Flour Power: New Uses for Lentil Flour in Batters, Breading, and Coating Systems

1. Overview

The recent "Chicken Wars" at Quick Service Restaurants (QSR) across the United States (U.S.) not only reignited the chicken sandwich trend, but it also gave birth to new and innovative ways to bring menu items to market. With consumers more vocal than ever in sharing what they love (or hate), alternate methods of preparation are being explored to make everything from chicken sandwiches to French fries "new and improved."

One such study was recently released that found that crispier and crunchier fried chicken is possible, with lentil flour being the not-so-secret ingredient. In fact, the study[1], funded by Lentils.org and Pulse Canada, found that **adding lentil flour to an existing wheat flour breading for fried chicken demonstrated benefits including improved texture, hold time, and color, reduced cook time, and the removal of potential allergens.** The study also showed similar preliminary results for battered fried fish and coated potato products.

Researchers also tested the effects of both deflavored and raw lentil flour inclusion in various breading and coating systems including bone-in chicken thighs, chicken fillet tenders, fish fillet, and potato French fries.

2. What is Lentil Flour?

Lentils are a type of pulse crop, along with dry beans, field peas, chickpeas, and faba beans. The term "pulse" is used to describe the dried, edible seeds of legumes. Lentil flour is produced by grinding or milling lentils into a fine powder. Lentil flour can be deflavored using a heat treatment to remove some slight off flavors, or used in its raw untreated state.

3. B2B Opportunity – Lentils Enter the Chicken Wars

In a 2021 Datassential report, researchers found that on-site operators and consumers alike are not done with the chicken sandwich wars yet[2]. Thanks to the popularity of Popeyes vs. Chick-fil-A chicken sandwich debate, operators are aware that chicken sandwiches are all the hype. **Even with a global pandemic, the number of sandwich introductions released in October of 2020 nearly matched the numbers in former peak years like May of 2016 and April of 2018[3].**

The chicken sandwich trend, or fried chicken dish introductions in general, do not appear to be slowing down anytime soon, rather they continue to evolve and expand. In the past year, some of the fastest-growing menu items involve some sort of fried chicken like Nashville Hot (+47%), popcorn chicken (+20%), and fried chicken sandwiches (+14%), as well as those with more ethnic flavors such as Chicken Biryani (+10%) and Katsu (+7%)[3].

Due to the upward trending popularity of chicken offerings and recent inquiries by industry stakeholders, there may be opportunities to apply lentil flour in the foodservice market as a batter, breading, and/or coating agent. Until now, there existed little scientific evidence to highlight the benefit of lentil flour in this application. The following study was executed to assess the performance of lentil flour as a pre-dust, batter, and breading agent in food applications under simulated foodservice operator conditions.

4. Functionality and Sensory Research

Researchers took a three-phased approach to evaluating the effectiveness of lentil flour in a fried breading application. Phases included: 1) flour functionality, 2) preliminary testing and ingredient functionality assessment, and 3) formulation optimization and quality assessments.

Phase 1: Flour Functionality

In phase 1, researchers analyzed deflavored and raw red lentil flours for their composition, physical, and functional compositions.

The compositional characteristics between the deflavored and raw lentil flours were quite similar with only minor differences in moisture content and protein content of the flour samples (Table 1).

Table 1: Properties of deflavored and raw red lentil flour

Flour Properties	Deflavored Lentil Flour	Raw Lentil Flour
Composition		
Moisture[b], %	6.24	8.36
Starch Content, %	52.35 ± 0.49	53.15 ± 0.35
Amylose (% of total starch)	28.04 ± 0.73	27.23 ± 0.08
Amylopectin (% of total starch)	71.97 ± 0.73	72.78 ± 0.08
Total Dietary Fibre	9.05 ± 0.07	8.45 ± 0.21
Insoluble Dietary Fibre, %	6.55 ± 0.07	5.90 ± 0
Soluble Dietary Fibre, %	2.50 ± 0	2.55 ± 0.21
Protein, % (6.25 conversion factor)	25.65 ± 0.07	24.80 ± 0
Functional Properties		
Water Holding Capacity, g/g	1.93 ± 0.02	0.75 ± 0.03
Oil Holding Capacity, g/g	0.66 ± 0.01	0.71 ± 0.01
Physical Properties		
Particle Size Distribution[b] (%)		
>600 µm	0.8	1.12
450 - 600 µm	0.9	0.88
250- 450 µm	4.2	1.75
150 - 250 µm	6.7	8.70
100 - 150 µm	22.6	29.28
75 - 100 µm	25.9	26.23
45 - 75 µm	28.8	26.39
Thru 45 µm	10.0	5.65
Differential Scanning Calorimetry		
onset Temperature °C	68.02 ± 1.03	62.80 ± 0.11
enthalpy (normalized, J/g)	0.86 ± 0.10	9.72 ± 0.31
peak temperature °C	74.75 ± 1.42	73.83 ± 0.61

