European Journal of Nutrition & Food Safety

Volume 16, Issue 7, Page 179-194, 2024; Article no.EJNFS.117269
ISSN: 2347-5641

Innovations in Breakfast Cereal Incorporating Fruits and Vegetables: Enhancing Nutritional Profile and Sensory Characteristics: A Review

Pawan Shrestha [a], Naphishisha Jyrva [a], Ahmed Irfan [a], Gursharan Kaur [a] and Sourabh Kumar [a++*]

[a] Department of Food Technology and Nutrition, School of Agriculture, Lovely Professional University, Punjab, India.

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: https://doi.org/10.9734/ejnfs/2024/v16i71466

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/117269

Review Article

Received: 09/04/2024
Accepted: 16/06/2024
Published: 17/06/2024

ABSTRACT

Consuming breakfast is essential as it provides energy for the upcoming day and facilitates the intake of vital nutrients. Studies indicate that individuals who have breakfast typically maintain healthier dietary patterns. Breakfast cereal consumption is related to diets high in vitamins and minerals and low in fat. Still, it is not associated with increased intakes of total energy or sodium or the risk of dental caries. Dietary guidelines emphasize the significance of breakfast cereals, particularly those rich in whole grains or cereal fiber, due to their high nutrient density, making them a valuable source of essential nutrients. Although many studies are cross-sectional, with few intervention trials, breakfast cereal consumption could indicate a holistic, healthy lifestyle. This

[++] *Assistant Professor;*
**Corresponding author: Email: sourabhkumarkec@gmail.com;*

Cite as: *Shrestha, Pawan, Naphishisha Jyrva, Ahmed Irfan, Gursharan Kaur, and Sourabh Kumar. 2024. "Innovations in Breakfast Cereal Incorporating Fruits and Vegetables: Enhancing Nutritional Profile and Sensory Characteristics: A Review". European Journal of Nutrition & Food Safety 16 (7):179-94. https://doi.org/10.9734/ejnfs/2024/v16i71466.*

paper aims to offer a concise overview of various breakfast cereals infused with fruits and vegetables, highlighting their nutritional value, texture, shelf life, and sensory attributes. It demonstrates the potential of incorporating fruits and vegetables to develop nutrient-rich breakfast cereals.

Keywords: Breakfast; balanced diet; fiber; protein; nutrition; fruits; vegetables.

1. INTRODUCTION

Breakfast is the first meal you eat in the morning, typically within a few hours of waking up. It's called "breakfast" because it breaks the overnight fasting period. Eating breakfast is crucial because it gives you energy for the day ahead and helps you get essential nutrients. This is especially important for kids, who might need more energy and nutrients if they skip breakfast. A study of 10-year-old kids in the US found that those who consumed breakfast had a higher consumption of vitamins and minerals than those who didn't. Some studies even suggest that eating breakfast can improve school performance and attendance in children. Having breakfast can also help maintain a healthy weight. It might help curb cravings for unhealthy snacks later in the day. Research advises that regular breakfast cereal, like cornflakes, is linked to a decreased BMI (Body mass index) and a reduced risk of obesity [1]. Skipping breakfast, on the other hand, has been linked to an increased risk of heart disease and poor cognitive performance in men [2]. There are two main types: cooked cereals and Ready-To-Eat (RTE) cold cereals like cornflakes in the breakfast market cereal. RTE cereals dominate the market, making up over 86% of sales in 2016 (Technavio).

Ready-to-eat (RTE) cereals used to be super popular and innovative, loved by many, things have changed. Their popularity and sales have decreased, while other breakfast options have become more popular. People want breakfast foods that are easy to grab and healthier, like fresh foods with lots of fiber or protein and no artificial colors or flavors. In the United States, most RTE cereals still have too much sugar and carbohydrates and not enough fiber. In the past, smart people came up with ways to make cereals from grains, but not all made them tastier or healthier. We must think differently about breakfast cereals and how they fit into healthy diets. We should look at grains differently, considering how they affect digestion, and be open to using new ingredients to make better cereals. RTE cereals' future is about making them tastier, with better texture, and more nutritious. Skipping breakfast can seriously affect your health, so having tasty and healthy options is important.

1.1 Incorporation of Fruits and Vegetables in Breakfast Cereals

Diets high in vegetables and fruits are broadly recommended for their health properties. These foods have long been valued for their rich vitamin content, particularly vitamins C and A, and essential minerals like electrolytes. More recently, they've gained attention for their abundance of phytochemicals, which act as antioxidants and promote health. In addition to vitamins, minerals, and phytochemicals, vegetables and fruits are good dietary fiber sources. This fiber is essential for maintaining digestive health and can help prevent various diseases. Including plenty of fruits and vegetables in your diet is a great way to support your overall health and well-being. They provide many essential nutrients and protective compounds, contributing to a balanced, nutritious diet.

Fruits and vegetables contain essential micronutrients (vitamins and minerals), fiber, and various phytochemicals. These compounds offer a range of health benefits, acting as antioxidants, anticarcinogens, and immunomodulators. Some phytochemicals are even known as chemo-preventive agents because they can help prevent or slow down cancer development. To build up the functional and nutritional qualities of breakfast cereal commodities globally, boosting their dietary fiber content and enriching them with micronutrients and bioactive compounds is essential. The by-products of vegetables and fruits originated during manufacturing operations offer a promising solution. Despite environmental concerns related to their disposal, Fruits and Vegetables By-products (FVB) are rich in nutrients and phytochemicals, making them valuable for incorporation into BCP. Transforming FVB into flours or powders creates high-value ingredients that are good sources of fiber and bioactive compounds (phenolic compounds and

carotenoids). Extrusion processing, a cost-effective technique commonly used to produce BCP, can easily incorporate these FVB powders. This approach enhances BCP's dietary and functional aspects while minimizing waste and maximizing health benefits. In summary, utilizing by-products of foods in breakfast cereal production presents an innovative way to increase the nutritional value of these foods and promote overall health [3].

