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Development of a Batter Using Cassava, Chickpea and Soy Flour for Deep- Fried Chicken

H. Jayasingha[a,*], N.M.N. Nambapana[b]

[a] Department Food Science and Technology, Post Graduate Institute of Agriculture University of Peradeniya, Peradeniya.

[b] Department of Animal Science, Uva Wellassa University, Badulla.

*** Corresponding author email address**: harshimadushan@gmail.com

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Abstract:

This study examined the effects of different flour-batter compositions (wheat, chickpea, cassava, and soy) on deep-fried chicken, evaluating both overall satisfaction and sensory preferences. The batter made with cassava flour was the most popular option, while the batter made with soy flour was the least popular. After several sensory evaluations with 100 panelists, it was discovered that the blend of 35.9% cassava flour and wheat flour had the highest level of general approval. Accepted batter and deep-fried chicken qualitatively analyzed over the time and it recorded that, the pH, water-holding capacity, and microbial count of this ideal composition decreased. The final batter's approximate analysis included 5.09g of moisture, 2.53g of proteins, 12.3g of fat, 1.86g of fiber, and 1.13g of ash (0.69,0.07,0.46,0.10,0.71,0.32,0.75). Important information about flour selection for deep-fried goods is provided by the study, which emphasizes water-holding capacity, pH variations, batter composition, sensory qualities, and microbiological dynamics. These results provide insightful direction for new culinary art, product development, guaranteeing.

Keywords: Flour, Batter, Sensory, Chicken, Deep-fried, Quality

1. Introduction

Battering and breading are common culinary practices used in various cooking settings, including home cooking and the food industry. These methods enhance the quality of fried and baked foods, making them crispy on the outside while retaining a tender and juicy interior [1]. They are applied to a wide range of ingredients, such as fish, seafood, cheese, vegetables, poultry, and meat products, improving attributes like shelf life, texture, appearance, and flavour [2], [3]. Battered and breaded foods have a long history in various cultures. However, recent shifts in the dietary choices of young adults, influenced by socioeconomic factors, have resulted in increased consumption of these foods. The availability of pre-cooked, ready-to-eat, and take-away battered and breaded products in the market has made them a convenient and affordable meal option for many [4, 5]. Due to these reasons consumption of coated food firstly became popular in American continent then spread to the other region such as Japan, Europe and Oceana including developed and developing [2,6]. Furthermore, a notable surge in the application of batter and breading to chicken products has been witnessed since the 1980s, making it the dominant category in the further-processed poultry market [7]. Typically, batter consists of a liquid blend comprising water, wheat flour, starch, and seasonings but it cannot find exact recipes exist for batter systems. In contrast, wheat flour is the most common choice for batter due its functional properties [8, 9]. However, alternatives for wheat flour have also been explored due to health drawback of wheat flour such as high glycaemic value, gluten allergic and diabetic etc. conditions [8,10].

To answer the problems associated with wheat flour, it can be replaced with legumes such as chickpea and soy flour. Except legumes, cassava also proven to be good alternative [11]. These flour types have garnered significant attention from scientists for their versatile roles. As they serve as structure and texture enhancers, provide essential nutrients and bioactive compounds, and offer a low-glycemic-index ingredient and gluten-free flour [11,12]. Meantime, legumes and cassava flour being popular due to its wide availability, and cancer healing [13,14] and those flour exhibit excellent binding properties due to their unique composition, making them suitable for use in batter formulations and applications [15,16].

However, up to date study on commercial use of Cassava, Chickpea and Soya as a batter was not reported. Hence, the primary goal of this research is to assess the suitability of chickpea, soy, and cassava flour as potential replacements in the batter formulation for deep-fried chicken. The study aims to achieve two main objectives: firstly, to identify the batter that offers the best balance of nutritional value and sensory qualities for deep-fried chicken, and secondly, to determine the shelf life of the batter when stored under refrigeration conditions for potential commercial applications.