[a] Results reported as average ± standard deviation unless otherwise indicated. Recorded from two sample reps for each lentil flour.
[b] Results reported from 1 sample

With respect to functional properties of the flours, the application of heat treatments in the production of deflavored lentil flour may result in partial gelatinizication of starch granules, as indicated by differential scanning calorimetry. Gelatinized starch granules maintain the ability to swell and imbibe water at room temperature, which could contribute to the higher water absorption capacity of deflavored lentil flour. Additionally, partial denaturation and unfolding of proteins during processing may result in the exposure of hydrophilic regions and further improve the water absorption capacity relative to the raw flour. Similarly, exposure of hidden hydrophobic regions during protein denaturation may influence oil retention properties and account for the differences between deflavored and raw flour.

Phase 2: Preliminary Testing and Ingredient Functionality Assessment

Boneless Chicken Tenders

Breading Composition, Pick-Up, and Cook Yield

The moisture and fat contents of cooked chicken tenders containing lentil flour were slightly higher than the control, with raw lentil flour systems retaining more moisture, and deflavored lentil flour retaining more fat than the alternative treatments (Table 2). The pre-dust pick-up for control samples (4%) was comparable to that of tenders formulated with raw (~4%) and deflavored (3-4%) lentil flour (Table 3). Percentage of breading pick-up systems containing lentil flour were slightly higher than control (11%), where no distinct differences were noted between deflavored or raw lentil flours which ranged from 13-14%. There were no distinct differences in the cooking yield of chicken tenders during par fry cook (all ranging from 84-89%), however for final fry, systems containing raw lentil flour displayed higher cook yields (76-79%) than control (69%) and deflavored (68-74%) lentil flour samples. The maximum final frying yield was demonstrated by the raw red lentil flour at 30% inclusion in the chicken tender breading coating.

Table 2: Moisture and Fat composition of fully cooked whole fried chicken tenders coated with a control breading system, deflavored (DF) and raw (R) red lentil flour.

	Coating Type						
	Control	**DF20**	**DF30**	**DF40**	**R20**	**R30**	**R40**
Moisture (%)	49.53	46.08	48.98	53.07	54.71	56.44	54.42
Fat (%)	5.00	11.85	10.10	9.35	6.95	6.10	6.95

Breading Pick-Up, Par-fry Yield, and Final Frying Yield

Table 3: Average breading pick-up of chicken coated with a control breading system, deflavored (DF) and raw (R) red lentil flour.

Sample	Pre-Dust Pick-up (%)	SD	Breading Pick-up (%)	SD
Control	3.87	± 0.46	11.22	± 0.06
DF20	3.75	± 0.58	14.09	± 2.07
DF30	3.81	± 0.77	12.91	± 1.17
DF40	2.99	± 1.81	13.32	± 1.82
R20	4.12	± 0.49	12.94	± 0.51
R30	4.05	± 0.22	12.52	± 0.75
R40	4.19	± 0.38	13.62	± 1.61

Sensory Evaluation

The overall sensory scores of chicken tenders were comparable to control, with no evident negative affects associated with the incorporation of red lentil flour into the breading mix. The addition of both raw and deflavored lentil flour significantly improved the overall coating color acceptability of the chicken tenders, providing a desirable reddish, golden-brown exterior (Tables 4 & 5). Textural improvements were also associated with the addition of lentil flour to the systems, where both raw and deflavored lentil flour samples improved the coating firmness and crispiness, with additional improvements to coating crunchiness in deflavored lentil flour samples, with the highest crispiness and crunchiness scores attained at an inclusion rate of 20%. Despite the slightly higher moisture and fat contents reported for systems containing red lentil flour (previous section), no detectible differences in the sensory scores for moistness and greasiness were detected. The addition of both raw and deflavored lentil flour did contribute to the intensity of undesirable off-flavors, where sensory scores were comparable to that of control systems. Overall, the addition of red lentil flour resulted in improved overall texture most evident in deflavored samples, improved color, and similar overall chicken tender quality to that of the control.

Table 4: Sensory evaluation of fried chicken tenders coated with raw (R) red lentil flour and a control coating system.

