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Original Research Article

A critical review on development, characterisation and utilisation of composite flour as a value added product

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Abstract: Background: Composite flours, created by blending various plant-based ingredients, offer a sustainable and health-focused alternative to traditional wheat flour. With rising health concerns like gluten intolerance and nutritional deficiencies, these blends enhance food products by increasing nutritional, functional and therapeutic properties. The potential of composite flours extends to be used in fortified food products, contributing to food security, public health, and sustainability goals. As consumer awareness grows regarding health and environmental concerns, composite flours are poised to play a key role in creating inclusive, functional food systems. Aim: This review explores the development, characterization, and application of composite flour formulations over the past decade. Method: Extensive literature review has been carried out via various search engines to compile the findings of research since 10 years. Conclusion: Numerous studies have demonstrated the effectiveness of composite flours in improving the nutritional and functional properties of baked and extruded products such as bread, biscuits, noodles, and wafers. These blends enhance water and oil absorption, dough stability, and shelf life, while maintaining or even improving sensory acceptability when properly formulated. Gluten free and fortified blends shown promising rheological performances allowing partial or even complete replacement of wheat flour without major loss of sensory quality. Composite flour ingredient's like millets, quinoa, amaranth, chickpeas, moringa and hempseed contribute unique nutrients and therapeutic properties like antioxidant, hypoglycaemic and hypocholesterolemic effects. However, continued research and standardization are needed to fully realize their industrial and health benefits in global food markets. Major findings- There has been notable rise in research and development of composite flour in past 10 years especially after 2023. The largest share of composite flour utilization was reported to be in bakery products (bread, biscuits, cookies and cakes) followed by extruded products (noodles and sev) and ready to cook mixes.

Keywords: Characterisation, Composite flour, Functional properties, Nutritional value, Value added products.

INTRODUCTION

Since ages, flour has been a staple component in human diets, primarily derived from cereal grains, with wheat being the most popular and acceptable due to its consumption in various forms. However, wheat flour consumption is increasingly scrutinized due to growing health concerns related to gluten and declining nutritional value, especially in refined flour. With the increasing advancements in food science and technology, researchers have begun to identify alternative sources that could enrich flour composition while addressing the dietary limitations of wheat flour. The incorporation of alternative flours, such as those from legumes, pseudocereals, oilseeds and tubers, into composite formulations has opened new pathways for enhancing the nutritional profile of conventional products. The concept of blending flours, though practiced for centuries in various cultures, was formally recognized in scientific literature as *composite flour* in 1960s. The development of gluten-free and hypoallergenic products is an upcoming area of interest. Its growing applications in the food industry marks a significant advancement, as it encourages the utilization of locally available and underused crops while optimizing the quality, acceptability, and nutritional value of food products. For example, millets have long been staples in African and Indian cuisines, prized for their resilience and rich nutritional profile[1]. With the rise of globalization, however, traditional grains have often been overshadowed by wheat and rice as dominant food crops, leading to a decline in the cultivation and consumption of many other indigenous grains. Though the sedentary lifestyles and poor nutrient density of conventional food products remains concerns, increasing nutrition and health awareness together with consumer's willingness to opt for alternative flour for wheat and explore value added products has led to greater acceptance of composite flour and promoted encouraged extensive experimentation in this area.

1.1 Composite flour

Composite flour refers to the purposeful combination of two or more different types of flours, often including wheat together with alternatives such as millet, rice, legumes, tubers, and other grains to create a product with enhanced properties like nutritional , functional, sensory, or economic surpassing those of its individual components. Compared to refined wheat flour, composite flours often boast higher levels of proteins, vitamins, and other micronutrients, making them especially beneficial in combating malnutrition and promoting dietary diversity[1]. The various categories with their examples have been listed for their nutritional and functional benefits have been tabulated in Table 1.

Table 1. Various composite flour's formulations and characterization[1]

S.No.	Category	Examples	Nutritional & Functional Benefits
1	Cereals	Maize, rice, millet, sorghum, barley, oats	Low GI, antioxidant, improved fibre & mineral content
2	Pseudocereals	Amaranth, quinoa, buckwheat	Complete proteins, rich in fibre, minerals.
3	Legumes	Chickpeas, lentils, mung beans, cowpeas	High protein, lysine-rich, hypoglycaemic properties.
4	Roots/Tubers	Cassava, sweet potato, taro, yam	Fibre-rich, gluten-free, climate-resilient crops.
5	Fruits & Veggies	Avocado, spinach, cauliflower, banana peels	Rich in antioxidants, vitamins, improved taste.
6	Mushrooms	Oyster, lion's mane, reishi	Antioxidant, antimicrobial, neuroprotective.
7	Microalgae	Spirulina, Nannochloropsis	High protein, omega-3s, antioxidants.
8	Nuts & Seeds	Flaxseed, chia, walnut, cashew	Omega-3s, protein, fibre.
9	Herbs & Spices	Cinnamon, cumin, saffron	Antioxidant, antidiabetic, flavour enhancement.

Various brands offer composite flour products, including biscuits, bread, noodles, and pasta, catering to health-conscious consumers and those with dietary restrictions (e.g., gluten-free options). Each ingredient in a composite flour blend contributes unique colour, texture, and nutritive characteristics, enhancing the sensory appeal and health value of the final product. Composite flours exhibit improved functional properties such as water absorption, swelling capacity, and emulsion stability, which are beneficial for baking. The rheological properties of dough made from composite flours vary depending on the blend but can be optimized for specific bakery products. Regular consumption of composite flours can help manage lifestyle disorders such as diabetes, cardiovascular diseases, hypertension, obesity, and celiac disease. Specific benefits include lowering blood glucose levels, reducing cholesterol, improving digestive health, and providing antioxidant properties[2]. Importance of composite flour can be characterized in following ways:

- Nutritional and therapeutic impact – Nutritionally they are rich in dietary fibre, essential amino acids, antioxidants, and phytochemicals. Reduced glycemic index, improved protein and starch digestibility, reduced risk and impact of type 2 diabetes, heart disease, obesity, and certain cancers, chronic disease prevention includes their therapeutic effect[2].