2. Introduction

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3. Materials and method

Cassava flour, soy flour, and chickpea flour, along with various other ingredients like corn flour, salt, chili powder, pepper, eggs, coconut oil, turmeric powder, and chicken, were sourced from the commercial market.

3.1. Sample preparation

The batter formulations maintained a 1:1.5 ratio of solids to water, with the solid portion consisting of an equal measure of corn flour, salt, and egg. In order to assess the impact of different flour types (Soy, Cassava, and Chickpea), these flours were individually incorporated into the batter formulations as substitutes for wheat flour. Wheat flour were used as controls for comparison. The batter mixture was stirred at a very low speed for a duration of 3 minutes and then allowed to cool to an optimal temperature of 10°C for effective application.

Then samples were deep-fried at a temperature of 175±5°C containing 500 ml of coconut oil. To maintain consistent frying conditions, only 5 pieces were placed into the frying oil at a time, minimizing any fluctuations in the internal oil temperature. After each batch of frying, the oil level was carefully monitored.

3.2. Detail Study

The experiments were performed in two trials. In the first trial as shown in table 01, various flour types (cassava, chickpea, and soya) were tested as substitutes for wheat flour to determine the best combination. The goal was to improve the textural qualities of deep-fried chicken, including crispiness, aroma, taste, and color. These attributes were compared to a control batter made solely with wheat flour and other ingredients. A sensory panel of 100 untrained individuals assessed these qualities according to nine-point ranking system, and based on their feedback, the best flour combination was selected for further evaluation in the second trial.

In the second trial, different proportions 17.9%, 27.9%, 35.9% and 53.8% of the highest-scoring flour were mixed with wheat flour to maintain texture and consistency of batter, table 02. This experiment helped identify the best combination by sensory evaluation with 100 untrained panellist with nine point ranking system and selected final product were further assessed for quality attributes such as pH (ORION 3 Star series, USA), water holding capacity/ Moisture content (AOAC method 934.01), Crude fiber (Fritted Glass Crucible AOAC method 978.10), Crude protein (Kjeldahl Copper AOAC method 2001.11) [17] and microbial quality (*Escherichia coli, Staphylococus aureus* and total colony count) over the time were measured. Final results were analysed using MINITAB package with 5% significance.

During sensory analysis samples were coded with three-digit numbering system with reference numbers of 123, 456, 789, and 369. Coded samples were tested by panellist for appearance, colour, texture, crispiness, taste, aroma and general acceptability.

Table 1: Trial 01- The formulations for batter preparation for four different types of flour

Ingredients	Ingredients for each mixing ratio %			
	Control	Treatment 1	Treatment 2	Treatment 3
Chick pea flour	-	53.8	-	-
Soya flour	-	-	53.8	-
Cassava flour	-	-	-	53.8
Corn flour	17.9	17.9	17.9	17.9
Salt	5.8	5.8	5.8	5.8
Egg	20.4	20.4	20.4	20.4
Turmeric powder	2.1	2.1	2.1	2.1

Contral: Wheat 53.8 % flour; **Treatment 1:** Chick pea 53.8 % flour batter, **Treatment 2:** Soy 53.8 % flour batter, **Treatment 3:** Cassava 53.8 % flour batter.

Table 2: Trial 02- The different percentage formulations for batter preparation for four different types of flour

Ingredient	Ingredients for each mixing ratio %			
	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Wheat flour	35.9	25.9	17.9	-
Selected flour (Cassava)	17.9	27.9	35.9	53.8
Corn flour	17.9	17.9	17.9	17.9
Salt	5.8	5.8	5.8	5.8
Egg	20.4	20.4	20.4	20.4
Turmeric powder	2.1	2.1	2.1	2.1

Treatment 1: Cassava flour 17.9% batter**, Treatment 2:** Cassava flour 27.9% batter, **Treatment 3:** Cassava flour 35.9% batter, **Treatment 4:** Cassava flour 53.8 % batter

4. Results and discussion

As shown in section 2.2 Table 01. throughout this investigation batters made out of different combinations of chickpea, soy, cassava, and wheat flour were utilized for sensory experiments with 100 panelists. The finished batter coated fried-goods (Chicken) were assigned with distinct three-digit codes to conduct blind sensory analysis.