Sensory Characteristic	Control	SD	R20	SD	R30	SD	R40	SD
Coating Coverage	8.3	± 1.1	8.7	± 0.5	8.7	± 0.5	8.8	± 0.4
Coating Firmness	6.2	± 2.2	6.3	± 1.6	6.8	± 1.3	6.5	± 1.4
Overall Coating Color	4.5	± 1.5	6.2	± 1.3	6.5	± 1.0	6.5	± 1.0
Coating Crispiness	4.0	± 1.6	4.5	± 1.6	5.0	± 1.7	4.0	± 1.8
Coating Crunchiness	4.2	± 2.0	5.2	± 0.8	4.5	± 1.6	3.7	± 1.8
Off Flavor Intensity	2.3	± 1.9	2.5	± 2.0	2.0	± 1.5	2.2	± 1.9
Moistness	5.0	± 2.4	5.2	± 1.5	4.5	± 1.2	4.3	± 2.1
Greasiness	4.3	± 1.8	3.2	± 1.2	3.7	± 1.5	3.2	± 1.2
Overall Texture	5.3	± 1.2	5.5	± 1.4	5.5	± 1.0	5.3	± 0.8
Overall Quality	5.7	± 1.6	5.7	± 1.5	5.7	± 1.0	6.0	± 1.3

Table 5: Sensory evaluation of fried chicken tenders coated with deflavored (DF) red lentil flour and a control coating system.

Sensory Characteristic	Control	SD	DF20	SD	DF30	SD	DF40	SD
Coating Coverage	8.7	± 0.8	8.3	± 1.6	8.3	± 0.8	8.3	± 1.0
Coating Firmness	6.0	± 1.5	7.5	± 0.8	6.8	± 1.5	7.2	± 1.2
Overall Coating Color	3.8	± 0.4	6.8	± 1.6	7.0	± 0.9	7.2	± 0.8
Coating Crispiness	3.5	± 0.8	7.2	± 0.4	6.2	± 0.8	6.0	± 0.6
Coating Crunchiness	3.3	± 1.0	6.7	± 0.8	5.7	± 1.0	5.8	± 1.6
Off Flavor Intensity	1.5	± 0.8	2.0	± 1.1	2.0	± 1.3	1.8	± 0.8
Moistness	4.7	± 1.6	5.3	± 1.9	4.3	± 1.0	4.7	± 1.0
Greasiness	4.0	± 1.4	3.7	± 1.4	3.8	± 1.5	4.7	± 1.6
Overall Texture	5.2	± 1.0	6.8	± 1.0	6.3	± 0.5	7.2	± 0.4
Overall Quality	6.0	± 0.6	7.0	± 0.9	6.5	± 0.5	7.5	± 0.6

Instrumental Color

Color of lentil flour inclusions in chicken tenders was characterized with more red (a*) and more yellow (b*) intensity compared to the control sample, where the raw lentil flour samples yielded a brighter (L*) product (Table 6).

Commercial breading systems generally follow a dry, wet, dry procedure where the wet step involves a water, milk, or egg wash. Interestingly, the color development of lentil flour inclusions in breading and coating systems using a water wash was similar to the level of color development achieved in the control sample when a milk wash was included in the product formulation (Figure 1). This presents as an opportunity to replace dairy based ingredients in these systems without compromising the chicken tender color, where inclusion of lentil flour may allow for dairy-free and potentially allergen-free formulations of these products. The color matching was more pronounced in the use of deflavored lentil flour as compared to raw lentil flour (Figure 2) which did not achieve a similar level of color development in the chicken tender until a minimum 40% inclusion of raw lentil flour in the coating system.

Table 6: Instrumental color of fried chicken tender coated with a control breading system, deflavored (DF) and raw (R) lentil flour.

Sample	L*	a*	b*	Delta E
Control	58.4	15.2	30.4	
DF20	54.3	19.3	36.8	8.7
DF30	59.4	18.4	36.1	6.7
DF40	57.5	19.6	36.5	7.6
R20	63.9	15.8	34.6	7.1
R30	62.5	18.0	36.0	7.6
R40	64.2	17.4	35.6	8.2

L*= color brightness
a* = red color intensity
b* = yellow color intensity

Figure 1: Control and deflavored red lentil flour coated chicken tenders. L-R control (water wash), control (milk wash), 20% deflavored lentil flour, 30% deflavored lentil flour, 40% deflavored lentil flour.

Figure 2: Control and raw red lentil flour coated chicken tenders. L-R control (water wash), control (milk wash), 20% raw lentil flour, 30% raw lentil flour, 40% raw lentil flour.

