insight on how interactions between texture, sensory profile and sustainability labels affect the marketability of lentil-enriched crackers. The outcome can direct future lentil cracker development and marketing efforts to promote local value-added agriculture.

INTRODUCTION

Lentils (*Lens culinaris*) are a nutritious and sustainable crop that fixes nitrogen back into the soil [1]. Montana is the largest producer of lentils in the United States [2] and utilizing locally produced Montana lentils can support Montana's local food initiative. Currently, lentil products on the market are rarely labelled as environmentally sustainable. Plus, to the best of our knowledge, there has not yet been a study that utilized lentils to create a cracker product and studied the instrumental texture, sensory property, and overall consumer acceptance with labelling effect.

AIM

This study aims to analyse the overall consumer acceptance related to instrumental texture, descriptive sensory profile, and labelling of lentil-enriched crackers.

METHODS

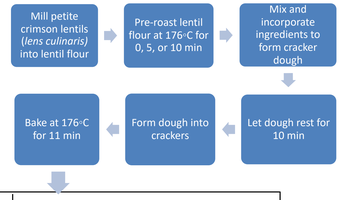
Table 1. The formulation and coding of lentil-enriched crackers.

Sample code	Lentil flour pre-roasting time (min)	Lentil flour/ wheat flour ratio (w/w, d.b.)
Control	-	0/100
0R50L	0	50/50
0R100L	0	100/0
5R50L	5	50/50
5R100L	5	100/0
10R50L	10	50/50
10R100L	10	100/0

Control

10R100L

Lentil-enriched cracker baking procedure



Instrumental texture analysis

- TA-XT Plus texture analyzer (Texture Technologies Corp, La Cresenta, CA)
- Crackers stacked in threes and compressed with a 25C probe (10 mm)
- ANOVA analysis with least significant difference test (LSD, $\alpha = 0.05$, XlStat, New York, NY)

Quantitative descriptive analysis

- 9 panelists screened and recruited
- Panelists trained for 30 days in which they generated terms and definitions and rated references and samples on a 15-pt scale
- ANOVA, LSD, and Pearson correlation analyses ($\alpha = 0.05$)
- Principal component analysis & agglomerative hierarchical cluster analysis (AHC)

Consumer acceptance test

- 9-pt hedonic scale
- 108 panelists
- 15 samples (5 formulations under 3 labeling effects: no label, "Made in Montana" and "Low Carbon Footprint").
- ANOVA, LSD ($\alpha = 0.05$), and AHC
- Fisher's exact test of the cluster demographics

Figure 1 – Labels presented in the consumer acceptance test of the crackers: "Made in Montana" label [3] and "Low Carbon Footprint" label [4].

RESULTS

Instrumental texture analysis

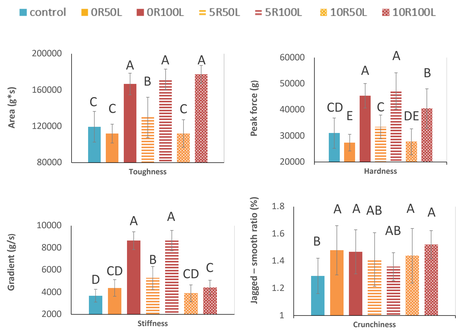


Figure 2 – The instrumental texture properties of the lentil-enriched crackers. The values labeled with the same letters are not significantly different ($\alpha = 0.05$).

- Increased lentil/wheat ratio increases cracker toughness.
- Pre-roasting lentil flour for 10 minutes decreased hardness and stiffness for the 100% lentil cracker.
- Lentil-enriched crackers with 0 or 10 minutes of pre-roasting were significantly higher in crunchiness than the control.

Quantitative descriptive analysis

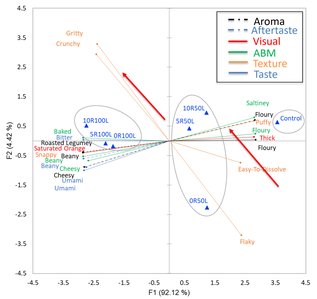


Figure 3 – Principal component biplot of significant QDA terms of the lentil-enriched crackers.

