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Development, Nutritional Evaluation and Sensory Acceptability of an Oat-Based Fruit Pancake

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Abstract: ***This study's aim was to create a pancake mix that is ready-to-cook, contains whole grains, fruits and vegetables, and has an enhanced level of nutrition while maintaining sensory appeal. Oats, bananas, papayas, carrots, black carrots, beets and dried dates were combined with milk powder to create the pancake mix, and then tested for proximate, functional, antioxidant and organoleptic characteristics. The pancake mix had high nutritional value, minimal water activity (long shelf-life) and significant antioxidant activity. Sensory tests confirmed that the product was highly rated by consumers, indicating the potential viability of functional pancake mixes.***

Keywords: functional food, pancake mix, nutritional enrichment, antioxidant activity, sensory evaluation, proximate analysis

1. Introduction

Convenience foods have become increasingly prevalent in modern dietary patterns due to time constraints and evolving lifestyles, but many of these products have relatively low nutrient density. This has stimulated the development of functional foods that provide additional nutritional and health benefits while remaining convenient and sensory-acceptable, including bakery items and mixes enriched with fruits, vegetables, and whole grains [1] [2]. Thus, the development of improved pancake mixes could provide a convenient health-oriented product [3].

The use of pancakes is common and accepted as breakfast food; however, their nutritional composition can be enhanced by incorporating whole grains, fruits, and vegetables. Oats are a functional cereal rich in β-glucan and other bioactives that can help improve lipid profiles and reduce cardiovascular risk, making them suitable for heart-healthy formulations [4] [5]. Fruits such as banana, papaya, and dates contribute natural sugars, fibre, vitamins, and diverse phytochemicals, while vegetables like carrot and beetroot add carotenoids, betalains, and other antioxidants; similar fruit–vegetable enrichments have successfully improved the nutritional and antioxidant properties of baked products and snack-type foods [1] [2]. Milk powder can increase protein and calcium content and has been widely used to enhance the nutritional and sensory quality of functional snack bars and cereal products [6]. Spices such as cinnamon are valued both for flavour and for their content of bioactive compounds with antioxidant potential, complementing the health-oriented profile of such foods [5].

The aim of the present study was to develop a nutritionally improved pancake mix and to evaluate its nutritional, functional, and organoleptic properties so that it can serve as an easy-to-prepare functional food product [3] [4].

2. Materials

The process involved many trial-and-error procedures before coming up with the perfect formula for the pancake mixture, which provided optimal taste, nutritional value, and texture. Oat flour was chosen as the base because it gave structure and fiber, whereas powders of fruits and vegetables like bananas, papayas, carrots, black carrots, beetroots, and dried dates were chosen to add some extra sweetness, color, and nutrition. Finally, milk powder was used to increase protein content. The role of salt and ground cinnamon was that of flavor balance enhancers, while the inclusion of baking soda and baking powder was meant to provide leavening action for the required fluffiness. The well-optimized blend of these ingredients ensured that the pancake mix contained high nutritional value.

Table 1: Ingredients and Quantity Used for Pancake Formulation

S. No.	Ingredient	Quantity (g)
1	Oats (powdered)	45.0
2	Carrot powder	10.0
3	Banana powder	20.0
4	Papaya powder	20.0
5	Black carrot powder	5.0
6	Beetroot powder	5.0
7	Dry dates powder	5.0
8	Milk powder	12.5
9	Salt	0.4
10	Baking powder	1.0
11	Baking soda	0.5
12	Cinnamon powder	0.036

3. Methodology

The pancake mix was prepared by blending pre-processed and powdered ingredients in standardized proportions to obtain a homogeneous and stable dry formulation with desirable nutritional and sensory qualities.

3.1 Preparation of Pancake Mix

This formulation involved the selection of ingredients taking into account the nutritional and functional benefits offered by each ingredient used. Oats were selected as the main ingredient owing to its high content of fibre and structural

integrity, while banana, papaya, carrot, black carrot, beetroot, and dry dates provided vitamins, minerals, antioxidants, and colour and flavour. The milk powder added additional protein content and improved mouthfeel, while the salt and cinnamon helped improve flavour and mask the vegetal taste.

