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Mitigating Waste through Valorization of Waffle Cones : Exploring the Potential of Banana Peel and Jackfruit Seeds in Sustainable Waste Management Solutions

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Abstract:- The rapid increase in plant waste production in the agri-food industry is a significant global issue, considering storage, disposal, environmental impacts and potential health risks. However, the use of agricultural waste as by-products to recover value-added compounds brings new opportunities in industrial production and waste management. After banana harvest, almost 60% of banana biomass remains as waste. Around 114.08 million tons of banana waste is generated worldwide, leading to environmental issues such as excess greenhouse gas emissions. Banana waste, especially the peel, could be a useful alternative source of value-added products such as fiber, bioactive components and essential minerals. When consuming fruits and vegetables, the inedible parts need to be discarded, creating challenges such as waste management and environmental pollution. The fibrous peel is a tasty food, although it has a slightly bitter taste. They are rich in fibre, antioxidants, polyphenols, essential minerals like potassium, provitamin A, carotenoids, starch and non-starch polysaccharides like B1, B2 and C, which play a dietary role in human health. Jackfruit seeds have good nutritional value and are useful in producing healthy and nutritious food. Nutrient composition reveals that jackfruit seeds contain moisture 21.10-71.92%, fibre 1.56-3.96%, ash 2.12-0.89%, protein 10.09-18.12% and fat 4.29%. The objective of this study was to find out whether Musasava banana skin flour (BPF) and jackfruit seed flour are suitable as substitutes for maida flour in making waffle cones. Here, different percentages of BPF and JSF were combined to replace maida in different percentages and the results were checked. These different percentages of maida substitutes will give the best results in case of bulk waffle preparation and nutritional analysis. 100% maida waffle cone was considered as the control and used for comparison with a cone prepared from a combination of 40% JSF as maida substitute and 10% BPF as maida substitute and this waffle preparation had 50% additional maida making up the rest. Jackfruit seed flour and banana peel flour have high water and oil absorption capacity and hence can be used as a complete or partial replacement for maida in other value added foods. The permeability of ice cream in the waffles was checked at certain time and temperature intervals. Nutritional analysis of the waffles showed protein 5.8%, fat 0.86%, sugar 40.15%, fibre 1.08%, ash 0.26%, pH 6.8 and moisture 6.48%.

Keywords:- *Fruit Waste Utilisation, Banana Peel (BPF), Jackfruit Seed(JSF), Waste Management.*

I. INTRODUCTION

The amount of organic waste from fruits and vegetables is constantly increasing, causing problems in terms of waste disposal and environmental pollution. Organic residues are an important source of nutrients and it has been proposed to use them as valuable ingredients or raw materials in some production processes, or for use in the development of new products.However, most research focuses on the treatment of waste to obtain bioactive compounds, which implies additional processing that in turn generates other types of waste .In this study, Saba bananas have been used instead of Cavendish bananas in the making of banana peel waffle cone. The acceptance of waffle cones based on their batter will be determined by a number of factors, including their pH, color, tensile strength, and nutritional content. Food pH is significant because it indicates the acidity or alkalinity of food as well as its direct measurement of the acid content (H+). In addition, the food's color influences its content and may serve as a draw for consumers. Since it will impact how the food is handled and stored, the strength of the food must also be taken into account. The strength of food will alter its form and texture depending on how it is consumed. Consuming a well-balanced diet is essential for overall health and wellness.

Therefore, the information about calories, protein, important fats, vitamins, and minerals that humans require to survive, grow, and operate effectively is provided by the nutritional values of food. One of the most widely grown food crops in over 100 nations, particularly in tropical and subtropical areas, bananas are thought to be essential to both

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the economy and food security. Furthermore, bananas are an effective and reasonably priced source of energy that is simple to process. A, C, and B6 vitamins, as well as a few minerals, are abundant in bananas. Furthermore, the crop may be grown in a range of temperatures and processing methods, offering a year-round source of income in addition to a wholesome staple diet. Approximately 87% of all bananas planted worldwide for domestic use or sale on regional and national marketplaces are produced by small-scale farmers. According to Shahbandeh (2021), the world's annual production of bananas was approximately 30,460 thousand metric tonnes, with India being the top producer, followed by China, Indonesia, and Brazil. Banana farms, however, will generate tons of waste and underutilized byproducts, such as banana leaves, pseudostems, and peels, because many edible bananas are grown primarily for their fruit. Poor waste management can have detrimental effects on the environment. When the bananas' fruits are consumed, the fibrous peels are typically thrown away.