Table 1. Various breakfast cereals prepared with incorporation of fruits/vegetables flours

Fruits and Vegetables	Form of Addition	Quantity	Breakfast Cereals	References
African yam bean, Rice, and orange flesh sweet potato flour	flours	In the ratio of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. (African yam bean blend: Orange flesh sweet potato)	Ready-to-eat Breakfast cereals. • Increase in pro-vitamin A content. • The sample with (90% blend + 10% orange flesh sweet potato flour) were highly accepted.	Okoronkwo et al., [5]
Amaranth	Whole-amaranth flour	10 % to 20 %–30 % to 40 %	Protein (g/100 g) • Wheat bread: 14.29g • Enriched bread: 14.66–16.30g • Microelements (µg/g): • Wheat bread: 39.14 • Enriched bread: 50.98–92.27	Miranda et al., [6]
Pineapple	Whole fruit flour	Extrusion variable as 10.5% and 21%	Increase in FVB flour content result in decrease of EI and WSI with an increment in BD.	Selani et al., [7]
Strawberry	Fruit Pulp	--	Protein content in corn-based breakfast cereals was found to be 4.1/100g, fat 0.5g/100g, Dietary fibre 7.1g/100g	Bhavya and Prakash [4]
Banana	Fruit Pulp	--	Protein content in corn-banana breakfast cereals was 4.4g/100g, fat 2.1g/100g, Dietary fibre 6.8g/100g.	Bhavya and Prakash [4]
Mango	Fruit Pulp	--	Protein content in corn-mango breakfast cereals was 4.7g/100g, fat 0.5g/100g, Dietary fibre 7.8g/100g.	Bhavya and Prakash [4]
Blueberry	Dehydrated fruit powder (1%)	Extruded white cornmeal cereals (temperature <130℃)	The phenolic and Anthocyanins was found to be 138.5g and 0.46g per 100 mg.	Camire et al., (2006)
	Dehydrated	Extruded white cornmeal cereals	The phenolic and Anthocyanins was found	Camire et al.,

Fruits and Vegetables	Form of Addition	Quantity	Breakfast Cereals	References
Concord Grape	fruit powder (1%)	(temperature <130℃)	to be 118.4g and 0.21g per 100 mg.	(2006)
Cranberry	Dehydrated fruit powder (1%)	Extruded white cornmeal cereals. (temperature <130℃)	The phenolic and Anthocyanins was found to be 132.6g and 0.36g per 100 mg.	Camire et al., (2006)
Red raspberry	Dehydrated fruit powder (1%)	Extruded white cornmeal cereals (temperature <130℃)	The phenolic and Anthocyanins was found to be 124.2g and 0.29g per 100 mg.	Camire et al., (2006)
Micronized roasted coffee from green coffee fruits	Roasted coffee produced in an Extruder (Single Screw)	2,5and 9%	The cereal produced with MRC (5%) got better acceptability by consumer.	Sampaio et al., [8]
Jackfruit Flour	Powder	5-15%	Cake • ↑ in protein. • Decrease in Fat. • Reduction of calories in cake	Arpit and John [9]
African yam bean and tiger nut residue	Flours	20%	Cookies • Crude protein: 11.20-15.08% • Crude fibre: 3.85-7.65% • Cookies with 15% African yam bean and 15% tiger nut residue were well accepted.	George et al., [10]
Pomelo Fruit	Dry pomelo segments	5%-20%	Bread enriched with 20% fresh and 5% dry pomelo segments showed better sensory acceptability. Bioactive components were preserved to greater extent.	Reshmi et al., [11]
Soybean Cake, Finger millet, and Carrot pomace	Pomace	(60:25;15) %	A significant increase in protein content (19.2g/100g). Perform better among experimental diets and comparable to casein.	Akinyemi et al., [12]
Chicken Egg white	Ovalbumin	3.34%	Protein content 15.12% low in fat (4.32%)	Randeniya et al., [13]
Banana	Peel and pulp	140g	Significant difference in taste, appearance, and aroma with no significant difference in mouthfeel and overall acceptability.	Tay et al., [14]

Fruits and Vegetables	Form of Addition	Quantity	Breakfast Cereals	References
Soyabean and Groundnut	flour	(10-15%) and (15-35%)	Protein content of breakfast cereals increased to 20.90 to 23.01%, fat (10.52 to 11.28%), crude fibre (2.98 to 3.90%), carbohydrate decreased (57.09-52.66) % and energy (406.64-403.79 kcal)	Ujong et al., [15]
Beetroot	Flour	10%	Protein 3.22-7.32%, fat 0.98-1.23%, fibre 3.32-4.55%	Ukeyima et al., [16]
Oyster Mushroom	Powder form composited with yellow maize and sesame seed	0-20%	Protein (16.14-22.54%), fat (16.04-12.83%), fibre (4,30-8.22). Acceptable to the panelist with 10% supplementation of mushroom.	Orngu et al., [17]
Carrot pomace	Blend with millet, soy cake, rice bran	5-10%	Protein content (22.37%), fat (22.05%), fibre (3.09%)	Akinyede et al., (2020)

However, incorporating fruit products into cereals can be tricky due to their high moisture and sugar content, which can strain extruder motors. Using spray-dried powders instead can make the process easier. It has been shown that incorporating fruit powders into extruded corn breakfast cereals can be challenging (Camire et al., 2006). The study by Bhavya and Prakash [4] found that the levels of anthocyanins from fruit powder were too low, resulting in lower levels of anthocyanins and phenolics in the final cereal products. Other studies have examined enriching corn-based ready-to-eat breakfast cereals with fruits like strawberries, bananas, and mangoes. These cereals showed good nutritional qualities, with protein and fiber contents ranging between 4.0-4.6g and 6.4-7.6g per 100g, respectively. They also contained significant levels of iron, vitamin C, and carotenes. However, the protein digestibility was low, while bioaccessible calcium and iron levels were immense due to low oxalate and phytic acid.

Additionally, breakfast cereals made of rice developed from green coffee fruits in the form of micronized roasted coffee (MRC) have been studied. These cereals showed increased caffeine, caffeic acid, and chlorogenic acid levels with higher MRC concentrations. They also had a darker color and higher fiber content, making them a potential source of bioactive compounds for breakfast cereals. Finally, incorporating pomelo fruit segments into breads increased their volume and decreased crumb firmness. Breads containing dry pomelo (5%) segments retained many bioactive components (phenolics, flavonoids, naringin, and carotenoids). Overall, these studies highlight the potential for using fruit-based ingredients to enhance breakfast cereals' nutritional attributes and sensory appeal.