- 100% lentil crackers were attributed with baked, beany, cheesy, roasted legumey, umami, and saturated orange terms. Control was attributed with saltiney, floury, thick, and puffy terms.
- Increasing pre-roasting of lentil flour resulted in higher intensities in gritty and crunchy texture.

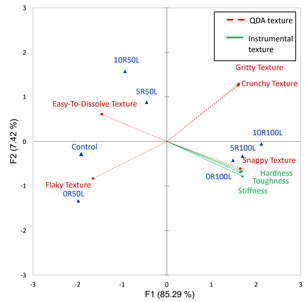


Figure 4 - Principal component biplot of the significant QDA texture terms and instrumental texture measurements.

- Instrumental toughness, hardness, and stiffness correlated positively with Snappy QDA texture and negatively with Easy-to-dissolve QDA texture.
- Instrumental crunchiness was not correlated with Crunchy QDA texture.

Overall consumer acceptance

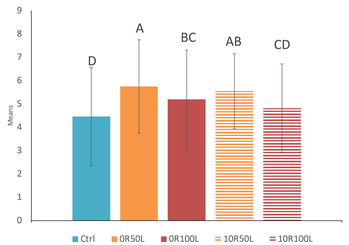


Figure 5 - The overall acceptance of lentil-enriched crackers with no labeling effect. The values labeled with the same letters are not significantly different ($\alpha = 0.05$).

- 0R50L and 10R50L were the most preferred samples.
- There was no significant difference between labeling effect in any of the samples.

Consumer cluster analysis

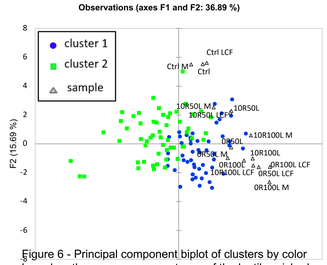


Figure 6 - Principal component biplot of clusters by color based on the consumer acceptance of the lentil-enriched crackers, see Table 1. for sample codes, M stands for "Made in Montana" and LCF stands for "Low Carbon Footprint."

- Cluster analysis differentiated two clusters:

	Cluster 1	Cluster 2
Percentage of panelists in agriculture and health fields ($P < 0.05$)	Lower	Higher
Product acceptance ($P < 0.05$)	10R50L & 10R100L: LCF > M	0R50L: M > LCF

- None of the demographic categories, including field of study, shopping location, education, age, gender and residency, solely determined the cracker acceptance.

CONCLUSIONS

	Increased lentil to wheat ratio	Increased pre-roasting time of lentil flour
Instrumental texture	• Toughness • Hardness • Stiffness	• Hardness • Stiffness
QDA	• Baked • Beany • Cheesy • Saturated orange • Snappy	• Roasted legumey • Bitter • Gritty • Crunchy
Consumer acceptance	• Acceptance compared to control	• Pre-roasting did not affect overall consumer acceptance

Overall labeling conclusions

- Labeling effect was dependent on sample and consumer demographics.
- Two distinct consumer clusters differed in the field of study and the responses to labeling, but none of the demographic categories solely determined the cracker acceptance.
- Future studies will further research education, labeling, and other demographic effect on lentil cracker acceptance.

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[3] **Montana Department of Commerce** (2017) Made in Montana Logo, Retrieved April 1, 2020 from Made in Montana USA website: https://madeinmontanausa.com/portals/_default/skins/DOC/Resources/images/MMM/MiMlogo.png
[4] **Meyerding, Stephan G.H., Schaffmann Anna-Lena and Lehberger, Mira** (2019). Figure 1. Carbon footprint designs on this study, [graphic]. From Consumer Preferences for Different Designs of Carbon Footprint Labelling on Tomatoes in Germany – Does Design Matter? (pg.2), Mereyding et al., 2019, Sustainability 11,1587.