Banana peels have a number of advantageous components, much like their flesh does. Rather than ending up in a landfill, they should be used. Although eating bananasm especially the bits that peel may not seem normal, individuals all across the world do so since they are perfectly edible (Szalay, 2017). It's also critical to keep in mind that banana peels are neither harmful nor poisonous. Additionally, research has demonstrated that banana peels are a great source of fatty acids, fiber, calcium, and potassium. Banana peels can be utilized as a useful ingredient in rich starch products because this study has shown that they have a significant amount of nutritional fiber.As a result, BPF can be substituted for creating banana peel waffle cones. The jackfruit is regarded as the largest fruit in the world. Jackfruit is typically farmed in Asia and other nations, such as India . This fruit variety is composite, meaning that each fruit is made up of an inner rind, rachis, meat (which can be yellow, golden, or white), and seed . About 10-15% of the fruit weight is made up of seeds, which are a significant source of protein and carbohydrates, primarily starch .

Nutritional composition showed that jackfruit seed flour per 100 gram is , energy-353 kcal, protein-12.5 gram, total carbohydrates – 74.5 gram, total sugar- 4 gram, addeed sugar not added, total - 0, cholesterol – 0 , sodium – 4.8 gram, dietary fibre – 3 gram. The primary protein found in jackfruit seeds, jacalin, helps to strengthen the body's immune system. Owing to its antioxidant properties, jackfruit seed also includes additional secondary metabolites such as saponins, phytonutrients, lignins, and isoflavone, which can help prevent cancer, hypertension, aging, ulcers, and many other conditions . It is thought that jackfruit seeds themselves have not yet found any industrial purpose; instead, they are thrown away, dried, cooked, or occasionally used in regional cuisine prepared at home as snacks or curries . Seeds are naturally resistant to change and sprout quickly, much like ripening fruit. As a result, seeds should only be kept fresh for a week before they deteriorate and increase post-harvest loss.

As a result, they required processing, one of which is milling, to improve their storability and utilization. The flour obtained from grinding jackfruit seeds has a lot of potential and can be added value or used as a substitute in a variety of foods. states that jackfruit seed flour can be used in place of wheat flour while making bread, chapatti, griddle cakes, buttered biscuits, and noodles. In order to incorporate jackfruit seed flour into extruded items like as snacks, noodles, vada, and vermicelli, Praveenasri et al. conducted research created low-gluten bread by substituting 5, 10, and 20% of wheat flour with jackfruit seed flour.

Similar to this, Butool & Butool and Meethal et al. substituted different amounts (10–30%) of jackfruit seed flour for wheat flour in their snack bars and bread cookies, respectively. Therefore, another goal of this project is to investigate the physicochemical characteristics of waffle cones made with jackfruit seed flour (JSF) and banana peel flour (BPF) in place of some of the maida flour. To determine whether waffle cones are accepted, it is necessary to investigate a number of factors, such as pH, texture, color, tensile strength, and nutritional content. Thus, the purpose of this work is to investigate if BPF and JSF may replace maida flour while making waffle cones.

II. MATERIALS & METHODS

- *Materials*

Banana peel flour, jackfruit seed flour, maida flour, sunflower oil, caramel, water, suagr, lecithin were used.

- *Analysis of Raw Materials*

For banana peel powder and jackfruit seed flour - moisture, pH, Viscosity, brix percentage and density, water holding capacity and oil holding capacity and nutritional analysis was done. For maida flour sieving is done and checked for any other extraneous matter.

- *Banana Peel Powder and Jackfruit Seed Flour*

3kg of banana fruit is bought from local market in town and then washed in clean tap,water and then peel is taken out and then dipped in 0.5% citric acid solution. After 10 minutes peels were sliced into pieces & kept for oven drying at temperature 105 ℃ for 24 hours after one day of drying in hot air oven they were taken out and weighed and then powdered it by the help of mixer 120 grams of powder is obtained & jackfruit seed flour is bought from market directly.