2. QUALITY ASSESSMENT OF BREAKFAST CEREALS

2.1 Nutritional Content Analysis

Having breakfast is connected to better school performance and attendance among kids, as shown in certain studies [18]. Breakfast cereal contributed 10% of the total daily energy among breakfast cereal consumers, as well as 8% of protein, 4% of total fat, 14% of carbohydrates, and 7% of total sugars. For micronutrients, breakfast cereal contributed 8% of total daily sodium; between 7% and 10% of the minerals calcium, magnesium, and potassium; 35% of iron; and between 17% and 37% of the B Vitamins thiamin, riboflavin, niacin, and folate [19]. It can help to stay at a healthy weight by preventing you from snacking on unhealthy foods in the morning. Studies suggest that eating breakfast regularly can be related to having a low body mass index (BMI) and a low chance of obesity. However, other lifestyle factors might affect this connection [1].

Table 2. Sugar, salt and fat content of common breakfast cereals

Breakfast Cereals	Serving Size(g)	Sugar (g) Per 100g	Salt (g) Per 100g	Fat (g) Per 100g	Sugar (g) Per Serving	Salt (g) Per Serving	Fat (g) Per Serving
Corn-Flakes	30	8	1.75	0.9	2.5	0.5	0.3
Rice- Krispies	30	10	1.65	1	3	0.5	0.3
Coco Pops	30	34	1.15	3	10.2	0.35	0.9
Shreddies	45	15.5	0.8	1.9	7	0.4	0.8
Weetabix	37.5	4.4	0.65	2	1.7	0.24	0.8
Muesli (Swiss style)	45	23.1	0.38	5	10.4	0.17	2.3

Source: Manufacturers' labels (Kellogg's Nestle Weetabix)

Table 3. Vitamin-B, iron and fibre content of breakfast cereals

Breakfast Cereals	Serving Size in g	Vitamin B1 (mg)	Vitamin B2 (mg)	Vitamin B3 (mg)	Vitamin B6 (mg)	Vitamin B12 (µg)	Folic Acid (µ g)	Iron(mg)	Dietary Fibre(g)
Cornflakes	30	0.4	0.4	4.5	0.5	0.25	50	2.4	0.9
Muesli (Swiss style)	45	0.2	0.3	4	0.7	-	63	2.6	3.2
Coco Pops	30	0.4	0.4	4.5	0.5	0.25	50	2.4	0.6
Shreddies	45	0.4	0.4	4.5	0.5	0.3	50	3.5	4.4
Weetabix	37.5	0.4	0.5	5.7	0.1	0	64	4.5	3.8
Rice-Krispies	30	0.4	0.4	4.5	0.5	0.25	50	2.4	0.3
DRV (women 19-50 years)	-	0.8	1.1	13	1.2	1.5	200	14.8	18

Source: Producer's labels (Kellogg's Nestle Weetabix): Food Standards Agency (2002)
DRV (Dietary Reference Value)

In addition to their fat, sugar, and salt content, breakfast cereals are good sources of essential micronutrients like Vitamins B and iron, especially if they are enriched with other nutrients. However, not all cereals are fortified—options like porridge, muesli, and oat-based cereals usually aren't. Table 4 portrays the vitamin B, iron, and fiber content of several breakfast cereals, with most being fortified except for Swiss-style muesli. Keeping in mind that some cereals may also be fortified with other vitamins and minerals like vitamin D and calcium. Data from the NDNS (National Diet and Nutrition Survey) reveals fortified breakfast cereals play a significant role in providing essential micronutrients, especially for children. They're a key source of B vitamins, including folic acid, and iron. Research from the NDNS among young people aged 4–18 years found that those who consume higher amounts of breakfast cereals (around 30–40 grams per day) have 20%–60% higher intakes of iron, B vitamins, and vitamin D compared to those who consume less cereal. Consumption of High breakfast cereals tend to have improved levels of folate, riboflavin, and cobalamin [20].

Breakfast cereals is packed with a punch when it comes to nutrients, making them a valuable addition to your diet. Alongside providing essential vitamins B and iron, some cereals are fortified with vitamin D and Calcium, further boosting their nutritional value. Plus, when paired with milk, they offer a protein-rich meal and essential nutrients like vitamin A, vitamin B2, vitamin B12, zinc and calcium. This makes them particularly beneficial for certain groups, like girls and women of childbearing age who may need more iron, or older adults who often lack essential micronutrients. Moreover, many breakfast cereals contain fiber, especially whole grains, oats, nuts, or dried fruit. These cereals offer extra benefits, like lowering the chances of cardiovascular disease. So, looking for cereals with whole grains and added fruit is an excellent initiative to make the healthiest choice for your breakfast.

2.2 Sensory Analysis

Sensory evaluation can be defined as the scientific discipline that involves all the methods to measure, analyze, evoke, and interpret the human responses to the characteristics of food as well as products as perceived by the five human senses such as smell, hearing, sight, taste, and touch. Product quality characterizes consumer acceptance of a product; hence, it is essential to assess the sensory quality of recently formulated products to ensure they meet the consumers' expectations [21]. It is essential to check the quality of the product to make sure the people accept it, by testing how it smells, feels, tastes, and looks by experts first describing the product's characteristics then the regular people try it out. This testing is used in many industries to ensure that food and beauty products meet consumers' expectations. Sensory evaluation is all about understanding how humans experience things through their senses, like smell, sight, taste, hearing, and touch. Hence, it is essential to ensure that food is healthy and enjoyable.

2.2.1 Sensory analysis for breakfast cereals (corn flakes) with banana peel and pulp

The taste of the optimized flakes, which included banana pulp and peel, scored significantly higher (P<=0.05) compared to Kellogg's corn flakes. This is because the optimized flakes had a sweeter taste due to the natural sugar from the banana pulp. Sweetness is known to enhance the eating experience and trigger pleasure responses, leading to an improved sense of taste in food items [22]. However, the appearance of the optimized flakes received a substantially smaller (P<=0.05) score compared to Kellogg's corn flakes. This may be attributed to the dark yellow color of the optimized flakes, possibly by the Maillard reaction of sugar and enzymatic browning of PPO in bananas [23].

Interestingly, consumers generally have a negative association with dark yellow color, linking it to feces, vomit, or rotting food, which likely affected the perception of appearance [24]. Regarding mouthfeel, there was no considerable difference between the two samples, although slightly more people leaned towards Kellogg's corn flakes. Both samples had similar overall acceptability scores, but Kellogg's cornflakes had better overall acceptance than the optimized flakes.

