RESEARCH ARTICLE

READY-TO-SERVE SANDWICH SPREAD MADE FROM POTATO (*Solanum tuberosum*): PRODUCT DEVELOPMENT AND SHELF-LIFE EVALUATION

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ABSTRACT

The busy lifestyle has increased consumer demand for convenient, healthy, ready-to-eat food products. Therefore, this study was conducted to develop a ready-to-serve sandwich spread by using potato, gelatin, and corn flour as the main ingredients for the spread's base. Thirty untrained panelists were asked to rate the sensory attributes on a 5-point hedonic scale. Sensory evaluation data were analyzed using the Friedman test at 0.05 significance level. The treatments showed a significant difference ($P < 0.05$) in sensory properties. The shelf-life evaluation was carried out for three treatments: potassium sorbate added spread, sodium benzoate added spread, and spread with no preservatives to evaluate the effect of preservatives. pH and color; (lightness, redness, and yellowness) changed significantly ($P<0.05$) with storage time. Also, the pH and lightness of the three treatments were significantly different ($P<0.05$). The redness and yellowness of the three treatments were not significantly different ($P>0.05$). In brief potato spread with preservatives could be stored for up to one week under refrigerated conditions without any microbial growth and without quality deterioration.

Keywords: *Potato, Ready-to-eat food, Sandwich spread, Sensory attributes, Shelf-life*

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1. INTRODUCTION

Sandwich spread is a convenience product that can be used directly to eat with bread. Also, a sandwich is a food that can be eaten at any time of the day. Meat-based fillings were highly popular among consumers in 1996 [1]. About half of the US adult population

consumed one or more sandwiches per day. Therefore, sandwich consumption can have amajor effect on people's diet quality and calorie intake. Nowadays, sandwich consumers show a marked interest in consuming vegetable-based spreads to improve the overall diet quality and to reduce daily total calorie intake [2].

Changes in the socioeconomic environment and technological advancements in agriculture and marketing have changed food consumption patterns. People are more concerned with health and nutrition issues. Consumers have shifted away from animal-based products and have turned toward vegetable-based products [5]. There is a high demand for ready-to-eat convenience products, due to the busy lifestyles and employment of married women [7]. A ready-to-eat product consists of prepared food within a container. In these products, the ingredients have already been transformed into food. It could be consumed directly after purchase or need little preparation or heating before consumption. A lack of time for cooking and the cost-effectiveness of such products have caused for the increase in popularity of ready-to-eat products [6].

Potato can be used as the main ingredient in formulating a sandwich spread. The most common species is the white potato, *Solanum tuberosum*. It is considered one of the most important crops in the world, and it is ranked fourth in the world's annual crop production. Potato is considered as a diet with high digestibility. Potatoes have high energy potential [4]. Potato tubers are rich in nutrients, calories, and biologically active phytochemicals. The main nutrient is the stored polysaccharide starch. Except for the starch content, potato tubers contain minerals, protein, carbohydrates, vitamins, and bioactive compounds. Biologically active phytochemicals in potatoes are polyphenols, tocopherol, β-carotene, ascorbic acid, α-lipoic acid, dietary fiber, and selenium. Also, it is considered an inexpensive source of good-quality protein and energy. Advantageously, potatoes have low fat content [9].

A variety of microorganisms cause food spoilage and lead to foodborne diseases; and different kinds of preservatives can be used to prevent or delay food deterioration and to enhance food safety. Potassium sorbate and sodium benzoate are widely used as antimicrobial preservatives in the food industry. In fact, sodium benzoate and potassium sorbate are used against yeast, moulds, and many bacteria [3, 8]. This research aims to develop a sandwich spread using potato as the main ingredient and evaluate the effectiveness of potassium sorbate and sodium benzoate on the shelf life of the developed sandwich spread. The potato sandwich spread was optimized by using different ingredients through sensory analysis. Chemical preservatives added sandwich spread samples were analyzed for total plate count and yeast and mould count for a period of two weeks. The findings of this study will contribute to the effective formulation of a sandwich spread that may be commercialized.

2. MATERIAL AND METHODS

2.1 Materials

Potato, corn flour, gelatin, mustard, salt, pepper, turmeric, sugar, butter, flour, fresh milk, garlic, chilli flakes, coconut oil, eggs, lime juice, vinegar, curry leaves, potassium sorbate, and sodium benzoate were purchased from a local retail shop. Curry leaves were dried at 50 – 60 °C for 4 – 5 h in a commercial dehydrator before use.

2.2 Preparation of sandwich spread

Boiled potato was made into a paste by blending. Dissolved gelatin, dissolved corn flour, spice mixture, white sauce, garlic-curry leaves paste were added to the potato paste. Then, the mixture was cooked at 60 ^{0}C for 10 min. Potato spread was filled into sterilized glass bottles, cooled to room temperature and stored in a refrigerator.