Instrumental Texture Analysis

Fried chicken tenders with lentil flour breading systems were held under a heat lamp for 60 minutes under 50°C. The initial puncture force of the chicken tenders was higher with lentil flour ingredients (1770-2460 g) versus that of the control chicken tenders (1400 g). Throughout the 60 minute heat lamp hold time, the control chicken tender generally retained its texture (~1500 g) where chicken tenders formulated with lentil flours demonstrated an increase in puncture force over the holding period (Table 7). This increase in texture may be due to starch retrogradation of lentil flours to create a gel-like structure within the coating system, causing the development of a harder crusted coating.

When the chicken tenders were held within a clamshell style take out container, the texture of the control sample had an initial firm, strong network and higher initial puncture force than most of the tender coatings formulated with lentil flour (Table 8). Within the 1 hour holding period, the control chicken tenders demonstrated a loss of texture at approximately 30 min of holding, with a subsequent increase in puncture force as the sample further cooled for the remainder of storage. Interestingly, the lentil flour coating systems did not demonstrate this dip in texture suggesting that the lentil flour inclusion helped to retain texture at the 30 minute mid-point of the holding time.

Table 7: Change in texture (puncture force, g) of fully cooked chicken tenders coated with a control breading system, deflavored (DF) and raw (R) lentil flour held under a heat lamp at 50°C.

	Peak Force (g)						
Time	**Control**	**DF20**	**DF30**	**DF40**	**R20**	**R30**	**R40**
0	1403.3	2463.8	1677.5	1766.5	1748.5	1813.8	1838.3
15	1409.3	3072.3	3511	3099.5	1354	2286.5	2633.3
30	1555.8	3534	2610.5	1734.3	1656.8	2721	1945
45	2102	3292.5	2303	1982.8	2061.8	2647.5	2263.3
60	1563.5	2787	3169.3	2527	2152.5	3238.5	3243.5

Table 8: Change in texture (puncture force, g) of fully cooked fried chicken tenders coated with a control breading system, deflavored (DF) and raw (R) lentil flour held in a clam shell take out container.

	Peak Force (g)						
Time	**Control**	**DF20**	**DF30**	**DF40**	**R20**	**R30**	**R40**
0	2368	2086.5	1845.8	2582.3	1987.5	1482.5	1917.3
15	2321.8	2310	2224.5	2679.8	2153	1826.8	1898.5
30	1218.5	3386.5	2722	2652	2409	2250.5	2451.5
45	1989.3	3567	2242	3530.3	2463.8	2951.0	2735.5
60	3143	3326.8	3824.5	3177	2644	2593.3	2193.3

<u>Bone-in Fried Chicken Thighs</u>

Preliminary testing and ingredient functionality assessment of bone-in fried chicken thighs resulted in similar trends to that observed in chicken tenders, however results were more variable given the non-uniformity of samples. Overall, no significant differences relative to the control were noted in the moisture content, fat content, batter pick-up, and cook yield for chicken thighs formulated with red lentil flour. This is with the exception of a slightly higher final fat content in raw red lentil chicken thigh systems. Improvements in the sensory scores for coating firmness and crispiness were only observed for chicken thighs incorporating deflavored lentil flour, where minor decreases were noted when raw flour was used. The sensory panel only detected improvements in coating color scores for raw red lentil flour systems, however instrumental color analysis revealed increases in both redness (a*) and yellowness (b*) for all chicken thighs with lentil flour inclusions when compared to the control. The uneven sample surface of the chicken thigh made it difficult to analyze the texture of the samples, however an increase in the initial puncture force was observed for four out of the six red lentil flour treatments relative to the control.

Figure 3: Control breaded thigh

Figure 4: 20% raw lentil flour breaded thigh

Figure 5: 30% raw lentil flour breaded thigh

Figure 6: 40% raw lentil flour breaded thigh

Figure 7: 20% deflavored lentil flour breaded thigh

Figure 8: 30% deflavored lentil flour breaded thigh

Figure 9: 40% deflavored lentil flour breaded thigh

Phase 3: Formulation optimization and quality assessment

Based on the results from phase 2, deflavored lentil flours were selected for optimization in fried coating and batter applications. Sensory and instrumental results indicate that deflavored lentil flour improves desired texture characteristics of coated fried products including coating firmness, crunchiness, and crispiness. Deflavored lentil flours also rapidly produce a desirable even golden-brown coating on fried products, whether it was bone-in chicken thighs, chicken fillet tenders, potato French fries, or fried fish, which has the potential to reduce cook time.