2.2.2 Breakfast cereals incorporated with ovalbumin from chicken white egg

Breakfast cereals containing ovalbumin exhibit specific color characteristics, with low redness and high yellowness and lightness (a*-3.96±0.36, b*-35.20±0.56, and L*- 69.20±1.12). Colour values of the product were reported to change due to treatments that applied in production process [25]. According to Mandge et al. (2011), increasing the processing temperature reduces the values of L*, a*, and b*. This phenomenon occurs due to the Maillard browning reaction of sugar. A higher yellow value indicates a lower Maillard reaction, favorable for product gelatinization. The developed breakfast cereal containing ovalbumin has a higher L* value due to a lower Maillard browning reaction during processing. This lower reaction rate allows the gelatinized starch to be more rapidly digested after ingestion. Therefore, the cereal retains its lightness and yellowness, providing desirable texture and appearance while ensuring efficient starch digestion.

2.2.3 Breakfast meal in the form of flakes using yellow maize and coconut

This study aimed to enhance the value of yellow maize and coconut by creating a nutritious and convenient breakfast cereal in the form of flakes. Frimpong et al., [26] They experimented with five different formulations, varying the ratio of maize to coconut (80/20, 77.5/22.5, 75/25, 72.5/27.5, and 70/30). Using the Design-Expert's D-optimal design, they produced the cereal through a drum drying process and evaluated its acceptability with a consumer panel. The panelists gave the cereal high acceptability ratings, with the preference increasing as the coconut content increased. The formulation with a 70/30 maize-to-coconut ratio was the most favored. After processing, all five formulations showed a significant increase in protein, fat, ash, fiber, carbohydrate, and energy content. Additionally, the safety of the cereal was confirmed as the coliform and Bacillus cereus counts were found to be less than 10 cfu/g, indicating good microbial quality [26]. Yellow maize is not only rich in essential minerals, vitamins, and carotenoids (particularly beta carotene, a precursor to vitamin A), but it also possesses properties like gelatinization, pasting, and crystallization that are beneficial for producing breakfast cereals [27].

2.2.4 Incorporation of micronized-roasted coffee from unripe fruits in rice extruded breakfast cereals

The sensory assessment of breakfast cereals showed almost the same scores in all qualities, with great acceptability in the formulation (BC-5), meeting the acceptance criterion of scores above 6. No significant differences ($P > 0.05$) were observed in texture attributes or appearance, suggesting that adding MRC effectively preserved these qualities even at concentrations ranging from 2% to 9%. However, aroma scores ranging from 'neither like nor dislike' to 'like slightly' maybe possibly due to the loss in volatile compounds from coffee powder during extrusion, along with water vapor, as bubbles formed during an expansion [8]. Overall, the cereals received sensory outcomes greater than 5, representing consumer acceptance.

2.2.5 Breakfast cereals (yellow maize enriched with soyabean and groundnut flours)

In the study conducted by Ujong et al. [15] the sample (control) was favored for all sensory characteristics, with mean scores decreasing significantly with increase in addition of soybean and groundnut flour. However, among the developed breakfast cereals, these attributes were high in samples enriched with 2 soybeans (20-30%) and groundnut flour (10-15%). Despite the decrease, sensory scores for the formulated breakfast cereals remained above average (6), indicating acceptable levels. The overall acceptance for the control sample was considerably higher than that for formulated breakfast cereals. However, among the formulated cereals, the sample with soybean (15%) and groundnut flour (20%) had the highest overall acceptability. This aligns with the results of Mbaeyi-Nwaoha and Uchendu [28], who found that panelists approved of the sensory quality of breakfast cereals formulated from a mixture of acha and fermented soybean paste. These results suggest that breakfast cereals can be formulated with blends of yellow maize, soybean, and groundnut at specific ratios (65:20:15) without significantly changing the sensory quality of the product.

2.2.6 Breakfast Cereals incorporated with sorghum (whole grain)

In a study by Mkandawire et al. [29], tannin (red) and non-tannin (white) sorghum flours were investigated for their suitability in the extruded cereals using a twin-screw extruder. It was found that white sorghum flour had significantly high starch content, yellowness (b*), and a brighter appearance compared to red sorghum. On the other hand, red sorghum had increased protein content and bulk density. Cereals with sorghum flour (700g/kg) resulted in denser cereals with low water solubility and absorption. While there were some drawbacks concerning aroma and appearance, the overall acceptability of these cereals remained like a commercial oat reference. Non-tannin sorghum showed promise for the industry with less impact on nutrition and sensory aspects. The sorghum cereals achieved a "like slightly" overall acceptance, with appearance and aroma scoring lower than the oat reference. However, the flavor was generally similar, except for red sorghum with high flour content. Interestingly, while red sorghum had a better-liked appearance, it was rated lower in flavor than white sorghum. Moreover, the flour content (550 vs 700 g/kg) did not significantly affect the acceptability of the cereals.

2.2.7 Cereal flakes with yellow maize and coconut

In a study by Frimpong et al. [26] on breakfast flakes made from yellow maize and coconut, 5 formulations were developed using the Design-Expert's D-optimal design, with varying ratios of maize to coconut (80/20, 77.5/22.5, 75/25, 72.5/27.5, and 70/30). The overall acceptability of cereal decreased as the percentage of coconut decreased. Interestingly, the panelists preferred the formulation with a 70/30 ratio of maize to coconut. Panelists rated the color of the flakes between 5 (like moderately) and 7 (like extremely). The acceptability of color increased initially with higher maize percentages (e.g., 77.5/22.5) but declined with the 80/20 formulation. The increment in the strength of the yellow color in the breakfast cereals was unappealing to the panelists. Regarding texture, all formulations were accepted by the panelists, with ratings ranging from 4 (neither like nor dislike) to 6 (like very much). However, texture acceptability was slightly decreased with increasing maize addition.

2.2.8 Wholegrain wheat flour breakfast cereals

The study done by Wójtowicz et al. [30] on the recipe for breakfast cereals found that increasing the wholegrain wheat flour content and moisture

led to reduced energy consumption during the cooking by extrusion process. However, higher initial moisture content led to a reduction in the solubility index, expansion ratio, and water absorption of the cereals. Furthermore, increasing the moisture level resulted in higher textural parameters and bulk density, such as chewiness and hardness. During sensory evaluation, breakfast cereals made with 17% moisture and 50% whole wheat flour were found to have the best overall quality, with a mean score of 4.02. Conversely, higher moisture or whole wheat flour content was associated with lower sensory quality.

2.2.9 Inulin incorporated RTE multigrain breakfast cereals

In this study, Kapoor et al. [31] attempted to produce Ready to Eat (RTE) breakfast cereal, i.e., fiber-rich and sugar-free, by supplementation of a standardized fraction of inulin. The breakfast cereals with an inulin concentration of 16 % had a mean acceptability score of 7.8 ±0.06. Inulin incorporated in breakfast cereals provides multiple benefits for fibre enrichment and of a sweetener.