Fig 1 Waste Banana Peel Kept for oven Drying

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Fig 2 Dried Banana Peel


Fig 3 Banana Peel Flour

Fig 4 Jackfruitseed Flour

➢ *Water and Oil Holding Capacity*

25 mL of distilled water or commercial olive oil was mixed with 1g of dried sample. The mixture was stirred and incubated at 40, 60, or 80 ℃ for 1 h. The tubes were centrifuged at 3000 × g for 20 min and the supernatant was discarded. The tubes were then placed at a 45° angle and allowed to drain for 10 min. The residue was weighed and the water holding capacity (WHC, in g water per 100 g sample) and oil holding capacity (OHC, in g oil per 100 g sample) were calculated.

➢ *pH Analysis*

A balance was used to weigh out 4% banana peel powder.

The powder was then poured into a centrifuge tube and 15 ml of distilled water was added. The mixture was then vortexed for 5 minutes and left for an additional 30 minutes (Savlak et al., 2016). The acidity of the supernatant was measured using a pH meter.Measurements were performed in triplicate.

➢ *Product Formulation*

Different proportion and trials of BPF, JSF and maida flour were checekd before making this formulation, i,e 1st trial was 60% JSF & 40% maida flour inorder to reduce the usage of maida flour in cone preparation and the 2nd trial was 10% of banana peel was used and ramaining 90% was maida is used here, 3rd trial was 20% banana peel flour was sustituted and in the 4th trial 40% of banana peel flour was substituted, 5th trial was maida 80% and BPF 20%, 6th trial was 50% maida, 10% BPF, 40% JSF and in 7th trial maida is replaced with wheat and then some of the trials were carried out it was like 40% wheat flour and 60% JSF was subsituted, in 8th trial 80% wheat flour and 20% BPF is used, in 9th trial 50% wheat flour, 10% BPF and 40% JSF was added. Among all these trials 6th trial and 9th trial showed the good result for the cone preparation but we perfomed 6th trail i,e 50% maida flour, 40% JSF,10% BPF because when compared with the 9th trial (i.e 50% wheat flour, 10% BPF, 40% JSF) the best texture and taste was observed in the cone made with maida i,e the 6th trial therefore we have formulated the product according to this requirement. For the making of waffle cones the standard recipe followed is maida - 36%. Sugar -15.32%, oil-1.09%, caramel - 0.072%, water - 45.98%.

Table 1 Product Formulation

Ingredients	Std chart	% of incorporation	Quantity
Water	45.98 %	45.98 %	230 g
Maida	36 % i,e (180 gram)	18%	90 g (remaining 90 g will be comes from JSF(40%) & BPF (10%)
Sugar	15.32 %	15.32 %	76.6 g
JSF	-	40 %	72 g
BPF	-	10 %	18 g
Lecithin	1.094 %	1.094 %	5.47 g
Oil	1.09 %	1.09 %	5.45 g
Caramel	0.072 %	0.072 %	0.35 g

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➢ *Preparation of Waffle Cone*

Mix all the mentioned ingredients in the required proportions and make batter with the required consistency i,e strive for a smooth and lump free batter this is achived by whisking the wet and dry ingredients thoroughly and then strain the batter through a fine mesh strainer to get rid of any clumps and let the batter rest for about 5 minutes to allow it to thicken slightly. Scoop 2 to 3 table spoon of the batter onto the preheated waffle cone maker & close the lid and cook on medium-high heat for approximatley 10-15 minutes at temperature of 60℃ (untill the waffle turns golden brown) / here we used microwave oven to bake the batter at 60 ℃ for 35 min . And then rolling the cones i,e done by after the batter get ready then it is rolled to a cone shaped mold while it's still hot and pliable. This step sets the shape of the cones and ensures it won't break apart it cools. While handling the hot waffle cones, use heat resistant cooking gloves inside to protect the hands from burns. Role the waffle cones when it's still super hot, otherwise they will turn too hard and crispy to be rolled. Place the rolled waffle cones on a wire cooling rack to cool completely.This prevents moisture buildup and keeps the cones crisps. Adjust the amount of batter in each scoop to control the size of cones in addition to this easily turning the waffle cone made using this recipe into a waffle bowl by gently shaping it into a bowl and allowing it to cool and to maintain the crispiness, store the waffle cones in an airtight container or ziplock bag.