Research Results

Overall, the study found that incorporating lentil flour into the batter and breading process improved texture, color, and hold time, and reduced cook time and allergens in fried chicken, with similar results seen in fried fish and potato products as well. The best results were found with a 100% lentil flour pre-dust, 20-30% lentil flour inclusion to a regular wheat flour breading with neutral spice mix, and without the need for milk inclusion in the wet wash step. This set up resulted in the following beneficial attributes:

1. Texture – the lentil flour improved the overall texture of the fried chicken compared to the control, with improved crispiness to the initial bite and crunchy texture during chewing – this means a more texturally desirable mouth feel and crispy factor on the chicken when biting into it.

2. Color – the lentil flour saw a significantly improved color compared to the control. The lentil flour resulted in consistent and even batter pick-up and color distribution, specifically resulting in a visually appealing golden brown, Southern fried coloring of the fried chicken product.

3. Hold time – the lentil flour, in initial experiments, resulted in a longer hold time than the control, with an additional 15 minutes allowance to optimal texture under both a heat lamp, and in a to-go container. Further exploration is required to quantify this outcome more precisely. With the importance of off-premise dining during, and even coming out of the pandemic, and the overall rise of delivery, this is an important factor in the quality of food during holding and/or travelling.

4. Cook time – lentil flour used in a batter or breading system saw a reduction in cook time versus the control. The system utilizing lentil flour was able to produce the desired color and texture in 25% less time in the fryer, while still reaching the optimal internal cooked temperature – this is important when it comes to overall time to produce the product, in the end producing 25% more in the same amount of time, an important factor when labor is an ongoing challenge in foodservice kitchens and manufacturing environments.

5. Removal of allergens – the study found that a desirable golden color and optimal texture was realized using the lentil flour in a system utilizing water only in the wet step, with results comparable to that of using milk and/or eggs. Many systems require milk and/or eggs in the wet step in order to achieve the desirable color and texture of typical fried products. The lentil system favored water on its own with no additions. Removing milk and/or eggs from the system can remove allergens from the batter system, and possibly reduce the cost of the system as well.

5. Opportunities

The positive attributes of deflavored lentil flour in coated fried applications presents the following opportunities in commercial applications:

Reduced Cook Times

Lentil flour used in a batter or breading system saw a reduction in cook time versus the control. In 25% less time, the lentil flour product produced the desired color and texture while still reaching the optimal internal cooking temperature. With less time in the fryer, more products can be made in a shorter amount of time improving overall production times which can benefit both operators and manufacturers.

“When labor is an ongoing challenge in commercial kitchens, reducing the cook time of a product, especially by 25%, is incredibly important,” says James Bickmore-Hutt, Lentils.org Corporate Chef.

Improved Hold Time

The lentil flour, in initial experiments, resulted in a longer hold time than the control, with an additional approximately 15-minutes allowance to optimal texture under both a heat lamp, and in a to-go container. Further exploration is required to quantify this outcome more precisely. With the importance of off-premise dining during, and even coming out of the pandemic, and the overall rise of delivery, this is an important factor in the quality of food during holding and/or travelling.

Allergen Removal

Many breading systems require milk and or eggs during the wet step in order to achieve the right color and texture. However, during this study the lentil flour produced the optimal color and texture when using only water.

According to the previously mentioned Datassential study[3], more than 25% of operators want products that can cater to specific dietary trends. Adopting lentil flour into battering or coating practices could be beneficial to operators developing menus to accommodate those with certain food allergies or participating in dietary trends like non-dairy.

Also, by simply adding lentil flour to the breading system, operators don't have to purchase milk or eggs for the sole purpose of the wet step. This allows operators to reduce the purchase of more perishable items like eggs and milk and, depending on the amount normally needed, potentially result in a cost savings as well.

6. Conclusion

Through this study, researchers found that by adding lentil flour to their batter, breading, and coating system, operators have the opportunity to increase hold time, decrease cooking time, and remove allergens without sacrificing characteristics like texture and color. Results demonstrated that these characteristics of chicken thighs and tenders formulated with 20-30% lentil flour actually improved quality, resulting in a crunchier, crispier texture, and positive golden-brown color.

The findings of this research can play a positive role in the current climate of the foodservice industry by helping reduce food waste, minimize loss, and accommodate dietary allergies while still providing on-trend menu items and fried chicken sandwiches that taste great and satisfy the consumer's desire for optimal texture and color under varying dining scenarios.

To learn more about using lentil flour in your batter, breading, and coating systems, please contact our team at info@lentils.org for a personalized consultation on applying this method.

References

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