Fruits and vegetables were sourced from local markets for the sake of quality, whereas dry components were ordered from dependable sources. The fresh raw materials were then cleaned, peeled, and cut into small pieces before being dehydrated at 55-60ºC in a hot-air oven to reach a constant weight. These materials were allowed to cool down to room temperature and pulverized to make powders, except oats which were subjected to slight roasting before milling. All the powdered components were passed through a 60-mesh sieve. Based on preliminary trials, the ingredients were blended in predetermined proportions (Table 1) to obtain the final pancake mix.

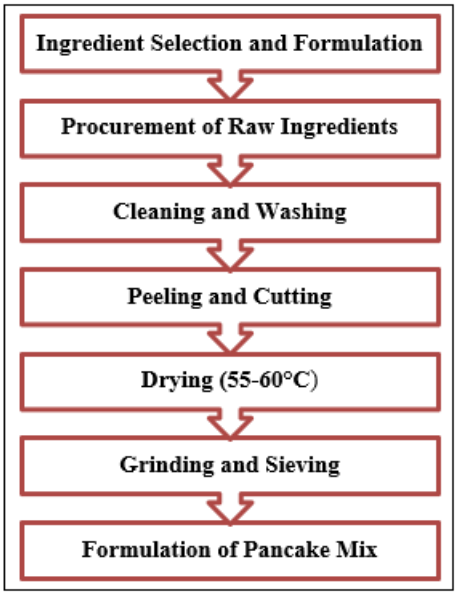

Figure 1: Process Flow Diagram

Figure 2: Developed pancake mix (powder form)

3.2 Analytical Methods

The developed pancake mix was analysed for proximate composition, functional properties, antioxidant activity, and bioactive compounds using standard analytical procedures. Moisture content of the sample was evaluated by drying it in a hot air oven maintained at 105°C until a constant mass was obtained, while ash content was measured by subjecting the dried sample to high-temperature incineration in a muffle furnace at 550°C until only inorganic residue remained [7]. Lipid content of the sample was quantified using Soxhlet extraction with petroleum ether as the extraction solvent. The total energy value was calculated using Atwater general conversion factors [8].

Functional properties were evaluated through sensory and physicochemical analyses. Sensory evaluation was conducted using a 9-point hedonic scale to assess appearance, colour, aroma, texture, taste, and overall acceptability [9]. The acidity level of the formulation was assessed using a calibrated digital pH meter after preparing a uniform slurry. Colour characteristics were determined using a colorimeter based on the CIE L*a*b* system. Water activity (aw) was measured using a water activity meter under equilibrium conditions to evaluate shelf-life stability [7],[10].

Antioxidant activity was assessed using DPPH radical scavenging and ferric reducing antioxidant power (FRAP) assays. The DPPH method measured the decrease in absorbance at 517 nm [11], while the FRAP assay evaluated the reduction of Fe^{3+} to Fe^{2+} at 593 nm [12]. Vitamin C content was determined using the 2,6-dichlorophenol indophenol (DCPIP) titrimetric method [7].

Total phenolic content (TPC) was determined using the Folin–Ciocalteu method with absorbance measured at 765 nm and expressed as gallic acid equivalents [13]. Total flavonoid content (TFC) was estimated using the aluminium chloride colorimetric method with absorbance recorded at 415 nm and expressed as quercetin equivalents [14].

3.3 Statistical Analysis

All analyses were performed in triplicate, and the results are expressed as mean ± standard deviation.

4. Results and Discussion

4.1 Proximate Analysis

The proximate analysis of the prepared pancake mix gives an indication of the quality of the mix and its shelf-life stability. The water content of the prepared mix was noted to be 11.66%, which is within the permissible limits for dehydration foods. Water contents lower than 12% have been known to give better shelf-life stability by limiting microbial growth and enzyme action.