Table 03. showed sensory Pannel results for different combinations of flour utilized. Three-digit coding scheme which was used for the sensory assessment were; control batter (123), chickpea flour batter (369), soy flour batter (456), and cassava flour batter (789).

Table 3: Treatment mean score for trial 01 sensory evaluation

Quality character	Treatment means score (Coded)				
	Control (123)	Treatment 1 (369)	Treatment 2 (456)	Treatment 3 (789)	P- value
Appearance	7.13	6.88	7.13	7.38	0.097
Color	7.00	7.25	7.00	7.75	0.141
Texture	6.88	7.13	6.38	7.13	0.017
Crispiness	7.00	7.00	6.00	7.00	0.003
Aroma	6.75	7.25	6.50	7.50	0.002
Taste	7.25	7.25	6.75	7.75	0.000
General acceptability	7.25	7.50	6.50	7.75	0.000

Contral: Wheat 53.8 % flour (123); **Treatment 1:** Chick pea 53.8 % flour batter (369); **Treatment 2**: Soy 53.8 % flour batter (456); **Treatment 3:** Cassava 53.8 % flour batter (789).

The impact of employing various types of flour on the overall sensory qualities of deep-fried food products were investigated in this extensive sensory study. According to the results, the choice of flour had no effect on appearance or color. Hence, the characteristics were not significantly differed from the control group. This suggests that the three alternative flours could generate visually pleasing outcomes that were on par with those made with wheat flour. However, there were notable differences in texture. According to Singh, et al. (1996), soy flour lagged behind by giving the fried products a harder texture. Chickpea flour (369) and cassava flour-based batters (789), on the other hand, displayed the highest textural properties, imparting a desirable mouth feel. Additionally, there was the crucial quality of crispiness that deep-fried dishes must have [18]. Moreover, there were notable variations in the four varieties of batter when it came to aroma, which an important organoleptic component that affects customer perception. Soy flour-based batter (456) had the lowest aroma rating, while cassava flour-based (789) batter had the highest. This suggests that the olfactory profile of the finished product can be significantly influenced by the flour selection. Even though, taste of a food driven by the human individual perception and emotions [19] there were significant variation on the overall sensory acceptancy on the taste of the individual batter types. This is shown by Soy flour-based batter (456) scoring the lowest means score for taste, and followed by batters based on wheat flour (123), chickpea flour (369), and cassava flour (789) respectively.

Further, the three batters were considerably different in terms of general acceptance; the batter made from cassava flour (789) received the highest acceptance means score, indicating that it might be the alternative that consumers choose. These may due the high viscosity and clear appearance of cassava flour [20] Conversely, batters made with soy flour (456) were the least popular, whereas, general acceptancy of batters made with wheat flour (123) and chickpea flour (369) lay between the cassava(789) and soy(456) flour based batter.

Conclusively, results of sensory evaluation with 100 randomly selected panelist offer significant perspectives on the optimal flour variety selection for attaining the targeted sensory qualities in deep-fried food items. Since, treatments and control were blind coded and panelist were individually reacted, the test results got the minimum interference from each other. Hence, organoleptic properties like crispiness, taste, texture, aroma, and overall consumer acceptability are truly depended on the individual panelist preference. These results lead to obtain the cassava flour-based batter as an optimum general acceptancy.