III. RESULTS AND DISCUSSION

➢ *Banana Peel Flour and Jackfruit Seed Flour*

Banana peel waste has a high microbial load, reason why guaranteeing sanitary safeness of the BPF is required. To that end, the combination of physical and chemical methods for washing serves to eliminate the dirt and microorganisms responsible for quality lost. The use of 0.5% citric acid solution is very effective and differs from other decontamination technologies in that, together with direct decontamination where as the jackfruit seed flour was directly bought from market and the quality as so good to use.

➢ *B. Chemical and Physical Properties of Green Banana Peel Flour and Jackfruit Seed Flour*

Table 2 WHC=Water Holding Capacity (g of Water per g of Sample at 40 ℃, 60 ℃ and 80 ℃), OHC=oil Holding Capacity (g of oil per g of Sample at 40 ℃, 60 ℃ and 80 ℃)

Parameter	Banana peel flour	Jackfruit seed flour
pH	6.66	5.32
Moisture	3.48%	4.32%
Protein	0.2 %	0.5%
WHC 40 ℃	3.51	3.70
WHC 60 ℃	3.81	4.8
WHC 80 ℃	4.41	6.06
OHC 40 ℃	1.05	1.04
OHC 60 ℃	3.02	3.08
OHC 80 ℃	3.2	3.23

The above table 2 shows that chemical and physical properties of green banana peel flour and jackfruit seed flour pH of BPF was 6.6 alightly acidic where as JSF having pH of 5.32 i,e more acidic compared to BPF. Protein in BPF is 0.2% and where as in JSF 0.5% is protein found and moisture in BPF is 3.48% , JSF has slightly higher moisture compared to BPF i,e of 4.32%. WHC at 40 ℃ for JSF is 3.70 (slightly higher compared to BPF WHC) where as BPF has WHC of 3.51 at 40 ℃. At 60 ℃ WHC of JSF is 4.8 i,e higher compared to that of value obtained at 40 ℃ and for BPF At 60 ℃ the WHC is 3.81 i,e higher compared to that of value obtained at 40 ℃. And WHC at 80 ℃ for JSF and BPF shows that JSF has 6.06 WHC where as 4.41 in BPF and both BPF & JSF has the slight higher WHC at 80 ℃ compared to that of 60 ℃ .

The OHC (oil holding capacity) at 40 ℃ for BPF is 1.05 where as JSF has 1.04 here we get to know that there is not much difference between BPF and JSF's oil holding capacity.Where as at 60 ℃ BPF shows the OHC of 3.02 and JSF showed the OHC of 3.08 , it shows that very slight difference is found i,e negligble. And at 80 ℃ JSF shows slight rised level of the OHC i,e 4.32 where as BPF shows that 3.2. Thus we came to know that with the increase in temperature, value of WHC and OHC also showed an increase in both flour samples. The green banana peel flour and Jackfruit seed flour had significantly higher WHC at 60 ℃ and 80 ℃ than at 40 ℃.

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➢ *The Water Holding Capacity of Saba Banana Peel Powder and Jackfruit Seed Flour*