It was observed that the content of ash is 2.43 ± 0.17%, which indicates that total mineral matter was present in the mixture. This could have been due to the addition of carrot, beetroot, and dried dates to the formula.

The percentage content of crude fat in the mixture was 4.00 ± 0.33%, which is relatively low compared to conventional formulations. Low fat content is beneficial in reducing lipid oxidation and improving shelf stability, while still contributing essential fatty acids from natural ingredients.

The calculated energy value of 363.64 kcal/100 g aligns with values reported for cereal-based convenience foods and this indicates that the product can serve as an energy-dense breakfast option.

Table 2: Proximate Composition

Parameter	Value
Moisture (%)	11.66
Ash (%)	2.43 ± 0.17
Fat (%)	4.00 ± 0.33
Energy (kcal/100g)	363.64

Overall, the proximate composition suggests that the developed pancake mix is nutritionally balanced and suitable for extended storage.

4.2 Functional Analysis

Table 3: Functional Properties

Parameter	Value
pH	6.29
Water Activity (aw)	0.3882
L*	9.36 ± 1.55
a*	2.51 ± 3.06
b*	5.56 ± 3.61

The color parameters of the pancake mix, expressed in CIE L*a*b*, demonstrated dark coloration (L* = 9.36 ± 1.55) because of the occurrence of natural coloring substances contained in beetroot and black carrot. pH value was found equal to 6.29, meaning neutral medium. It is a good parameter ensuring the stability of a particular product and proper functioning of leavening agents. Water activity (aw) value was measured to be 0.3882; it was significantly less than the threshold value for microbial activity, i.e., <0.6. Therefore, foods having aw <0.6 are regarded microbiologically stable [10]. This confirms the effectiveness of the drying process.

4.3 Sensory Analysis

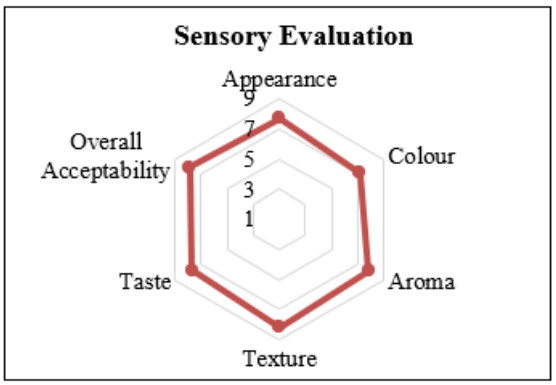

Figure 3: Sensory Evaluation

Sensory evaluation revealed good acceptability of the pancake mix, with scores ranging from 7.14 to 8.14 on a 9-point hedonic scale. The overall acceptability score of 7.86 indicates that the product was well received by panellists.

Texture obtained the highest score (8.14), suggesting that the formulation provided desirable softness and structure, which is influenced by baking properties and ingredient interactions. This may be attributed to the combined effect of oats and leavening agents. Aroma (7.86) and taste (7.71) were also positively rated, likely due to natural sweetness from fruits and flavour enhancement by cinnamon. Colour received the lowest score (7.14), which may be due to the darker appearance of the product. However, according to sensory evaluation standards, scores above 7 indicate good acceptability [9]. Overall, the results demonstrate that nutritional enhancement did not adversely affect sensory quality.

4.4 Antioxidant Analysis

Table 4: Antioxidant Activity

Antioxidant Assay	Observation
DPPH scavenging activity (%) at 100 µL	85.78
DPPH scavenging activity (%) at 200 µL	71.84
DPPH scavenging activity (%) at 300 µL	75.93
DPPH scavenging activity (%) at 400 µL	80.54
DPPH scavenging activity (%) at 500 µL	87.71
FRAP value (µmol Fe^{2+}/g)	1207.51 ± 146.79

The FRAP values ranged from 1084.88 to 1371 µmol Fe^{2+}/g, with a mean value of 1207.51 ± 146.79 µmol Fe^{2+}/g, indicating considerable ferric reducing capacity and antioxidant potential. The FRAP assay measures the electron-donating capacity of antioxidants and is commonly used for evaluating reducing power in foods [12].