2.2.10 Wheat whole grain and sorghum breakfast cereals

Breakfast cereals made with whole wheat and sorghum were compared with parameters such as sensory acceptance and bioactive compound content in the study done by Anunciação et al. [32] The sensory analysis was conducted by using the food action rating scale. The results obtained showed that the breakfast cereal containing sorghum (70.6%) had a greater sensory acceptance than the whole wheat (41.18%). The Sorghum cereals had a higher TPC (98.2%), antioxidant activity (87.9%), 3-deoxy anthocyanidin content (100%), and lesser vitamin E (78.6 %) as compared to whole wheat cereals.

2.2.11 Jabutica (*Myrciaria cauliflora*) peel and whole grain wheat flour breakfast cereals

In the study by Oliveira et al., [33] the outcome of incorporating jaboticaba peel powder (JPP) into extruded cereals was examined to assess consumer acceptability and technological quality. The results showed that JPP significantly influenced the color of the breakfast cereals, and consumers preferred the inclusion of JPP in the cereals. Interestingly, a ratio of 10% JPP was found to provide color and flavor to the cereal without affecting its technological characteristics. Additionally, JPP was found to enhance the sensory attributes of aroma, appearance, flavor, and texture of the extruded cereals, improving overall consumer satisfaction.

2.2.12 Granola substituted with maize and coconut blend

In the study by Oliveira et al. [33], granola was prepared using maize and coconut as substitutes for walnuts and oats. The sensory analysis revealed no significant changes in texture, crispiness, flavor, and overall acceptability between the two types of granolas. However, there were noticeable differences in color and taste. Chemical analysis showed that the yellow maize granola had higher moisture content and carbohydrates but lower fat content, energy, protein, sugar, starch, and amylopectin than the oat-granola. Meanwhile, white maize granola had the highest value for amylose and crude fiber. These findings suggest that substituting walnuts and oats with maize and coconut in granola production can result in differences in nutritional composition and specific sensory attributes.

2.2.13 Breakfast cereal incorporated with malted acha-soy

In a study conducted by Agu et al. [34], a breakfast cereal was formulated using malted soybean flour (MSFs) and acha (*Digitaria exilis Stapf*) cereal grain. The process involved soaking the grains for 24 hours, followed by germination for 96 hours, drying at 60°C for 8 hours, devegetation, winnowing, dry milling, and sieving to obtain ASC flour. The study found that the whole meal acha breakfast gruel (100%) scored the highest mean value across most parameters, except for flavor. In contrast, the ASC (acha soy breakfast cereal) gruel (60:40%) had the lowest mean value in all parameters. The best sensory qualities were observed in the gruel made from 10% and 20% MSFs. These findings suggest the potential utilization of Acha in breakfast cereal formulations, which could be beneficial for individuals with diabetes.

2.2.14 Breakfast cereals (amaranth and roasted sesame blends)

According to Ojedokun et al. [35] a breakfast meal with high nutritional quality along with low glycaemic index was developed by substituting

malted amaranth with roasted sesame. The findings revealed that the sample with 50% sesame and 50% amaranth had the best acceptability in terms of sensory attributes, except for color. Furthermore, the sesame-substituted samples improved the total dietary, insoluble, soluble fiber content, and amino acids. Conversely, a decrease was observed in reducing sugars, total sugar, glycaemic index/load, and reducing sugar content in the samples. These results suggest that substituting roasted sesame for malted amaranth in breakfast meals can enhance their nutritional quality and lower their glycaemic index, potentially offering health benefits for consumers.

2.3 Texture and Mouthfeel Assessment

In the study by Mbaeyi-Nwaoha et al. [28] on cereals made from fermented soybean paste (okara) and acha, the sensory attributes were analyzed. For breakfast cereals made from 24-hour fermented okara flours, the mouthfeel values ranged from 6.55- 8.10, aftertaste values ranged from 7.20-8.10, and texture values ranged from 6.55-7.85. Among these samples, sample UFAC:FEOK2C (70:30 acha:okara) was rated highest for aftertaste (8.10a ± 0.85) and texture (7.60a ± 1.23), while sample UFAC:FEOK2A (90:10) received the highest rating for mouthfeel (8.10a ± 1.02). Sample UFAC:UFOK C scored highest at 7.85, likely due to the fine or smooth texture of acha. For breakfast cereals made from 36-hour fermented okara flour, the mouthfeel values ranged from 7.40-8.15, with sample UFAC:FEOK2A (70:30) scoring highest at 8.10. Texture values ranging from 7.05- 7.60, with sample UFAC:FEOK1E achieving the highest score of 7.50.

A study conducted by Frimpong et al. [26] on breakfast cereal made from coconut and maize was found that the texture of the cereals was generally accepted across all formulations, with scores ranging from 4 (neither like nor dislike) to 6 (like very much). However, as the proportion of maize increased in the formulation, the texture acceptance slightly decreased. This can be credited to reducing coconut copra content, which is high in fiber. The fiber content contributes to the crispy texture of breakfast cereal. Furthermore, the mouthfeel of the cereal was observed to decrease as the coconut composition decreased. This suggests that consumers preferred the presence of coconut in the cereal and disliked it when the coconut proportion was reduced. The mouthfeel scores obtained ranged between 4 and 6.

In the study by Usman et al., (2016), the incorporation of maize and defatted coconut in breakfast cereal resulted in significant differences between the samples (100:0 and 60:40) compared to the control and other samples when served dry. Another study by Alam et al. [40] focused on texture analysis of extruded puffs. This analysis aimed to assess puffs' textural and structural qualities (extruded), including parameters such as expansion, density, hardness, crispiness, and porosity. The supplementation of rye bran (10%) notably influenced the textural, structural, and mastication features in the flakes (extruded) and puffs, with puffs exhibiting higher porosity than flakes. The study also revealed a negative interaction between hardness and crispiness index and between density and porosity. Additionally, puffs required less work for mastication and exhibited more significant degradation into smaller particles than flakes.

The study conducted by Okache et al. [41] found that the incorporation of oil-bearing seeds, particularly at 40% inclusion, improved the mouthfeel of supplemented breakfast cereal samples as compared to the control (100% finger millet). The samples having higher inclusion levels exhibited better mouthfeel due to their oil content, contributing to palate-fullness and a smoother texture.