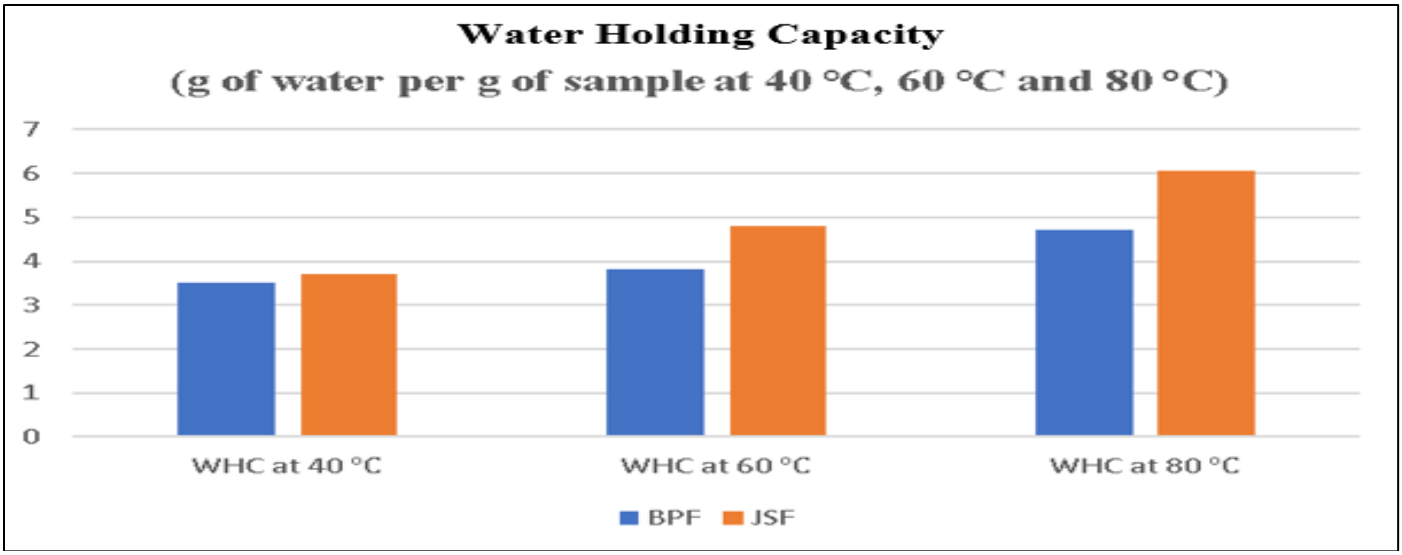

Fig 5 The Water Holding Capacity of Saba Banana Peel Powder and Jackfruit Seed Flour

Figure 5 shows the increasing water holding capacity for all the particle sizes as the temperature increases. Both banana peel powder and jackfruit seed flour contain starches that undergo gelatinization at higher temperatures. Gelatinization involves the swelling and hydration of starch granules, which increases their ability to absorb and hold water and oil. This phenomenon is more pronounced at higher temperatures due to increased molecular mobility and water accessibility. So at all the three temperatures 40℃, 60℃ and 80℃ the WHC of both the flours has been increased. Some components of banana peel powder and jackfruit seed flour, such as soluble fibers and sugars, may become more soluble or accessible at higher temperatures. This can contribute to increased WHC and as these soluble components interact with water. Thus, we can conclude that the increase in the ability of the banana peel powder and jackfruit seed flour to retain water is due to the increase in particle size.