- Anti-nutritional impact: Some composite flours contain anti-nutritional factors (e.g., phytates, tannins) that can hinder nutrient absorption. However, processing techniques like soaking, sprouting, and fermentation can mitigate these effects[2].
- Functional and Technological Properties: Improved dough rheology, texture, water/oil absorption, and shelf life in bakery and pasta products[2].
- Environmental impact: Sustainable, healthy, economically viable solution for functional food development, supports dietary diversification and food security[2].

1.2 Development and characterisation of composite flour

Numerous studies demonstrate that when different flours are added to wheat to develop composite flour for preparing baked goods, the functional characteristics of the combined samples will alter. Moreover the composite flour consists of a lot of amino acids, ash, protein, fibre, and minerals like zinc, copper, potassium, magnesium, and calcium. Multiple research studies on the various formulations of composite flours currently available in the market have been published in several journals due to the increased demand for foods with higher nutritional content. The following table 2. is a collection of such formulations/ compositions and their utilization from various reviews of research-based articles,

Table 2. Few Researched developments and utilizations of composite flou

S. No.	Compositions	Ratio	Application	References
1	Wheat flour (WF), Soy flour (SF), Mung Bean flour (MF), and Mango Kernel Flour (MKF) Blend	Variation I : 85% WF, 5% SF, 5% MF, 5% MKF Variation II: 70% WF, 10% SF, 10% MF, 10% MKF Variation III: 60% WF, 14% SF, 13% MF, 13% MKF	Bread	3
2	Wheat, Rice, Green Gram, and Potato Flour Blend	Wheat flour: rice flour: green gram flour: potato flour- 100:0:0:0, 85:5:5:5, 70:10:10:10, and 55:15:15:15.	Biscuits	4
3	Wheat flour, Sorghum Flour or Chickpea Flour	Wheat flour with 10% and 15% of either sorghum flour or chickpea flour	Sponge cake and biscuit	5
4	Plantain and Moringa oleifera	1:19	Dough meal	17
5	Oats, Sorghum, Amaranth and Wheat Flour,	Wheat flour: Mix flour - 75:25, 80:20, 85:15, 90:10, 95:5 and 100:0 (control sample) respectively.	Cookies	6
6	Wheat Flour, Sorghum Flour, Soyabean Flour	Wheat flour: Sorghum flour: Soybean flour in 2 variations- 60:30:10 and 40:40:20	Sev	21
7	Wheat, Potato Or Corn Flour	Wheat flour with Potato Flour or Corn Flour in the amount of 10 %, 15 % and	Biscuits	7

		20%		
8	Wheat, Quinoa And Buckwheat Composite Flour	T0 (control) 100% wheat flour, T1, T2 and T3 with 10%, 20%, 30% of buckwheat flour while T4, T5 and T6 with 10%, 20%, 30% of quinoa flour.	Cookies	8
9	Wheat, Date Palm Fruit Pulp, and Toasted Watermelon Seed Flour Blend	Wheat flour, date palm fruit pulp meal (DPFP) and toasted watermelon seed meal in the following ratios 90:5:5, 80:10:10, 70:15:15, 60:20:20, 50:25:25	Composite Flour	18
10	Red Kidney Beans, , Sweet Potato, Dried Amaranth Leaves, Dried Carrots	Red kidney beans: sweet potato: dried amaranth leaves: dried carrots- 60:20:10:10, 70:10:15:5, 50:30:15:5, 60:30:5:5.	Soup	25
11	Spelt Flour and Grape Pomace Powder	Spelt flour substituted with grape pomace powder at levels of 0%, 5%, 10%, 15%, 20%, and 25%.	Biscuits, cakes & rolls	10
12	Wheat-Sweet Potato-Soybean Composite Flours.	T0 control = 100% wheat flour; T1 = 25% sweet potato and soybean flours; T2 = 50% sweet potato and soybean flours; T3 = 75% sweet potato and soybean flours; T4 = 100% sweet potato and soybean flours	Biscuit	9
13	Wheat, Lima Bean And Tigernut	Wheat flour : lima beans : tigernut flour at the ratios of 90:5:5, 85:10:5, 80:15:5, 75:20:5 and 70:25:5, respectively.	Cookies	11
14	Rice, Mung Bean, Black Gram, and Meneri Flour	Rice Flour: Green gram Flour: Black gram flour: Meneri Flour 40:20:10:25, 40:20:15:25, 50:30:10:35, 40:30:15:35	Extruded products	22
15	Wheat, Sorghum, and Modified Cassava Flour	Sorghum flour: MoCaf: Wheat flour : A(40:30:30), B (30:35:35), C	Noodles	23