Borah et al. [42] evaluated the texture of the extruded breakfast cereals made with low-amylose rice and seeded banana using a texture analyzer. They determined that the optimal parameters for these cereals were 10% feed moisture content and a barrel temperature of 140 °C, resulting in higher preference levels for texture, color, and pasting qualities compared to other formulations. Additionally, Tay, et al., [14] analyzed the texture of flaked cereals containing banana pulp with the help of a texture analyzer. They observed that the fracturability of the flakes was influenced by the volume of banana pulp and the incorporated peel. Regression analysis revealed a significant negative effect on fracturability, indicating that as the amount of banana pulp and peel decreased, the fracturability of the flakes improved due to the moisture content of the banana. Therefore, incorporating higher volumes of fresh banana pulp and peel could result in flakes with higher moisture content and reduced fracturability.

Table 4. Quality parameters of breakfast cereals

Ingredients of Breakfast Cereal	Processing Steps	Quality Parameters	Key Findings	References
Banana, corn meal	Baking, sheeting, drying	Texture, sensory and colour analysis.	Fracturability of the cereal flakes was reduced when more banana pulp was incorporated with a higher moisture content.	Tay H. X., et al. [14]
Sorghum flour (red tannin, white tannin)	Extrusion	Colour, flavour, appearance, nutrition content, density, aroma and overall acceptability	Sorghum cereals achieved "like slightly" overall acceptance, with appearance and aroma scoring lower than the oat reference. Flavor was generally similar, except for red sorghum with high flour content. Notably, red sorghum had better-liked appearance but lower-rated flavor compared to white sorghum.	Mkandawire et al., [29]
Yellow Maize, coconut	Extrusion, drying	Sensory evaluation and nutritional profile	For the *zeaco* flakes overall acceptability rating were between 4 and 7 (7-point hedonic scale). With changing composition there was no significant difference	Frimpong et al., [26]
Wholegrain wheat flour, corn grit, rice flour, cocoa, sugar.	Extrusion, drying	Sensory, textural and physical properties	Breakfast cereals with 50-70% whole wheat flour and moisture content (17 %) gave good results.	Wójtowicz et al., [30]
Germinated flakes (barley, oat, rye, triticale, and wheat)	Soaking, washing, germination, flaking, drying	Sensory, physical-chemical, microbiological statistical analysis.	Fiber Cote® MG HB 60/40 pouches can store these flakes at 23±2 °C, for the duration of 10- 12 months and providing the best quality flakes in terms of sensory, physical, and microbiological properties.	Kince et al., [36]
Flours (Oats, foxtail millet (sprouted), amaranth (sprouted), inulin (powder), quinoa, baking powder and strawberry essence.	Baking	Sensory functional, nutritional, and shelf-life analysis.	Incorporation of inulin (16 %) in breakfast cereals having the mean acceptability score of 7.84 ±0.06 can provide benefits such as a fibre enrichment and as a sweetener.	Kapoor et al., [31]
Sorghum, whole wheat.	Milling, extrusion, granulated sugar, iodized salt	Sensory acceptance, Bioactive compounds content	Incorporation of whole-grain sorghum can be a better substitute in the food industry.	Anunciação et al., [32]

Ingredients of Breakfast Cereal	Processing Steps	Quality Parameters	Key Findings	References
Cornflour, Jabuticaba (Myrciaria cauliflora), whole grain wheat flour,	Extrusion cooking, and oven drying.	Mechanical properties, statistical analysis, consumer study, bowl life, and instrumental colour.	The extrudates obtained an average rating from 5.03 to 5.74.	Oliveira et al., [33]
Maize, coconut, peanut, wheat, sugar, milk, vanilla flavour and vegetable oil.	Milling, kneading, cutting, baking.	Sensory evaluation, statistical, chemical analysis, and functional characteristics.	Maize meal and coconut incorporated in granola can be used as an alternative for oat and walnut with acceptable organoleptic and nutritional qualities.	Joy et al., [37]
Maize grits, beetroot flour blends and partially defatted peanut,	Oven drying, milling, grinding, stirring, grit pressing, roasting	Proximate analysis, vitamin composition, in-vitro protein digestibility, sensory evaluation, statistical analysis.	The sample C (90 % maize flour, 10 % peanut flour, 10% beetroot flour) had the highest acceptability (8.40 ±0.83). ↑ in-vitro protein digestibility, protein, moisture, fat, fibre, and ash.	Ukeyima et al., [16]
Rice flour, green coffee beans.	Roasting, grounding, Extrusion, drying (fan oven).	Chemical analysis (bioactive compounds, TPC, Antioxidant activity), EI, texture analysis, colour, WAI, WSI, pasting properties, sensory evaluation	The breakfast cereal with 5 % MRC (micronized roasted coffee) favoured the sensory acceptance in terms of texture. The technological properties presented no variation for the hardness and expansion index.	Sampaio et al., [8]
popped pearl millet, flax seeds, sunflower seeds, popped amaranth, puffed wheat, raisin, sugar, honey, water, and oil	Extrusion and popping	Color, texture, taste, flavor, and overall acceptability	The sample (29.2% popped pearl millet) was more acceptable. Sensory properties of the cereals were highly acceptable.	Kumari et al., [38]
Amaranth grains and sesame seeds.	Roasting and extrusion	Soluble, insoluble, total dietary fibre, total sugar, reducing sugar, amino acid determination with statistical analysis, glycaemic index, blood glucose response and sensory characteristics.	The sample with sesame (50%) and amaranth (50%) was the most acceptable in all the sensory parameters except for colour.	Ojedokun et al., [39]

2.4 Shelf-Life Studies

In the study by Kapoor et al. [31] on breakfast cereal incorporated with inulin, the CBC1 sample (control) showed a higher value of Free Fatty Acids (FFA), possibly due to lipid degradation during germination. However, after 30 days of storage, there was no significant increase in FFA content in both CBC1 and IBC3 samples. Despite a significant increase in Initial Peroxide Value (IPV) after 30 days, both FFA and IPV values remained within standard limits, suggesting that both samples can be preserved for 60 days at ambient temperature without quality deterioration. According to Patil et al. [43], Ready-to-Cook flakes remained free from pests and insects throughout storage, with a slight increase in moisture uptake observed over six months. The processing technology applied, including packaging in metalized polyester PE packages, heat sealing, and storage in cardboard boxes at room temperature, contributed to reduced fat content and improved flake shelf life. Ready-to-cook flakes exhibited low moisture uptake and FFA, which are favorable for maintaining their shelf life. In another study by Senhofa et al. [44] on muesli with chocolate in addition to apricots, samples packed in paper bags showed the lowest moisture content after nine months of storage. However, the quantity of microorganisms increased after storage in all packaging types. Muesli samples in Doypacks exhibited the best sensory qualities after nine months, and they contained 18 volatile chemicals. The study concluded that paper bags were unsuitable for packing the chocolate and apricot muesli due to changes in quality during storage. In contrast, muesli packaged in paper tubes or Doypacks maintained their quality for nine months, indicating their suitability for extending the product's shelf life [45,46].