➢ *Oil Holding Capacity of Saba Banana Peel Powder and Jackfruit Seed Flour*

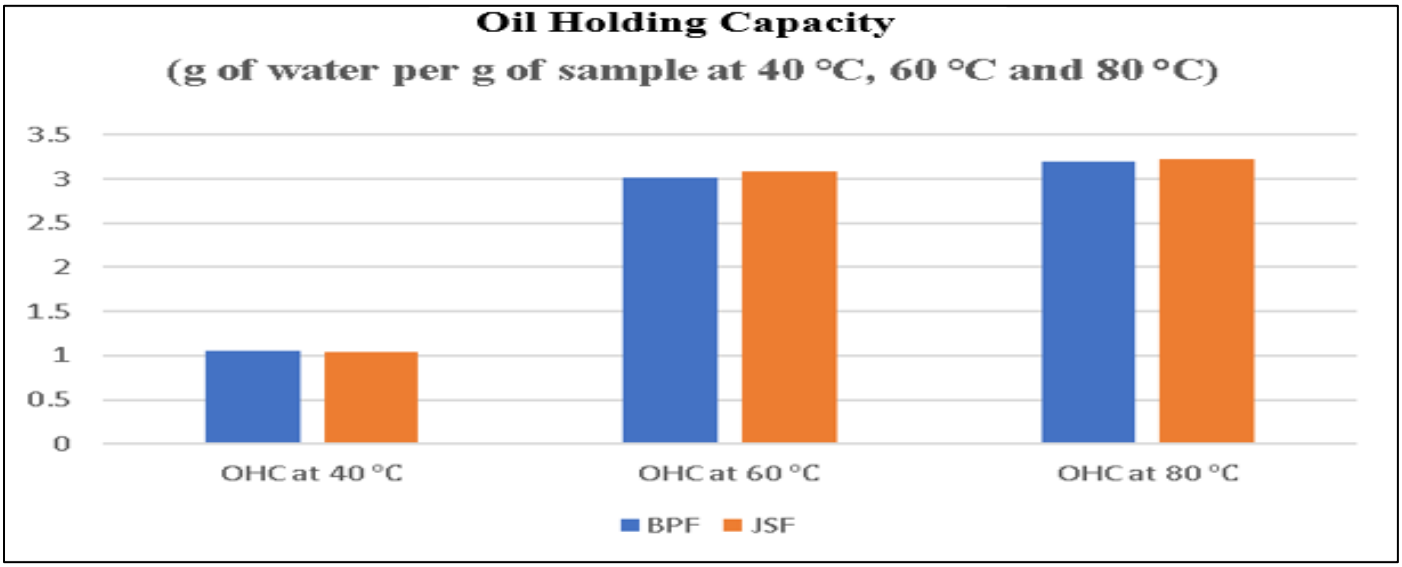

Fig 6 The Oil Holding Capacity of Saba Banana Peel Powder and Jackfruit Seed Flour

The oil holding capacity (OHC) of jackfruit seed flour & banana peel flour refers to its ability to absorb and retain oil when it comes into contact with it. This property is significant in various applications, especially in food and industrial processes where oil absorption is crucial. Finely ground jackfruit seed flour & banana peel flour has a higher surface area per unit mass compared to coarser particles. This increased surface area provides more sites for oil molecules to interact and adhere to, thereby increasing the oil holding capacity. Jackfruit seed flour & banana peel flour contains dietary fibers and polysaccharides, such as cellulose and hemicellulose. These components have hydrophilic (water-attracting) properties that can also interact with oil molecules through hydrophobic

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interactions. The structure of these fibers can entrap oil within their matrix, contributing to the flour's oil holding capacity.Proteins present in jackfruit seed flour can undergo changes at different temperatures or pH conditions, affecting their ability to bind with oil molecules. Denatured proteins, for example, may expose hydrophobic regions that can interact with oil, thereby enhancing OHC. Factors such as temperature, pH, and processing methods (e.g., drying, milling) can affect the physicochemical properties of jackfruit seed flour and consequently influence its oil holding capacity. Optimizing these conditions can enhance the flour's ability to absorb and retain oil.

➢ *Chemical Composition of Jackfruit Seed Flour*

Table 3 Chemical Composition of Jackfruitseed Flour

Parameter	**Nutritional fact / 100 grams**
Energy	353 Kcal
Protein	12.5 gm
Total carbohydrates	74.5 gm
Total sugar	4 gm
Added sugar	BLQ
Total fat	1.4 gm
Saturated fatty acid	0.4 gm
Unsaturated Fatty acid	0.5 gm
Trans fat	BLQ
Cholesterol	BLQ
Sodium	4.8 mg
Dietary fier	3gm

Jackfruit seed flour is a versatile and nutritious ingredient derived from the seeds of the jackfruit, a tropical fruit known for its sweet and fibrous flesh. Once dried and ground into a fine powder, jackfruit seed flour boasts a subtly nutty flavor with a hint of sweetness. Rich in protein, dietary fiber, and antioxidants, it serves as a healthy alternative to traditional flours in baking and cooking. Jackfruit seed flour is renowned for its gluten-free properties, making it suitable for those with dietary restrictions. It adds a unique texture and a boost of nutrients to a waffle cones and even as a thickening agent in soups and sauces. As interest in plant-based foods grows, jackfruit seed flour stands out as a sustainable and nutritious choice and it has nutrition facts per 100 gram i.e **energy** about 353 Kcal, **Protein** is 12.5 gm & **Total carbohydrates is** 74.5 gm and total sugars of about 4 gm here there's no added sugar so it has benefit to use in combination with wheat flour to make chapati for diabetic persons , **total fat** about 1.4 gm and **Saturated fatty acid** of 0.4 gm & **Unsaturated Fatty acid of about** 0.5 gm and there is no presence of cholesterol and trans fat, sodium is present is very little amount 4.8 mg and dietary fiber is about 3g so we get to know that JSF is a good source of protein and dietary fibre so the incorporation of this in waffle cones makes a excellent substitute to maida flour.