		(20:40:40).		
16	Wheat Flour, Cassava Flour And Soyabean Flour	Wheat flour- 100%, Cassava flour: Soyabean flour- 90:10, 80:20, 70:30, 60:40, 50:50	Biscuit	14
17	Fonio, Millet, Sorghum, and Wheat Gluten Flour	90% of local cereals (fonio, millet and sorghum) with 10% gluten flour.	Baked products	16
18	Hempseed, Corn Silk, and Chickpea Flour	Wheat flour: Hemp seed flour: Chickpea flour: Corn silk powder 60:15:15:10, 50:20:20:10 and 40:25:25:10	Indian flatbread (parantha)	19
19	Moringa Leaves, Great Millet, and Finger Millet Flour	Cakes- Maida: Millet flour: Moringa leave powder- 77:20:3, 57:40:3, 37:60:3 and 17:80:3 Wafers- Maida: Millet flour: Moringa leave powder- 80:20:1.5, 60:40:1.5, 40:60:1.5 and 20:80:1.5	Cakes and wafers	15
20	Whole Wheat flour, Kidney Beans, and Unripe Plantain Peel Flour Blend	Blend B: 80% WWF, 15% KBF, 5% PPF Blend C: 70% WWF, 20% KBF, 10% PPF Blend D: 60% WWF, 10% KBF, 30% PPF	Cookies	12
21	Wheat, Pigeon Pea, and Moringa Leaf Flour	Wheat: Pigeon Pea: Moringa Leaf Flour- 100:0:0 (Control), 80:15:5, and 70:20:10	Biscuit	13
22	Wheat Flour, Breadfruit Flour	Breadfruit: Wheat flour- 25:75 and 50:50	Sausage roll	24
23	Pearl Millet, Teff, And Buckwheat Grain Composite Flour	Pearl millet: teff: buckwheat flour- 40:55:5, 30:60:10, 20:65:15, 10:70:20, 0:100:0.	Composite flour	21

2. Material and Methods

Research studies during the time period of 2014-2025 published in English were considered. Search engines Google scholar, Scopus, Web of Science, PubMed were used to collect the data. Obtained data was analysed and represented by appropriate tables and figures followed by detailed discussion with reference to supporting studies.

3. Result and Discussion

Various food products have been prepared by using different compositions of composite flour as its potential utilization unfolded with passing years since 2014. Figure 1. depicts the prevalence of composite flour utilization in bakery products, flour development extruded products and ready to cook products during 2014-2025. Based on the reviewed studies it was observed that most utilization of composite flour has been for bakery products followed by flour development extruded products and ready to cook products. However, the studies on prevalence of composite flour utilization was recorded more after 2023, this may be due to declaration of year 2023 as the International Year of Millets (IYM 2023) by United Nations General Assembly.

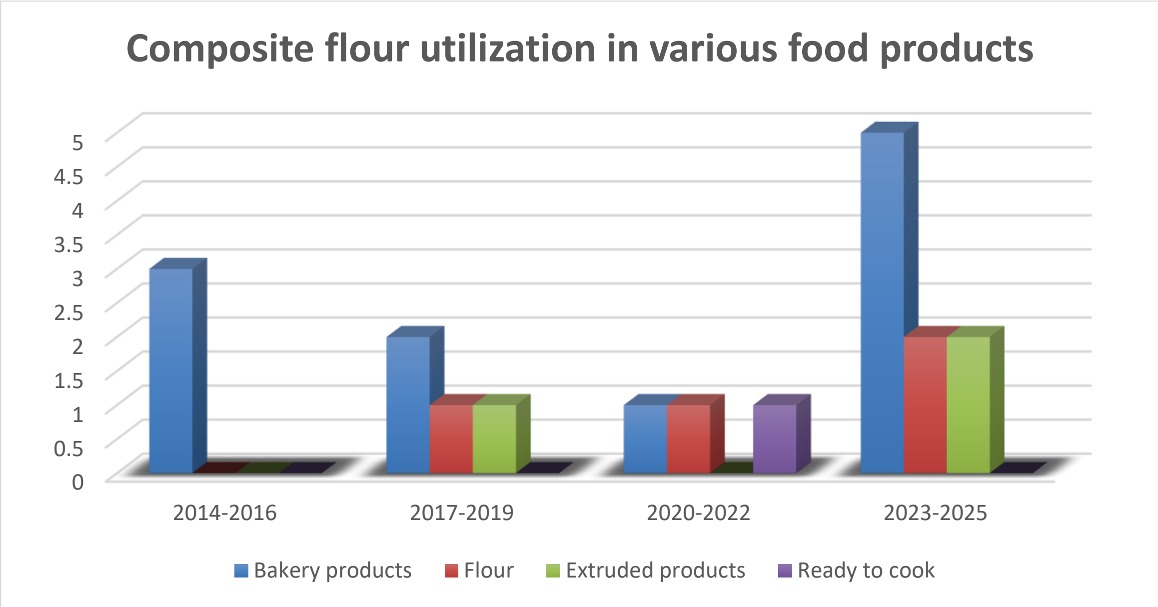

Figure 1. Composite flour utilization in various food products

3.1 Bakery products- In last decade, majority of the research have been carried out on bakery products formulations using variety of composite flours. In the research study bread was produced using composite flour prepared with *wheat flour (WF), soy flour (SF), mung flour (sprouted) (MF), mango kernel flour (MKF),* in three variations- Variation I : 85% WF, 5% SF, 5% MF, 5% MKF, Variation II: 70% WF, 10% SF, 10% MF, 10% MKF, Variation III: 60% WF, 14% SF, 13% MF, 13% MKF. It was reported that protein increase significantly ($p<0.01$) in composite flour breads (13.95–18.58 %). Increase in fat content for the composite flour bread variations was directly correlated with the percentage incorporation of high fat mango kernel flour and soy flour. The amount of total phenolic content was significantly higher ($p<0.01$) in composite flours due to the presence of mango kernel flour, since mango kernel had proved to be a good source of phenolics, though sensory evaluation of the bread scored less. The bulk density of the three experimental variations were significantly higher ($p<0.01$) than the standard refined wheat flour. The increase in water holding capacity for experimental variations were directly proportional to the incorporation of high starch mango kernel flour. The ability of flour to bind and hold more water was reported to have a significant correlation with its starch content. Water absorption capacity was least in standard refined wheat flour 62.7 % (±0.03) and was highest in the composite flour variant V-III i.e.,70.48 % (±0.04). The increased ratio of high starch mango kernel flour in composite flour variations led to the decrease in oil absorption capacity. The decrease in swelling index for experimental flours was inversely proportional with the increased substitution of standard refined wheat flour by high starch and high protein composite blends. The reduction in foaming capacity for composite flour blends in the present study indicates the ordered globular nature of the proteins contained in it[3].