2.2.1 Experiment 1: Selecting the best potato pulp, gelatin and corn flour combination

Three different potato pastes were prepared by varying the gelatin and corn flour amounts. The potato amount (60 g) was constant in all three treatments. The three levels of gelatin were 2.5 g (T1), 3 g (T2) and 3.5 g (T3). The three levels of corn flour were 4.5 g (T1), 4 g (T2) and 3.5 g (T3). A sensory analysis was conducted to select the best spread.

2.2.2 Experiment 2: Selecting the best combination of spices

Three different spice mixtures were made by using mustard, salt, pepper, turmeric and sugar. Spice mixtures were added to the selected potato paste from Experiment 1 (Table 1). A sensory analysis was conducted to select the best spread.

Table 1. Combinations of spices used in Experiment 2

Ingredients	**T1 (g)**	**T2 (g)**	**T3 (g)**
Mustard	0.15	0.35	0.15
Salt	1.1	1.1	1.1
Pepper	0.45	0.4	0.4
Turmeric	0.1	0.2	0.3
Sugar	0.5	0.5	0.5

2.2.3 Experiment 3: Selecting the best white sauce amount

Three different white sauce amounts were added to the selected potato spread from Experiment 2. The three levels of white sauce were 36 g (T1), 48 g (T2) and 60 g (T3). A sensory analysis was conducted to select the best white sauce added spread from Experiment 3.

2.2.4 Experiment 4: Selecting the best garlic and curry leaf paste amount

Three different amounts of garlic and curry leaves paste were added to the selected potato spread from Experiment 3. The three levels of the garlic and curry leaf paste were 1 g (T1), 3 g (T2) and 5 g (T3). A sensory analysis was conducted to select the best spread from Experiment 4.

2.2.5 Experiment 5: Selecting the best mayonnaise amount

Three different amounts of mayonnaise were added to the selected spread from Experiment 4 instead of white sauce. The three levels of mayonnaise were 10 g (T1), 15 g (T2) and 20 g (T3). A sensory analysis was carried out to select the best spread.

2.3 Sensory Evaluation

Sensory evaluations were conducted to select the best spreads from Experiment 1 – 5 using 30 untrained panelists. The panelists were asked to rate the sensory attributes such as texture, appearance, color, aroma, taste, flavor, density, mouthfeel, spreadability and overall acceptability. A 5-point hedonic scale was used from, 1 = "Dislike very much" to 5 = "Like very much". The final sensory evaluation was carried out using the best spreads from Experiments 2 – 5 and the control consisted of boiled potato pieces with added salt. The samples used in the sensory evaluation are given below (Table 2).

Table 2. Combinations used in sensory evaluation

Sample	Description (samples with best sensory properties)
S1	Sample with spices
S2	Sample with spices and white sauce
S3	Sample with spices, white sauce and garlic-curry leaves paste
S4	Sample with spices, white sauce, garlic-curry leaves paste and mayonnaise

2.4 Physicochemical Properties

The colour and pH of the selected potato spreads from Experiment 2-5 were measured. The samples were the control sample and the preservative added samples. The samples used are given in Table 3. pH was determined using a pH meter (BP3001 TRANS INSTRUMENTS) by mixing 1g of sample in 10 ml of water. Colour was determined using a colourimeter (PCE-CSM4 Colourimeter).

2.5 Shelf-Life Evaluation

Shelf-life evaluation was conducted using the control and two treatments prepared by adding preservatives. The control was the selected potato spread from the final sensory analysis without any preservatives. The other two treatments were the selected potato spread with potassium sorbate as the preservative and the selected potato spread with sodium benzoate as the preservative (Table 3). The control and treatments were stored under refrigerated conditions after the preparation. The pH, colour, and microbial count were measured at weekly intervals for two weeks. Potato Dextrose Agar (PDA) was used as the growth media for the yeast and mould count while Nutrient Agar (NA) was used as

the growth media for the bacterial colony count. The serial dilution method was used to dilute the product and 10^{-5} dilution was used to culture. Quebec Dark Field Colony Counter was used to count the colonies.

Table 3. Spreads used for shelf-life evaluation

Spread	Preservative (w/w)
A (control)	None
B	Potassium sorbate 0.1%
C	Sodium benzoate 0.1%

The formula used to calculate the Colony Forming Units (CFU) is given below.

$$\text{CFU / g} = \frac{\text{Number of colonies} \times \text{Dilution factor}}{\text{Volume of culture plate}}$$

2.6 Proximate Analysis

Proximate analysis was carried out for the selected best potato spread from the last sensory analysis. Moisture, ash, crude protein, and crude fat were determined according to Association of Analytical Chemists (AOAC) 2003 methods. The carbohydrate content and energy were derived from calculations.