3. CONCLUSION

Breakfast cereals incorporated with fruits and vegetables offer a promising avenue for enhancing both the nutritional profile and sensory appeal of these products. Incorporating fruits and vegetables into breakfast cereals can provide essential vitamins, minerals, fiber, and phytochemicals, contributing to a balanced and healthful diet. Additionally, the natural flavors and colors of fruits and vegetables can enhance the taste and visual appeal of breakfast cereals, making them more attractive to consumers. Studies revealed that the incorporation of vegetables and fruits into breakfast cereals can positively impact various sensory attributes such as appearance, flavor, and texture, leading to increased consumer acceptance. However, careful formulation is required to ensure that the addition of vegetables and fruits does not negatively affect the overall sensory quality of the cereal. Furthermore, research indicates that processing techniques and packaging methods play a crucial part in maintaining the shelf-life and quality of breakfast cereals incorporated with fruits and vegetables. Proper storage conditions and packaging materials can help maintain freshness and prevent the deterioration of sensory attributes over time. Overall, breakfast cereals with fruits and vegetables represent a convenient and nutritious breakfast option that aligns with consumer preferences for healthier food choices. Further research and innovation in formulation, processing, and packaging can continue to enhance the quality and appeal in these products, ultimately contributing to healthier dietary patterns and consumer satisfaction.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. De La Hunty A, Ashwell M. Are people who regularly eat breakfast cereals slimmer than those who don’t? A systematic review of the evidence. Nutrition Bulletin. 2007; 32(2):118-128.
2. Spence C. Breakfast: The most important meal of the day? International Journal of Gastronomy and Food Science. 2017;8:1-6.
3. Santos D, Pintado M, Da Silva JAL. Potential nutritional and functional improvement of extruded breakfast cereals based on incorporation of fruit and vegetable by-products-A review. Trends in Food Science and Technology. 2022;125: 136-153.

4. Bhavya SN, Prakash J. Comparison of nutritional qualities and antioxidant properties of ready-to-eat fruit-enriched corn based breakfast cereals. Malaysian Journal of Nutrition. 2012;18(3).
5. Okoronkwo NC, Mgbakogu CD, Mbaeyi-Nwaoha IE. Production and evaluation of breakfast cereals from rice, african yam-bean and orange-fleshed Sweet Potato. Asian Food Science Journal. 2019;11(1): 1–17.
6. Miranda-Ramos KC, Sanz-Ponce N, Haros CM. Evaluation of technological and nutritional quality of bread enriched with amaranth flour. LWT-Food Science and Technology. 2019;114:108418.
7. Selani MM, Brazaca SGC, Dos Santos Dias CT, Ratnayake WS, Flores RA, Bianchini A. Characterisation and potential application of pineapple pomace in an extruded product for fibre enhancement. Food Chemistry. 2014;163: 23-30.
8. Sampaio UM, Pereira APA, Campelo PH, Pastore GM, Chang YK, Clerici MTPS. Micronised-roasted coffee from unripe fruits improves bioactive compounds and fibre contents in rice extruded breakfast cereals. International Journal of Food Science and Technology. 2021;56(11): 5688-5697.
9. Arpit S, John D. Effects of different levels of jackfruit seed flour on the quality characteristics of chocolate cake. Research Journal of Agriculture and Forestry Sciences. 2015;3(11):6-9.
10. George IC, Igwe EC, Obiora CU, Omologbe F, Igwe PN, Ubaka I. Chemical composition and sensory properties of wheat, african yam bean and tiger nut residue composite flour cookies. Asian Journal of Food Research and Nutrition. 2023;2(4):536–545.
11. Reshmi SK, Sudha ML, Shashirekha MN. Starch digestibility and predicted glycemic index in the bread fortified with pomelo (*Citrus maxima*) fruit segments. Food Chemistry. 2017;237:957-965.
12. Akinyemi TY, Akinyede AI, Oluwajuyitan TD. Extruded breakfast cereal from finger millet flour blends: Nutritional composition, *In-vivo* protein quality assessment and biochemical indices of rat fed. NFS Journal. 2022;29:35-42.
13. Randeniya RDIP, Jayasinghe JMP, Abeyrathne EDNS. Development of ready to eat breakfast cereal incorporating ovalbumin from chicken egg white. International Journal of Research in Agricultural Sciences. 2016;3(5):255 -258.
14. Tay HX, Kuan CH, Chong GH, New CY, Son R. Development and optimization of flaked breakfast cereal processing parameters and formulation, incorporated with banana pulp and peel, using response surface methodology. Food Research. 2021;5(2):45-53.
15. Ujong AE, Aniefiok IE, Onyekwe JC. Nutrient composition and sensory properties of breakfast cereal made from yellow maize and enriched with soybean and groundnut flours. Turkish Journal of Agriculture-Food Science and Technology. 2023;11(4):651-656.
16. Ukeyima TM, Akor IA, Kyenge B. *In vitro* digestibility, nutritional and sensory quality of extruded breakfast cereal from maize grits, partially defatted peanut and beetroot flour. Asian Food Science Journal. 2021; 20(8):66-75.
17. Orngu OA, Mbaeyi-Nwaoha IE. Development and quality evaluation of a cereal-based breakfast product from yellow maize (Zea mays), sesame (*Sesamum indicum*) and mushroom (*Pleurotus ostreatus*) flour blends. International Journal of Food Science and Technology. 2022;57(6):3750-3759.
18. Rampersaud GC, Pereira MA, Girard BL, Adams J, Metzl JD. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. Journal of the American Dietetic Association. 2005;105(5):743-760.
19. Fayet-Moore F, McConnell A, Tuck K, Petocz P. Breakfast and breakfast cereal choice and its impact on nutrient and sugar intakes and anthropometric measures among a nationally representative sample of Australian children and adolescents. Nutrients. 2017;9(10):1045.
20. Gibson SA, Gunn P. What's for breakfast? Nutritional implications of breakfast habits: Insights from the NDNS dietary records. Nutrition Bulletin. 2011;36(1):78-86.
21. Chapman DM, Roby G, Ebeler SE, Guinard JX, Matthews MA. Sensory attributes of Cabernet Sauvignon wines made from vines with different water status. Australian Journal of Grape and Wine Research. 2005;11(3):339-347.