Similarly, another research study utilized composite flour in biscuits preparation and evaluated the functional properties of composite flours prepared by blending of *wheat flour with rice flour, green gram flour, and potato* flour in ratios of 100:0:0:0 (W_{100}), 85:5:5:5 (W_{85}), 70:10:10:10 (W_{70}) and 55:15:15:15 (W_{55}). It was found that the green gram flour enhanced protein content, addressing malnutrition concerns. It was also reported that swelling capacity increased with higher proportions of rice, green gram, and potato flour (from 16.00 ml in W_{85} to 22.30 ml in W_{55}), water absorption capacity was noted to be highest in W_{55} (176%) that may be due to starch-rich potato flour that enhanced viscosity for dough-based products. Oil absorption capacity peaked at 156% for W_{55} and W_{70}, attributed to non-polar amino acids in green gram and potato flours, emulsion stability was improved up to 48.65% in W_{55}, that was considered beneficial for bakery products. Foam capacity & stability was observed highest in W_{55} (17.60% FC, 13.40% FS), it was linked to protein interactions. With composite flour inclusion gelatinization temperature rose up to 60.56°C in W_{55}, that may be influenced by starch content, bulk density increased from 0.762 g/cc (W_{100}) to 0.820 g/cc (W_{55}), this aids in thickening properties of composite flour. By sensory evaluation, overall acceptability of W_{55} biscuit was highest[4]. Likewise the quality characteristics of sponge cake and biscuit prepared using *wheat, sorghum, chickpea composite flour* was studied. Wheat flour was partially substituted by 10% and 15% of either sorghum flour (SF) or chickpea flour (CF). It was reported that CF had the highest protein (23.26%), lipids (6.2%), ash (1.91%), and crude fiber (2.45%) compared to wheat and sorghum flours. SF contained higher fiber (1.97%) and lipids (3.0%) than wheat flour but lower protein (9.75%). Water absorption capacity increased with higher substitution levels of SF or CF due to their high protein and fiber content. Dough stability decreased with the addition of SF or CF, that lead to weakening in gluten structure. CF blends showed better extensibility than SF. Nutritional composition of cakes with 10–15% CF had significantly higher protein, lipids, and fiber than control (100% wheat flour). Physical properties of cakes with 10% CF had the highest volume (187–190 cm³) and specific volume (4.0 cm³/g). SF substitution reduced cake volume and specific volume. Sensory evaluation of cakes with 10% CF scored similar to control in terms of color, flavor, texture, and overall acceptability. However, higher SF levels (15%) led to low sensory scores and thereby its acceptability. Biscuits with CF had higher protein (up to 11.42%), ash, and fiber than control. Spread ratio and thickness were unaffected by SF or CF substitution. Specific volume decreased with 15% SF but remained stable with 10% CF. Sensory evaluation of biscuits with 10–15% CF was similar to control in terms of color, taste, and crunchiness. 15% SF biscuits were less acceptable due to inferior flavor and texture. Hence it was concluded that CF at 10% substitution improved nutritional value (protein, fiber) without compromising sensory or physical quality in both sponge cakes and biscuits unlike sorghum flour[5].

Following the similar research trend, another study evaluated various properties of composite flour formulated from *oats, sorghum, amaranth and wheat flour*, and produced cookies from that. In the study mixed flour was formulated by 5 parts of amaranth flour, 2.5 parts of sorghum flour, 2.5 parts of oats flour and the remaining wheat flour. Composite flour was prepared by replacing wheat flour with MF at various proportions i.e. 5% (C1), 10% (C2), 15% (C3), 20% (C4) and 25% (C5). The cookies were prepared with combinations of 75:25, 80:20, 85:15, 90:10, 95:5 and 100:0 (control sample) of WF: MF respectively. Substituting wheat flour with oats, sorghum, and amaranth (up to 25%) increased protein (14.42%), fat (2.84%) fiber (2.48%), ash, and energy (353 KJ) content in both flour and cookies. Amaranth flour was a significant contributor to improved nutrient density. Water absorption, swelling power, and porosity increased with higher composite ratios. Bulk and true densities, foaming stability, and sedimentation values declined due to the absence of gluten. Hardness and spread ratio of cookies increased with more composite flour. Also, physical characteristics like diameter and thickness decreased, while colour darkened, with higher amaranth content. Cookies with 10% composite flour achieved the highest overall acceptability based on colour, flavour, and texture[6].

Similarly composite biscuits supplemented with *potato or corn flour* were also prepared where wheat flour (WF) was supplemented by the potato flour (PF) or corn flour (CF) with the amount of 10, 15 and 20%. It was observed that WF had the highest moisture (14.37%) and protein (11.46%) content, while PF contained the highest ash (2.3%) and carbohydrate (81.3%) content, whereas CF showed highest fat content (3.62%) and energy (370.1 Kcal/100g). It was also observed that supplementation with PF or CF affected the physical characteristics of biscuits, such as diameter, thickness, spread ratio, and density. Biscuits with 15% PF or CF exhibited the best spread ratio and thickness. Ash content was highest in biscuits with 20% PF (1.09%). Protein content decreased with increasing PF or CF supplementation, while fat content increased slightly with CF. PF or CF can be effectively supplemented up to 15% with WF to produce nutritious and consumer-acceptable biscuits[7].