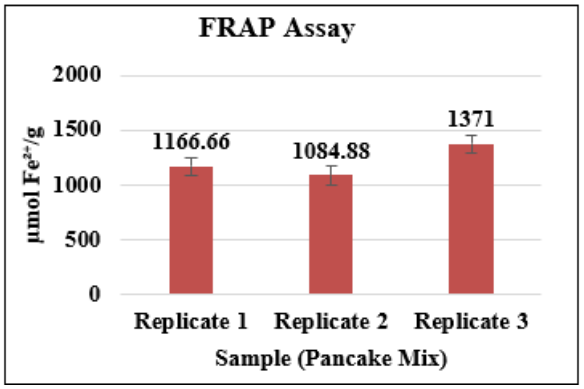

Figure 4: Ferric reducing antioxidant power (FRAP) of pancake mix

The DPPH radical scavenging activity of the developed pancake mix was evaluated at concentrations ranging from 100 to 500 µL. The scavenging activity varied from 71.84% to 87.71%, indicating significant free radical inhibition and concentration-dependent antioxidant activity. The highest scavenging activity was observed at 500 µL concentration (87.71%), while the lowest activity was recorded at 200 µL (71.84%). The antioxidant potential may be attributed to the presence of phenolic compounds, flavonoids, and natural pigments derived from the incorporated fruits and vegetables. The DPPH assay is a widely accepted method for measuring free radical scavenging activity in plant-based foods [11].

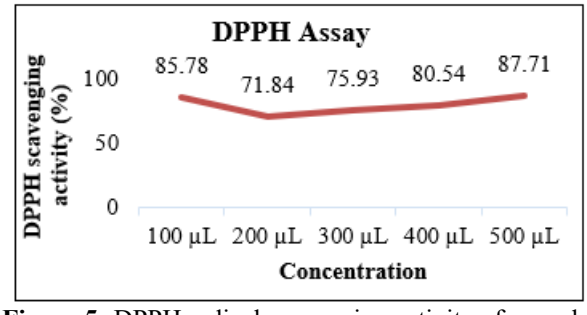

Figure 5: DPPH radical scavenging activity of pancake mix at different concentrations

These results indicate that the pancake mix possesses significant antioxidant potential, likely due to the presence of phenolic compounds and natural pigments from fruits and vegetables.

4.5 Vitamin C Analysis

The vitamin C content of the developed pancake mix was found to be 27.0 ± 12.0 mg/100, indicating a moderate level of ascorbic acid in the formulation. Vitamin C is recognized because of its ability to act as an antioxidant and its role in boosting immunity.

4.6 Bioactive Compounds

Table 5: Bioactive Compounds

Parameter	Value
Vitamin C (mg/100g)	27.0 ± 12.0
Total Phenolic Content (mg GAE/100 g)	38.68 ± 2.49
Total Flavonoid Content (mg QE/100 g)	54.65 ± 2.20

The total phenolic content was recorded as 38.68 ± 2.49 mg GAE/100 g. Whereas, the total flavonoid content was found to be 54.65 ± 2.20 mg QE/100 g, indicating the presence of flavonoid compounds that contribute to antioxidant activity and health benefits. The combination of phenolic and flavonoid contents proves that bioactive components have been successfully incorporated via fruits and vegetables.

5. Conclusion

In conclusion, a nutrient-rich pancake flour mix has been created by using oats, fruit and vegetables as ingredients. The results of this analysis indicate that this formulation has an acceptable nutritional profile, sufficient calories, and low moisture content and water activity, which typically mean long shelf lives of ready-to-cook products. The pancake flour's physicochemical properties are also within acceptable ranges, with constant water activity and an approximate pH of seven for high-quality products. The pancake flour mixture has functional food properties because it was found to contain additional nutrients such as vitamin C, phenolic, and flavonoid compounds, as well as having antioxidant activities. The texture, taste, and odour of the product were assessed by the sensory study, which showed no reduction in any of these attributes as a result of the addition of nutrient-rich ingredients to create the product.

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