➢ *Bpf & Jsf Substituted Waffle Cones*

Fig 7 BPF & JSF Substituted Waffle Cones

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➢ *Proximate Analysis of Bpf & Jsf Susbsituted Waffle Cone*

Table 4 Proximate Analysis of BPF & JSF Susbsituted Waffle Cone

Parameter	% of present
Sugar	40.15
pH	6.8
Moisture	6.48
Protein	5.8
Fibre	1.08
Fat	0.86
Ash	0.26

Table 4 summarises the results of proximate principles such as sugar, fibre, carbohydrate, moisture content, ash, fat and protein of BPF & JSF substituted waffle cone. It shows that total sugar present is 40.15 % in this 15.32% is added sugar as that we have shown in formulation Table 1 and remaining percentage of sugar was contributed by the banana peel and the jackfruitseed flour may be. And pH of this cone was 6.8 and moisture is this lower value will extend the waffle cone's shelf life without the growth of molds and protein was found to be 5.8 % so we get to know that waffle cone has the good source of protein and it was contribted by the JSF and also it varies with the type of the banana peel taken and fibre was founf to be 1.08 % so it was contributed by the banana peel flour and Jackfruitseed flour and fat was found to be 0.86% so prevents the waffle cone from getting rancid or fatty flavour and ash was found to be 0.26%.

IV. CONCLUSION

Based on this study, BPF & JSF can be utilised to produce value-added food such as waffle cones. The high water holding capacity of BPF & JSF can lower the tensile strength of waffle cones and fulfill the need for a water binding agent in the bakery and processed meat products industry.As the BPF containing the rich source of dietary fibre helps to improve the time taken by the ice cream to penetrate through the waffle cone.The replacement of maida by JSF of 40% and BPF of 10% . And also, the utilisation of BPF in processed food can reduce the dependency on wheat flour in food products and improve the development of low gluten foods based on our indigenous resources. Hence, the substitution of BPF into waffle cones accepted as the banana peel itself has a good value in WHC and OHC. The enrichment of waffle cones with unripe BPF is an effective way to enhance the nutritional and physiological aspects.

BPF rich in fiber which helps improve digestive health and can contribute to a feeling of fullness.And also conatining antioxidants which contains polyphenols and carotenoids, which may help reduce inflammation and oxidative stress and containing vitamins and minerals provides essential nutrients such as vitamins B6 and C, potassium, and magnesium. BPF containing good flavor and texture and mainly helps to maintain sustainability & waste reduction i,e by utilizing banana peels helps reduce food waste and promotes a more sustainable approach to ingredient use.

Jackfruit seed flour Containing protein and provides a good source of plant-based protein, which can be especially beneficial in vegan or vegetarian diets.And containing fiberit will enhances the fiber content, aiding digestion and contributing to overall gut health.JSF provides subtle nutty flavor i,e adds a mild, nutty flavor that can complement the taste of waffles and ice cream & contributes to a denser, more substantial texture in waffles and can provide a thicker consistency in ice cream.And mainly waste reduction i,e by utilizing jackfruit seeds, which are often discarded, promoting a more sustainable use of the fruit.

The main aim of this paper is investigated by determining the physicochemical characterstics of waffle cones made with jackfruit seed flour(JSF) and banana peel flour (BPF) in place of some of the maida flour. Thus the purpose of this paper is to investigate if BPF and JSF may replace maida flour while making waffle cones and the above mentioned and discussed results shows that this formulations for the replacement of the maida flour can be successfully formulate for the preparation of the waffle cones. The incorporation of BPF & JSF in the making of waffle cones helps to improve the texture similar to the control waffle cones and percentage of BPF and JSF addition can be varied. Continued research needs to be conducted to determine the ideal amount of BPF & JSF to add to waffle cones as it may interfere with the organoleptic properties of the waffle cones & more work can be done on this by using this formulation and to determine the tensile strength, hardness, toughness,crispiness, texture, flavour, colour analysis of the waffle cones need to be done.

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