Another study reported to use composite flour in bakery products. Study aimed to investigate rheological and sensory attributes of *wheat, quinoa and buckwheat* composite flour, followed by their use in bakery products. In the study following composition was used T0 (control) 100 % wheat flour, T1, T2 and T3 with 10%, 20%, 30% of buckwheat flour while T4, T5 and T6 with 10%, 20%, 30% of quinoa flour. Highest values of crude protein content (14.13%) were observed in the cookies having 30% buckwheat flour supplementation, while (13.94%) were observed in the cookies having 30% quinoa flour supplementation. It was mentioned that the content of fiber decreased due to the addition of buckwheat flour, while increased due to the addition of quinoa flour. Cookies having 30% buckwheat or quinoa flour was reported to possess higher values of thickness, diameter and hardness (4.92 kg for 30% buckwheat and 5.64 kg for 30% quinoa flour cookies). Spread factor ranged from 38.55 mm to 40.54 mm for buckwheat cookies and 41.48 mm to 44.26 mm for quinoa cookies. The cookies prepared with 10% buckwheat and quinoa flour supplementation got highest scores of overall acceptability. T_1 (10% buckwheat) and T_4 (10% quinoa) showed the best results in terms of nutritional benefits and sensory acceptability[8] .

In the similar manner nutritional composition of biscuits prepared from *wheat, sweet potato and soybean flour* was investigated in following formulations: T0 control-100% wheat flour; T1 -25% sweet potato and soybean flours; T2- 50% sweet potato and soybean flours; T3- 75% sweet potato and soybean flours; T4- 100% sweet potato and soybean flours. It was observed that the T3 biscuits had higher protein (13.08 g/100g) and fiber (4.2 g/100g) compared to the control (100% wheat flour). Reports indicated increased levels of copper, manganese, calcium, magnesium, and potassium. However carbohydrate and energy content was reduced, making them a healthier alternative. It was mentioned that substitution improved water absorption capacity (81.33%) and solubility index (29.88%) that are considered critical for dough handling and baking quality. It was perceived that the biscuits with 75% substitution of wheat flour (25% wheat, 300g sweet potato, 75g soybean flour) were the most preferred in sensory evaluation[9]. By the substitution of *spelt flour (SF) with grape pomace (GP) powder* (up to 25%) in biscuits, cakes and rolls led to 7–8 times increase in Total Phenolic Content (TPC), 7–8.6 times increase in Total Flavonoid Content (TFC), 16–18.7 times increase in antioxidant capacity. It was observed that despite heat exposure during baking, a good portion of bioactive compounds remained i.e., 41–63% retention for TPC, 37–65% for TFC, 48–70% and 45–70% for antioxidant capacity. It was also reported that pastries enriched with GP had increased ash and lipid content, reflecting higher mineral and healthy fat levels. However there was slight decrease in protein, as GP has less protein than spelt flour. Whereas higher energy content was present due to added GP fats and a slight moisture reduction was found that have potential to improve the shelf life[10].

Quality attributes of cookies from *wheat, lima bean, and tigernut composite flou*r at the ratios of 90:5:5, 85:10:5, 80:15:5, 75:20:5 and 70:25:5 respectively, was studied. It was observed that crude protein increased from 7.04% to 8.08%, indicating higher protein content due to lima bean inclusion; crude fibre ranged from 3.06% to 3.48%, ash content ranged from 1.65% to 2.10%, carbohydrates remained high around 72–73%. Further it was mentioned that water absorption capacity also increased up to 234.20% with substitution that was known to improve dough handling and freshness, oil absorption capacity ranged from 147.83% to 174.38% reported to enhance the mouthfeel and flavour retention. It was also found that the bulk density and swelling power also increased, contributing to better texture and structure in cookies. It was concluded that the sample with 70:25:5 ratio (wheat: lima bean: tigernut) had the highest overall acceptability score (8.05/9) indicating consumer preference for higher lima bean content[11].

In a research study proximate, mineral and anti-nutrient composition of cookies from *whole wheat, kidney beans and unripe plantain peel composite flour* was estimated. It was observed that protein content significantly increased with higher kidney bean substitution i.e., from 10.82% in 100% wheat cookies (control) to 14.24% in Sample C (70% wheat, 20% kidney bean, 10% plantain peel). Crude fibre was also reported to increase notably from 1.70% (control) to 3.02% in Sample D (60% wheat, 10% kidney bean, 30% plantain peel), ash content increased from 1.54% to 2.54%, fat content rose from 7.69% to 11.72% in composite samples. Whereas, carbohydrate content decreased with increased composite flours, making them suitable for low-carb diets. It was also reported that mineral profile like calcium increased from 45.22 mg/100g (control) to 75.31 mg/100g (sample D), magnesium increased from 32.00 mg/100g to 62.06 mg/100g, phosphorus from 20.26 mg/100g to 31.79 mg/100g. These enhancements reported to support better bone health and metabolic functions. While increased anti-nutrient content was still within acceptable limits like oxalate ranged from 2.27 mg/100g to 2.97 mg/100g, tannin increased from 1.18% to 3.28% and phytate from 1.11% to 5.12%[12].

Likewise, the nutritional and sensory properties of biscuit made *from wheat, pigeon pea, and moringa leaf* flour blends was studied and reported that biscuits made from 70:20:10 (wheat: pigeon pea: moringa) baked at 180°C had highest protein (17.86%), fiber (9.8%) ash (4.5%) and fat content 9.5%, while lowest carbohydrates (42.23%). Micronutrient profile revealed significant increase in zinc from 0.30 mg (control) to 4.58 mg, iron from 0.77 mg (control at 200°C) to 1.82 mg and vitamin C (30.96 mg). However this blend was found to be lowest in terms of vitamin A content. Most preferred sample was 80:15:5 blend baked at 200°C that scored highest in taste, color, appearance, flavor, texture, and overall acceptability[13].