The highest scoring cassava flour batter was then assessed further in accordance with section 2.2, Table 02 described ingredients mixing ratios and underwent a sensory evaluation with the same100 panelists. The sensory results obtained were summarized in Table 04 where, the best treatment was chosen and qualitative analysis were conducted further. As per the sensory evaluation results in Table 04, appearance, color, and texture remain consistent across all four treatments coded as 751, 752, 753, and 754. Each treatments receiving mean scores of 7.00 with p-values above 0.05, indicating no significant differences in these attributes. However, a notable distinction emerges in terms of crispiness, with treatment 3 with 35.9% of cassava flour (coded as 753) yielding the highest mean score (6.88) and followed by treatment 4 with 53.8% of cassava flour (754), this difference supported by a p-value of 0.003, suggesting a significant impact of the type of flour on perceived crispiness. On the other hand, attributes such as aroma, taste, show consistent mean scores of 6.50, 7.00respectively, across all treatments, with p-values above 0.05, indicating no significant differences. At last general acceptability highest in the treatment 03 were having 35.9% of cassava flour (753) as a proposition and lowest acceptability shows in treatment 02 (752) and 04 (754) were having 27.9% and 53.8% of cassava flour respectively. These findings underscore the influence of flour type and proportion of specific flour type on specific sensory characteristics, particularly crispiness, which can inform product development and consumer preferences.

Table 4: Treatment means scores for different percentages of cassava flour combinations (trial 02)

Quality character	Treatment mean score				P-value
	Treatment 1 (751)	Treatment 2 (752)	Treatment 3 (753)	Treatment 4 (754)	
Appearance	7.00	7.00	7.00	7.00	0.792
Color	7.00	7.00	7.00	7.00	0.384
Texture	7.00	7.00	7.00	7.00	0.338
Crispiness	6.13	6.13	6.88	6.38	0.003
Aroma	6.50	6.50	6.50	6.50	0.435
Taste	7.00	7.00	7.00	7.00	0.984
General acceptability	6.88	6.63	7.38	6.63	0.190

Treatment 1: Cassava flour 17.9% batter **(751)**, **Treatment 2:** Cassava flour 27.9% batter **(752)**, **Treatment 3:** Cassava flour 35.9% batter **(753)**, **Treatment 4:** Cassava flour 53.8 % batter **(754)**.

a. Proximate composition analysis of final selected batter (Cassava flour)

Treatment 03 where shows highest crispiness among the all four combinations were chemically analyzed for its quality attributes. Table 05 indicates the proximate composition of batter and batter coated deep-fried chicken.

Table 5. Proximate composition of final batter and final deep-fried chicken per 100 g

Component	Batter Composition	Std	Deep-Fried chicken composition	Std
Moisture	51.02%	0.69	37%	0.42
Crude protein	2.53 g	0.07	23.2 g	0.19
Crude fat	12.30 g	0.46	19.02 g	0.55
Crude fiber	1.86 g	0.10	0.19 g	0.002
Ash	1.13 g	0.71	1.014 g	0.018
Acid insoluble ash	0.33 g	0.32	0.288 g	0.008
Acid soluble ash	0.80 g	0.75	0.726 g	0.018

The compositional data for both the batter and deep-fried chicken provides valuable insights into their respective characteristics. In the batter, moisture content is notably high at 51.02%, which is typical of batters used for coating foods before frying. This high moisture content contributes to the batter's ability to adhere to the chicken and form a crispy outer layer during frying [21,22].

Moving on to the deep-fried chicken, the composition reveals significantly higher levels of crude protein (23.20 g) and crude fat (19.02 g) these agreed with previous studies as chicken high with protein and during deep-frying it absorb some amount of fat from the oil. These high protein and fat contents are primarily attributed to the chicken meat itself, which is a natural source of these macronutrients [23]. Additionally, during the frying process, the chicken and batter absorbs some of the cooking oil, contributing to the higher fat content observed. These observations agreed to the previous studies states that cassava flour uptake quite higher oil during batter frying than wheat flour [24, 25].

In terms of other components, the batter contains a moderate amount of crude fiber (1.86 g), these results agreed with the Nilusha et al,2021 which proves that cassava contain quite higher fiber than wheat flour. The ash content in both the batter and chicken is relatively low, with the batter showing a slightly higher value at 1.13 g. The presence of acid insoluble ash (0.33 g) and acid-soluble ash (0.8 g) in the batter indicates the presence of inorganic mineral components that may vary based on the specific ingredients used.