2.7 Statistical Analysis

Data from the sensory evaluation were analysed using a non-parametric analysis (Friedman test) method by Origin Pro software. Quantitative data were analysed by analysis of variance (ANOVA) using MINITAB 16 statistical software.

3. RESULTS AND DISCUSSION

3.1 Experiment 1

A sensory evaluation was conducted to determine the most preferred combination of gelatin and corn flour. Sensory attributes of the three treatments were not significantly different from each other ($P>0.05$). T2 showed the highest mean rank for appearance, colour, density, texture, and overall acceptability. T3 showed the highest mean rank only

for aroma. Therefore, T2 consisting of 60 g potato paste, 3g of gelatin, and 4 g of corn flour was selected for Experiment 2.

3.2 Experiment 2

This experiment was done to determine the most preferred combination of spices. There was a significant difference ($P<0.05$) in appearance, colour, flavor, mouthfeel and overall acceptability of the three treatments. There was no significant difference ($P>0.05$) in aroma, density, and texture among the three treatments. T2 showed the highest mean rank for appearance, colour, flavour, mouthfeel, and overall acceptability. Therefore, T2 which consisted of 0.35 g mustard, 0.2 g turmeric, 0.4 g pepper, 1.1 g salt and 0.5 g sugar was selected for Experiment 3.

3.3 Experiment 3

A sensory evaluation was conducted to determine the most preferred white sauce amount. There was no significant difference ($P>0.05$) in appearance, aroma, colour, density, flavor, mouthfeel, taste, texture, and overall acceptability among the three treatments. Therefore, T2 which consisted of 48 g (middle value) of white sauce was selected for Experiment 4.

3.4 Experiment 4

A sensory evaluation was conducted to determine the most preferred amount of garlic and curry leaves paste. There were significant differences ($P<0.05$) among the sensory attributes of the three treatments. T1 showed the highest mean ranks for all sensory attributes. Therefore, T1 which consisted of 1 g garlic and curry leaves paste was selected for Experiment 5.

3.5 Experiment 5

This experiment was conducted to determine the most preferred amount of mayonnaise. Apart from appearance, aroma and colour, other sensory attributes of the three treatments showed significant differences ($P<0.05$). T3 showed the highest mean ranks for density, flavour, mouthfeel, taste, texture, and overall acceptability. Therefore, T3 which consisted of 20 g mayonnaise was selected for the final sensory analysis.

3.6 Final Sensory Analysis

The final sensory evaluation was conducted to determine the most preferred product. All sensory attributes of the five treatments were significantly different from each other ($P<0.05$). S3 showed the highest mean ranks for appearance, colour, density, flavor, mouthfeel, overall acceptability, purchasing intention, taste and texture. Therefore, S3 which consisted of spices, white sauce, garlic and curry leaf paste was selected as the best potato spread for further tests.

3.7 Physicochemical Parameters

The pH and colour of the selected potato spreads from Experiments 2 -5 are included in Table 4. pH of S2 and S4 showed a significant difference from other treatments. There was no significant difference in pH in S1 and S3, when compared to S2 and S4. Despite the differences, the pH varied within a small range of 5.1-5.5. Thus, this product is a low-acid product. The lightness of S1, S2, S3 and S4 showed a significant difference from each other. Lightness had increased with the addition of white sauce and mayonnaise to the potato spread than only spices added potato spread. The redness of S1, S3 and S4 was significantly different from each other. There was no significant difference in redness in S2, when compared to S1 and S3. As with the lightness, the redness has increased with the addition of white sauce and mayonnaise. The yellowness of samples S1-S4 was significantly different from each other. On the contrary, the yellowness has decreased with the addition of white sauce and mayonnaise. White sauce is more powerful than mayonnaise to increase the lightness and decrease the yellowness.

Table 4. Variation of physicochemical parameters of sandwich spreads

Treatment [#]	**pH**	**Colour coordinates**		
		L^* (lightness)	**a^* (redness)**	**b^* (yellowness)**
S1	$5.30^{ab}\pm0.20$	$30.33^{d}\pm1.06$	$-4.17^{c}\pm0.70$	$83.72^{a}\pm1.94$
S2	$5.09^{b}\pm0.05$	$62.76^{a}\pm2.56$	$-3.38^{bc}\pm1.10$	$46.94^{c}\pm3.85$
S3	$5.32^{ab}\pm0.03$	$54.93^{b}\pm3.18$	$-2.08^{b}\pm0.48$	$35.16^{d}\pm1.95$
S4	$5.47^{a}\pm0.02$	$48.53^{c}\pm1.13$	$6.95^{a}\pm0.57$	$66.57^{b}\pm2.74$

[#]S1- Spices, S2- Spices + white sauce, S3- Spices + white sauce + garlic and curry leaf paste, S4- Spices + mayonnaise + garlic paste and curry leaf paste