Further, on continuous exploration of composite flour ingredients the utilization of *cassava/ soybean composite flour* in biscuit making was examined in the proportions of : 90% cassava flour and 10% soya bean flour, 80% cassava flour and 20% soya bean flour, 70% cassava flour and 30% soya bean flour, 60% cassava flour and 40% soya bean flour and 50% cassava flour and 50% soya bean flour. The other sample used 100% wheat flour, which served as the control sample. It was documented that blend of 80% cassava flour and 20% soybean flour produced biscuits with comparable protein content (13.21%) to 100% wheat flour (10.88%) while maintaining acceptable sensory attributes (color, texture, taste). It was observed that increasing soybean flour proportion raised protein (up to 21.48% at 50% soy) and fat content while reduced carbohydrates content (from 69.30% to 56.15%). Hence it was concluded that the blend of 80:20 showed the balanced nutrition and sensory quality which makes it a viable wheat substitute[14]. Keeping in mind the varied taste buds of population, a research study has been conducted to develop and evaluate ready to eat value added products : cake and wafer from composite flour made from *moringa leaves powder and great millet & finger millet flour*. For cakes- maida: millet flour: moringa leaves powder was combined in the ratio of 77:20:3, 57:40:3, 37:60:3 and 17:80:3 and for wafers- maida: millet flour: moringa leave powder in the ratio of 80:20:1.5, 60:40:1.5, 40:60:1.5 and 20:80:1.5. It was reported that protein, fibre, and mineral contents were significantly increased in both cake and wafer samples developed with composite flour (millets + moringa) compared to control (maida-based). Cake made from combination 17:80:3 comprised of protein 10.26 g, crude fibre 10.92 g, calcium 167.6 mg, iron 3.98 mg, thiamine 0.53 mg, niacin 1.16 mg, whereas, wafer prepared from 20:80:1.5 contains protein 4.87 g, crude fibre 5.88 g, calcium 87.28 mg, iron 2.09 mg, thiamine 0.37 mg, niacin 0.84 mg. It was mentioned that cake (17:80:3) and wafer (20:80:1.5) had the highest scores in appearance, taste, texture, and overall acceptability among all formulations[15].

Recently a research study explored the composite flour formulation prepared from 90% of local cereals *fonio, millet and sorghum* with 10% wheat gluten flour. It was quantified that the addition of 10% gluten flour to 90% local cereal flours (fonio, millet, and sorghum) significantly increased protein content wherein fonio composite showed change from 7.2% to 14.25%, millet composite from 7.1% to 14.36% and sorghum composite increased from 9.5% to 15.35% . Further improvements were also noted in fiber content and slight increase in iron, zinc, and vitamins like β-carotene and niacin was also observed. However, energy values remained adequate for daily dietary needs. Water absorption capacity was reported to be highest in fonio-gluten mix (180.29%) followed by sorghum (121.54%) and millet (115.62%). Also the oil absorption capacity was reported to be highest in fonio composite (104.38%), showing potential for better flavor retention. It was documented that all three blends showed baking strength ≥150 J, that met bread-making requirements. Its extensibility and toughness improved with gluten, especially in the sorghum blend. It was observed that sorghum-gluten blend had the highest extensibility (77.6 mm), toughness (135 mm) and best swelling index (18.7 m^3) indicating superior gas retention and loaf structure. It was concluded that fonio-gluten blend had the highest baking strength (160J)[16].

3.2 Mixed flour - Flour blend obtained from *plantain and moringa* showed significant difference in nutritional content and functional properties. Ingredients used was peeled plantain pulp flour (P), peeled plantain pulp flour with moringa (PM), plantain with the peel flour (PP), plantain with the peel and moringa flour (PPM). It was reported that protein and fat content increased in blends with moringa (e.g., crude protein: 7.11% in PM vs. 4.42% in control). Ash content was reported to be highest (3.85%) in the PPM blend, attributed to peels and moringa. It was also observed that the inclusion of plantain peels and moringa leaf powder increased total dietary fiber by over 50%, with insoluble fiber reaching up to 41.23% in the blend with peels and moringa. Also soluble fiber also rose significantly, enhancing potential health benefits like blood glucose modulation and cholesterol reduction. Plantain peels contributed significantly to antioxidant activity, with DPPH radical scavenging capacity 6-fold higher in unpeeled plantain flour compared to peeled pulp flour (P). Moringa addition boosted ferric reducing antioxidant power (FRAP), indicating improved electron-donating ability. Water absorption capacity increased with peel and moringa inclusion (up to 205.69%) that was reported to be beneficial for dough-based foods, while oil absorption capacity was reduced. It was also observed that foaming capacity declined with peel addition but remained stable with moringa. The flour blends with moringa and peels showed reduced peak viscosity (257.8 RVU in PPM vs. 367.4 RVU in control), indicating weaker starch gel formation and higher resistance to shear-thinning. Moringa blends had lower setback viscosity which shows reduced starch reordering and thus improved shelf-life. However there was no significant difference in sensory scores (taste, texture, color) between control and composite flour blends, demonstrating consumer acceptability despite added peels/Moringa[17].

A composite flour was developed with *date fruit pulp, toasted watermelon seed and wheat* in the following ratios- 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25. It was found that 50:25:25 had the best nutritional profile, its protein increased from 11.30% (control) to 20.00%., fat increased from 9.70% to 13.38%, crude fibre increased from 1.53% to 3.67%, ash increased from 3.34% to 5.84%, carbohydrate increased from 50.13% to 60.00%, whereas moisture content decreased with higher substitution which was considered to improve shelf life. While the functional properties were reported to be enhanced like bulk density got improved (0.72 g/ml to 0.85 g/ml) with increased substitution, foam capacity also increased from 9.48% (control) to 11.95% in 50:25:25, emulsion capacity increased from 1.52 g/ml to 3.17 g/ml, indicating better emulsification potential, gelation temperature rose from 60.55°C to 67.55°C, suggesting better thickening ability, pH increased from 5.63 to 6.71, indicating lower acidity, while viscosity decreased with substitution, that was likely to be due to increased fat and protein content. Study supported and reported that the composite flour was nutritionally enriched especially suitable for people with diabetes, due to the presence of natural sugar content in dates[18].