In summary, the compositional data for the batter and deep-fried chicken provides a comprehensive view of their respective attributes. The batter is characterized by high moisture and moderate fiber content, while the deep-fried chicken is rich in protein and fat, with some influence from the frying process. These insights are essential for understanding the nutritional aspects and culinary characteristics of these components in deep-fried chicken dishes with cassava flour coated batter.

b. Qualitative analysis of selected batter and the final product

According to Fig 01, the pH of the sample declined over time, with different patterns in its rate of decrease. Initially, in the first three weeks, the pH decreased rapidly, but after that period, the rate of decrease slowed down.

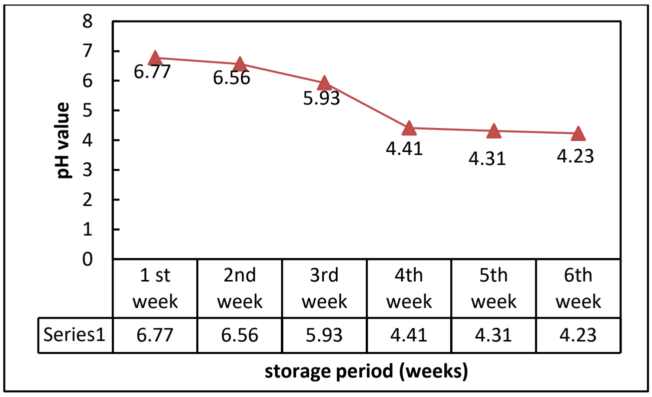


Fig. 1. pH changes of selected batter during storage

The batter was made from various types of flour that contained food enzymes capable of causing chemical degradation, leading to an increase in acidity and a subsequent reduction in pH [26] Additionally, the high carbohydrate content of the batter could be fermented by microorganisms present in the batter, resulting in the production of lactic acid [27, 28]. Furthermore, the proteins in the raw materials could be converted into amino acids, contributing to the decrease in pH. The primary factor responsible for the reduction in pH was the activity of microorganisms, which produced organic acids that further lowered the pH of the batter [29, 30].

The water holding capacity of the batter showed an interesting trend as shown in the figure 02 over a six-week period. Initially, in the first four weeks, it increased, but the rate of increase gradually decreased. However, in the fifth week, there was a sudden decline from 55.23% to 41.22%, followed by a further decrease, albeit at a slower rate, up to the sixth week. Water holding capacity is a critical property for food products as it impacts both the yield and quality of the final product [31].

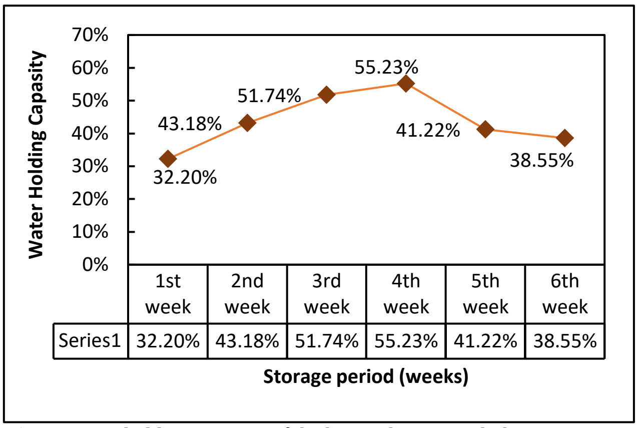
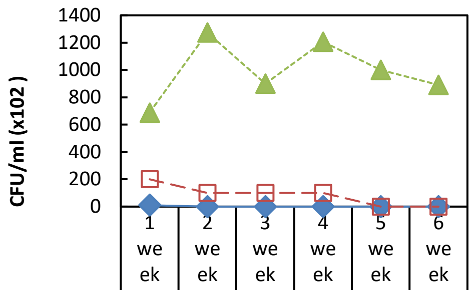