3.8 Shelf-Life Evaluation

The pH and colour variation of the three treatments selected for shelf-life evaluation is included in Table 5. There was a significant difference ($P<0.05$) in the pH of all three treatments with storage time. The pH reduced with time. Also, the colour of the treatments was significantly different. There was a significant difference ($P<0.05$) in the lightness of all treatments with time. The lightness of the spreads decreased after one week and again it increased. Also, the lightness of the three treatments was significantly different ($P<0.05$). There was a significant difference ($P<0.05$) in the redness of all treatments with time. Interestingly, there was no significant difference ($P>0.05$) in the redness among the treatments. Like the redness, there was a significant difference ($P<0.05$) in the yellowness of all treatments with time. However, the yellowness of the three treatments was not significantly different ($P>0.05$). In brief, the pH decreased with time. The lightness of the three treatments was different from each other, while the redness or yellowness of the three treatments was not different from each other. However, the colour of the three treatments changed with time.

Table 5. Variation of pH and colour of treatments stored under refrigerated temperature

Treatment [#]	**Time period (Week)**	**pH**	**L* (light)**	**a* (red)**	**b*(yellow)**
A	0	$6.40^{a} \pm 0.01$	$58.76^{a} \pm 1.57$	$-2.06^{a} \pm 0.40$	$37.13^{b} \pm 1.40$
	1	$6.38^{a} \pm 0.00$	$53.16^{b} \pm 2.60$	$-1.81^{a} \pm 0.42$	$43.25^{a} \pm 2.74$
	2	$6.20^{b} \pm 0.00$	$62.30^{a} \pm 0.73$	$-1.75^{a} \pm 0.60$	$38.59^{ab} \pm 0.94$
B	0	$6.41^{a} \pm 0.02$	$54.30^{a} \pm 2.20$	$-2.34^{a} \pm 0.91$	$38.22^{ab} \pm 2.13$
	1	$6.40^{ab} \pm 0.00$	$52.65^{a} \pm 2.59$	$-1.02^{a} \pm 0.51$	$42.47^{a} \pm 2.62$
	2	$6.38^{b} \pm 0.01$	$57.63^{a} \pm 1.30$	$-1.35^{a} \pm 0.74$	$35.59^{b} \pm 0.69$
C	0	$6.48^{a} \pm 0.01$	$60.73^{a} \pm 1.66$	$-2.00^{b} \pm 0.42$	$38.18^{a} \pm 2.64$
	1	$6.48^{a} \pm 0.01$	$55.73^{b} \pm 1.13$	$0.14^{a} \pm 0.06$	$43.19^{a} \pm 3.15$
	2	$6.40^{b} \pm 0.00$	$59.03^{a} \pm 0.49$	$-2.50^{b} \pm 0.20$	$40.02^{a} \pm 1.49$

[#]A- potato spread (control), B- potato spread + potassium sorbate, C- potato spread + sodium benzoate

Microbial test results are indicated in Table 6. B and C didn't show bacterial or yeast and mold growth within the first seven days. However, a bacterial and yeast and mold colony growth was observed in A within seven days. The shelf life of the potato spread was enhanced by the preservatives that added up to the recommended level. Therefore, the shelf-life of the potato spread could be nearly one week under refrigerated conditions. Further studies are required to enhance the shelf-life of the product by increasing the pasteurization time.

Table 6. Variation of microbial count with time

Time (Days after preparation)	**Treatment** [#]	**Bacterial colony count (CFU/g)**	**Yeast and mould count (CFU/g)**
0	A	Nil	Nil
	B	Nil	Nil
	C	Nil	Nil
7	A	0.1×10^5	0.2×10^5
	B	Nil	Nil
	C	Nil	Nil
14	A	Over grow	Over grow
	B	Over grow	Over grow
	C	Over grow	Over grow

[#]A- potato spread, B- potato spread with potassium sorbate, C- potato spread with sodium benzoate

3.9 Proximate Composition

Proximate analysis was conducted for the best potato spread from the final sensory analysis. The proximate composition of the best potato spread, which consisted of potato, corn flour, gelatin, spices, white sauce, garlic, and curry leaf paste is indicated in Table 7. These results show that the fat content of the formulated potato spread was much lower than fat-based spreads and that the carbohydrate content was much lower than the sugar-

based spreads available in the market. Thus, the formulated potato spread can be identified as a healthy spread.

Table 7. Proximate composition of the best potato-based spread

Constituent	**Percentage**
Moisture	83.2%
Ash	1.0%
Fat	0.1%
Protein	0.7%
Carbohydrate	15.0%
Energy	64 kCal/100g

4. CONCLUSIONS

The potato spread made with spices, white sauce, garlic, and curry leaf paste showed the highest preference for all sensory attributes. This product with preservatives could be stored for one week in the refrigerator without any microbial growth. Also, this product with low fat content can be identified as a healthy spread.

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