Similarly, the composite flour combination of *wheat flour: hemp seed flour: chickpea flour: corn silk powder* was investigated in the ratio of 60:15:15:10, 50:20:20:10 and 40:25:25:10 for its nutritional and bioactive properties. It was found to have enhanced crude protein content 17.06% (vs. 11.46% in whole wheat flour), crude fiber content 7.81% (vs. 3.20%), crude fat content 7.30% (vs. 2.16%), ash content: 3.48% (vs. 1.92%) that indicates better mineral content, total dietary fiber 21.37 g/100g (vs. 10.58 g/100g). Further it was quantified that total phenolic content was 223.51 mg GAE/100g (vs. 49.82 mg GAE/100g) and antioxidant activity (DPPH) 75.24% (vs. 36.32%). It was also mentioned that the water absorption capacity was higher than wheat flour 179.63 ml/100g, bulk density slightly more than wheat flour 0.77 g/ml. Whereas, oil absorption capacity was noted to be slightly lower than wheat flour, due to high fat from hempseed. Composite flour paratha was observed to have higher protein (16.36%), fiber (8.15%), and fat (11.02%) than the control and lower carbohydrate content (60.48% vs. 71.37%) that was considered to be beneficial for diabetic diets. It also showed higher antioxidant activity (DPPH inhibition 99.47%) than control (56.95%), high polyunsaturated fatty acids (PUFAs), while low saturated fats, minimal trans fats (0.04% in final product). Sensory scores showed that composite flour paratha (especially Blend 2: 20% hempseed, 20% chickpea, 10% corn silk) was highly acceptable in taste, texture, and overall appeal[19]. Likewise, the nutritional composition, functional and pasting properties of *pearl millet, teff, and buckwheat grain composite flour*. In this study, the effect of five blends of BR1 (40 % PMF, 55 % TF and 5 % BWF), BR2 (30 % PMF, 60 % TF and 10 % BWF), BR3 (20 % PMF, 65 % TF and 15 % BWF), BR4 (10 % PMF, 70 % TF and 20 % BWF), and control (100 % TF) were studied. It was reported that protein content range from 8.59% (control) to 9.94% (40% pearl millet, 55% teff, 5% buckwheat blend), crude fat increased from 3.70% (control) to 5.40% in blends with higher pearl millet content. It was also mentioned that inclusion of teff significantly enhanced the content of iron (8.64–11.12 mg/100g), calcium (72.82–93.14 mg/100g), and zinc (1.32–1.74 mg/100g) while pearl millet enhanced zinc content. It was found that total phenolic content was highest in the blend with 10% pearl millet, 70% teff, and 20% buckwheat (110.42 mg GAE/100g), whereas phytic acid and tannins was highest in buckwheat but blending reduced antinutritional effects while retaining health-promoting properties. Bulk density was reported to range from 555.08 to 597.81 kg/m³, with higher values in blends containing more buckwheat. While water absorption index got improved in composite flours (2.12–2.18 g/g) compared to control (2.12 g/g), indicating better dough consistency. Water solubility index showed higher solubility (6.63–7.00%) and suggested improved digestibility. Peak viscosity was found highest in buckwheat (3347 cP) with composite flours ranging from 1454 to 2071 cP, indicating good thickening ability. Pasting temperature was recorded to be lowest in the blend with 10% pearl millet, 70% teff, and 20% buckwheat (73.48°C), suggesting easier cooking. The blend of 70% teff, 20% buckwheat, and 10% pearl millet (BR4) was identified as the most nutritionally balanced, with enhanced functional and pasting properties, making it suitable for gluten-free food products like injera and baked goods[20].

3.3 Extruded products- An assessment of nutritional and keeping quality characteristics of value added composite flour sev prepared from *wheat flour, sorghum flour, soyabean flour* was carried out. Wheat flour: sorghum flour: soybean flour in 2 variations were used (with 2 varieties of wheat flour WH-1129 and HD-2967) in 60:30:10 and 40:40:20 which was compared to control-100% wheat flour. It was reported that protein content increased from 9.32% (control) to 11.36% (WH-1129 composite sev) and 11.19% (HD-2967 composite sev). Fat content increased from 13.48% (control) to 16.55% and 17.14% in composite sevs. Crude fibre also increased significantly from 1.56% (control) to 4.23% (WH-1129) and 3.53% (HD-2967) while ash content increased from 3.56% (control) to 3.87% (WH-1129) and 3.47% (HD-2967). WH-1129 wheat flour blends (40:40:20 ratio) scored highest (8.32) in overall acceptability[21].

Another research study wherein there was development of nutrient rich extruded product using *rice flour: green gram flour: black gram flour: meneri flour* in 40:20:10:25, 40:20:15:25, 50:30:10:35 and 40:30:15:35 proportion. Best formulation was found to be 50:30:10:35 with carbohydrates 63.37%, protein 20.91%, fat: 6.01%, dietary fiber 9.20%, ash 2.41%, Calcium 940.28 mg, sodium: 413.06 mg, iron: 6.73 mg, zinc: 3.22 mg. These values were higher than a comparable market product, especially in protein, fiber, and mineral content. This was the most nutritionally valuable and sensorially accepted formulation[22]. An experimental research with three different ratios of *sorghum flour: mocaf: wheat,* namely A (40:30:30), B (30:35:35), and C (20:40:40) was carried out to see the composition effect on the elongation, tensile strength, and acceptability of wet noodles. It was reported that composition C (20% sorghum : 40% mocaf : 40% wheat) had the highest elongation (12.96%), while A (40:30:30) had the lowest (7.26%). It was observed that higher wheat and mocaf content led to better elongation due to higher gluten and amylose content. However, composite flour composition did not significantly affect tensile strength. Hence by evaluating every aspect composition C was rated most acceptable[23].