Fig. 2. Water holding capacity of the batter changes with the time

The increase in water holding capacity during the first four weeks could be attributed to the absorption of water by proteins and starches in the batter, as well as the conditioning of the batter. When water is absorbed by starch, it swells and contributes to the water holding capacity. However, after a certain point, the swelled starch granules may break down, leading to a reduction in water holding capacity over time [32, 33].
Another factor influencing these fluctuations in water holding capacity could be the storage conditions, including the storage period and refrigerator conditions. It's worth noting that over time, these differences in water holding capacity between samples might become smaller and eventually even out during the storage period [33].

In summary, the water holding capacity of the batter initially increased, primarily due to water absorption by proteins and starches. However, this increase was not sustained, and there was a sudden decline, possibly due to factors such as the breakdown of swelled starch granules. Additionally, variations in storage conditions could contribute to fluctuations in water holding capacity, which may eventually stabilize over time [31, 32].

As per the microbial analysis of batter shown in the and figure 03, the initial count of *Escherichia coli* (*E. coli*) colonies was ten in the first week, but by the second week, *E. coli* colonies were not detected. This decline in *E. coli* count over time is likely due to the fact that the batter was an uncooked product, and the refrigeration may have played a role in inactivating the *E. coli* present in the batter [34]. However, the observed *E.coli* value were lower than the USDA recommended value of <20 cfu/gram. Refrigeration is known to slow down or inhibit the growth of many types of bacteria.



	1 week	2 week	3 week	4 week	5 week	6 week
E. coli	10	0	0	0	0	0
staphylococcus a.	200	100	100	100	0	0
TCC	688	1274	900	1206	1000	890

Storage period (weeks)

Fig. 3. Microbial population distribution over a six week of time

Similarly, the count of *Staphylococcus aureus* in the sample gradually decreased, and by the final two weeks, no *Staphylococcus* colonies were detected and it shows lower than the USDA recommended level of 10^3 colony-forming units per gram (cfu/g) of food. This low *Staphylococcus* count could be attributed to the meticulous preparation of the sample under aseptic conditions and the maintenance of hygienic practices during preparation [35, 36]. Controversy, the recommended E.coli in food Additionally, the sterilization of utensils used in preparation and storage may have contributed to the reduction in *Staphylococcus* count.

The total bacterial colony count (TCC) showed an uneven distribution up to the fourth week, but during the last two weeks, there was a reduction in TCC. Again, refrigeration may have played a role in inhibiting bacterial activity. It's worth noting that the batter was prepared without the use of any preservatives, which could have contributed to the presence of a significant bacterial count in the batter.

Additionally, since the batter was not a cooked product, this lack of heat treatment may have also contributed to the proliferation of bacteria in the early weeks of testing [37].

In summary, the decline in bacterial counts, including *E. coli, Staphylococcus aureus*, and total bacterial colony count, over time in the batter sample can be attributed to the refrigeration, aseptic preparation, hygienic practices, and sterilization of utensils. The absence of preservatives and the uncooked nature of the batter may have initially allowed bacterial growth, but refrigeration eventually inhibited their activity.

5. Conclusions

It can be concluded that valuable insights into the selection of flour types for deep-fried food products, emphasizing the impact on sensory attributes, particularly crispiness, while highlighting the batter's compositional data, pH changes, water holding capacity, and bacterial dynamics. The study underscores the significance of choosing the right flour to achieve desired sensory qualities and informs product development strategies to meet consumer preferences. Furthermore, the compositional analysis of the batter and deep-fried chicken provides a comprehensive view of their nutritional aspects, essential for understanding these components in deep-fried chicken dishes. Additionally, the pH and water holding capacity findings shed light on the chemical dynamics of the batter, while the decline in bacterial counts over time underscores the importance of refrigeration, hygiene practices, and sterilization in maintaining food safety in uncooked batter.

Conflicts of Interest

No conflict of interest to declare

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