22. Sclafani A. Sweet taste signaling in the gut. Proceedings of the National Academy of Sciences. 2007;104(38): 14887-14888.
23. Arpita S, Subroto D, Pinaki B, Bidyut B. Inhibition of polyphenol oxidase in banana, apple and mushroom by using different anti-browning agents under different conditions. International Journal of Chemical Science. 2010;8(5):S550-S558.
24. Schloss KB, Palmer SE. Aesthetic response to color combinations: Preference, harmony, and similarity. Attention, Perception and Psychophysics. 2011;73:551-571.
25. Jayasinghe PS, Pahalawattaarachchi V, Ranaweera KKDS. Seaweed extract as a natural food coloring agent in jelly desserts on chemical, microbial and sensory quality. Proceedings of the National Aquatic Resources Research and Development Agency NARA, Scientific Session. 2016; 2016.
26. Frimpong TG, Wireko-Manu FD, Oduro I. Development and sensory assessment of ready-to-eat breakfast cereal. International Journal of Food Science; 2022.
27. Žilić SM, Barać MB, Pešić MB, Mladenović Drinić SD, Ignjatović-Micić DD, Srebrić MB. Characterization of proteins from kernel of different soybean varieties. Journal of the Science of Food and Agriculture. 2011;91 (1):60-67.
28. Mbaeyi-Nwaoha IE, Uchendu NO. Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). Journal of Food Science and Technology. 2016;53:50-70.
29. Mkandawire NL, Weier SA, Weller CL, Jackson DS, Rose DJ. Composition, in vitro digestibility, and sensory evaluation of extruded whole grain sorghum breakfast cereals. LWT-Food Science and Technology. 2015;62(1):662-667.
30. Wójtowicz A, Mitrus M, Oniszczuk T, Mościcki L, Kręcisz M, Oniszczuk A. Selected physical properties, texture and sensory characteristics of extruded breakfast cereals based on wholegrain wheat flour. Agriculture and Agricultural Science Procedia. 2015;7:301-308.
31. Kapoor T, Haripriya A. Formulation and evaluation of functional, nutritional and sensory properties of inulin incorporated ready to eat multi-grain breakfast cereal. Indian Journal of Nutrition and Dietetics. 2020;57.4(2020):422.
32. Anunciação PC, De Morais Cardoso L, Gomes JVP, Della Lucia CM, Carvalho CWP, Galdeano, MC, Pinheiro-Sant'Ana HM. Comparing sorghum and wheat whole grain breakfast cereals: Sensorial acceptance and bioactive compound content. Food Chemistry. 2017;221:984-989.
33. Oliveira LC, Alencar NM, Steel CJ. Improvement of sensorial and technological characteristics of extruded breakfast cereals enriched with whole grain wheat flour and jabuticaba (*Myrciaria cauliflora*) peel. LWT-Food Science and Technology. 2018;90:207-214.
34. Agu HO, Ayo JA, Jideani AIO. Evaluation of the quality of malted acha-soy breakfast cereal flour. African Journal of Food, Agriculture, Nutrition and Development. 2015;15(5):10542-10558.
35. Akinyede AI, Oluwajuyitan TD, Dada JB. Influence of substitution on amino-acid profile, physicochemical and sensory attributes of breakfast cereal from millet, soy cake, rice bran and carrot pomace blends. MOJ Food Processing and Technology. 2020;8(1):19-27.
36. Kince T, Galoburda R, Klava D, Tomsone L, Senhofa S, Straumite E, Blija A. Breakfast cereals with germinated cereal flakes: Changes in selected physical, microbiological, and sensory characteristics during storage. European Food Research and Technology. 2017;243: 1497-1506.
37. Joy EE, Aswei BE, Nicholas GM. Preparation and evaluation of granola–a breakfast cereal, sustituted with maize (Zea May) and Coconut (*Cocos nucifera*) Blend. International Journal of Food Sciences and Nutrition. 2016;5(2016):47-52.
38. Kumari R, Singh K, Singh R, Bhatia N, Nain MS. Development of healthy ready-to-eat (RTE) breakfast cereal from popped pearl millet. Indian Journal of Agricultural Sciences. 2019;89(5):877-881.
39. Ojedokun FO, Ikujenlola AV, Abiose SH. Nutritional evaluation, glycemic index and sensory property of breakfast cereals developed from malted amaranth and roasted sesame blends. Scientific Journal of Food Science and Nutrition. 2020;6:12-19.
40. Alam SA, Pentikäinen S, Närväinen J, Holopainen-Mantila U, Poutanen K, Sozer N. Effects of structural and textural

properties of brittle cereal foams on mechanisms of oral breakdown and in vitro starch digestibility. Food Research International. 2017;96:1-11.
41. Okache TA, Agomuo JK, Kaida IZ. Production and evaluation of breakfast cereal produced from finger millet, wheat, soybean, and peanut flour blend. Research Journal of Food Science and Quality Control. 2020;6(2):9-19.
42. Borah A, Charu LM, Dipankar K. Quality attributes of extruded breakfast cereal from low amylose rice and seeded banana (Musa balbisiana, ABB). Journal of Food Research and Technology. 2015;3(1):23-33.
43. Patil KB, Chimmad BV, Itagi S. Glycemic index and quality evaluation of little millet (*Panicum miliare*) flakes with enhanced shelf life. Journal of Food Science and Technology. 2015;52:6078-6082.
44. Senhofa S, Straumite E, Sabovics M, Klava D, Galoburda R, Rakcejeva T. The effect of packaging type on quality of cereal muesli during storage. Agronomy Research. 2015;13(4):1064-1073.
45. Camire ME, Dougherty MP, Briggs JL. Functionality of fruit powders in extruded corn breakfast cereals. Food Chemistry. 2007;101(2):765-770.
46. Usman GO, Okafor GI. Organoleptic properties and perception of maize, African yam bean, and defatted coconut flour-based breakfast cereals served in conventional forms. Food Science and Nutrition. 2016;4(5):716-722.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/117269