An evaluation and optimization of the proximate composition, farinographical, extensographical and sensory properties of sausage rolls was performed which was made from *wheat flour (WF)- breadfruit flour (BF)* composite. It was observed that 5% BF blends showed optimal farinographical properties like higher dough stability, lower mixing tolerance index (indicating stronger dough). Extensographical analysis confirmed 25% BF blends maintained gluten-like elasticity that is considered to be suitable for baking. It was reported that composite flours with breadfruit flour substitution enhanced nutritional value. However reduced protein content (from 13.69% in WF to 11.60% in 50% BF blend) was observed but had improved water absorption capacity (up to 208.48% in 50% BF blend) which was known to aid in dough handling. It was reported that 25% breadfruit flour (BF) + 75% wheat flour (WF) produced sausage rolls with comparable sensory and rheological properties to 100% wheat flour (control)[24].

3.4 Ready to cook items- An analysis of the physicochemical properties and sensory evaluation of a bean-based composite soup flour was carried out. The composition of *red kidney beans: sweet potato: dried amaranth leaves: dried carrots* was used in 4 variations 60:20:10:10, 70:10:15:5, 50:30:15:5 and 60:30:5:5. It was reported that among these formulations 70:10:15:5 was preferred most in terms of nutritional and sensory parameters. It was found that formulations 70:10:15:5 was high in protein (20.58g/100 g) and met 158% of the daily dietary reference intake (DRI) for children aged 1–3 years, carbohydrates (59g/100 g) whereas, low fat (2.93g/100 g) and fiber (3.38g/100 g) content. Micronutrients like calcium (216.2 mg/100 g) was 43% of DRI, iron (3.83 mg/100 g) 55% of DRI, high vitamin C (166.36 mg/100 g) 1,109% DRI and vitamins B2 114% DRI. It was also observed that it had water absorption capacity (70.5%) which is considered ideal for soup consistency, oil absorption capacity (28%) known to enhance flavour retention, gelatinization temperature was found to be at 88.5°C that indicates intact starch granules for stable texture and foaming stability of 33.4% was considered to improve mouthfeel of soup[25].

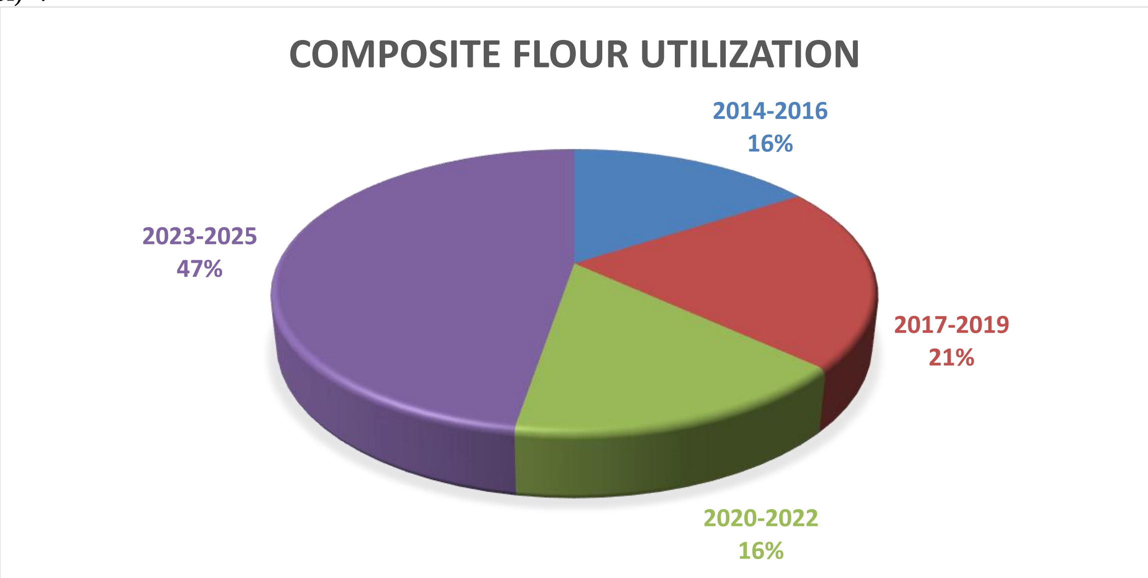

Figure 2. Composite flour utilization during 2014-2025

Figure 2. represents the percent utilization of composite flour during the time period of 2014 – 2025. There is significant growth in utilization of composite flour since 2014.

CONCLUSION

Composite flours are particularly relevant in addressing public health concerns. Consumption of composite flour can lead to the management of lifestyle-related diseases, provide healthier diet options and offers numerous applications in the food industry that further supports food security, and enhances economy. The rise in prevalence of gluten intolerance and coeliac disease has amplified interest in gluten-free flour blends, further boosting the demand for wheat-free composite flours. Vast research has explored the potential of composite flours, much of the focus to date has been on partial substitution of wheat flour. Full replacement in various research studied, holds promising potential for future innovation and wider dietary inclusion.

Composite flour's optimization and targeted research are needed for greater industry uptake.

5. Author's Contribution

Shashi Prabha investigated and drafted the manuscript; Sarvesh Rustagi and Poonam Lakra reviewed the manuscript and did the conceptualization. All authors have read and approved the final version of the manuscript.

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