Flatbread - A canvas for innovation: A review

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ABSTRACT

Flatbreads are among the oldest foods throughout the world. They are affordable, familiar, and authentic foods with a long history in several countries. Their high versatility puts forward their use as a canvas of innovation to create new flavors. Flatbreads can be also considered vehicles for adding health-beneficial ingredients to improve the nutritional profile and sensorial properties, and add peculiar flavors. These products suit modern lifestyle by offering convenient and easy to prepare snacks or meals. The use of wholegrains and multigrains will keep trending upward to attract health-conscious consumers. Future opportunities for expansion rely on the use of natural, sustainable, and clean label ingredients, and addressing niche markets such as vegan/vegetarians and consumers with intolerances and allergies. In this review, flatbreads formulations, types, and nutritional composition are reviewed. An in-depth market search was conducted to identify the main trends in new products development.

1. Introduction

Flatbreads are the oldest of all bread products and they are consumed worldwide (Neela & Fanta, 2020). They are traditionally consumed in the Middle East, North and South Africa, the Indian subcontinent, Central America, China, and Europe. The consumption of flatbreads is increasing throughout the world, and moved from traditional to commercial mechanical production (Fayaz et al., 2021). The global flatbread market size was valued at $38.8 billion in 2018, and then increased to $41.17 billion in 2019, and is estimated to reach $62.8 billion by 2026, at compound annual growth rate of 6.2% (Allied Market Research, 2021). By product type, the market is mainly categorized into tortilla, naan, pita, focaccia, fry bread and others (Allied Market Research, 2021). In term of region wise, flatbreads are sold across the globe with North America dominating two-thirds of the market in 2019 (Allied Analytics, 2021).

Flatbreads are generally made from a flattened dough of flour, salt, water, and yeast. The main production steps are kneading of ingredients, leavening (optional), shaping and baking (Pasqualone, 2018). Nutritionally, flatbreads are a major source of calories and nutrients (Fan et al., 2019). Several fortifying ingredients can be incorporated to further improve the nutritional value of flatbreads and to provide versatile products that meet consumers dietary lifestyle and needs (e.g., vegan, vegetarian gluten-free or dairy-free). The versatility of ingredients and baking processes provides different types of flatbreads (Kahlon, Avena-Bustillos, Brichita & Kahlon, 2019). Revisited flatbreads have been developed with the aim to provide healthy, ready-to-eat and convenient products in response to increased urbanization and awareness towards health and sustainability. Despite the importance of flatbreads, there has been few published literature focusing on this product category when compared with pan or volume breads. This review aims to outline the formulation, types, and nutritional value of flatbreads. Due to increased demand towards flatbreads, a section has been allocated to the main trends in new product development.

2. Formulation

2.1. Basic ingredients

The basic ingredients of flatbreads are flour, water, salt/ sugar, and yeast. The flours can derive from various gluten-containing or gluten-free grains or seeds. Cereals, especially wheat, maize, and rice are mostly used to make flatbreads (Serka, Getahun & Abegaz, 2019). Minor cereals such as barley, millet, oats, rye, and sorghum have also a long history in flatbread making in Africa and India (Boers et al., 2017; Mehfooz, Mohsin Ali, Arif & Hasnain, 2018a). Their addition increased protein, minerals and fiber compared to wheat-based flatbread but decreased water absorption and dough stability depending on the level of addition (Selleem & Oman, 2014; Yousif, Nhepera & Johnson, 2012). Despite the relevant impact of sorghum on flatbreads properties, adding 30% sorghum was perceived highly acceptable by consumers from Africa and middle East due to familiarity (Selleem & Oman, 2014). The addition of millet (up to 20%) improved the nutritional quality (protein and fiber) and improved puffing and resis-
tance, shrinkage, and baking time in comparison to wheat-based unleavened flatbread (Kumar, Kaur & Jambh, 2021). Pseudo cereals such as teff are widely used in South Africa to make flatbreads (Injera in Ethiopia) (Diddana, Kelkay & Tescha, 2021). Teff, quinoa and amaranth are rich sources of proteins, fibers and several bioactive compounds (Boukid, Folloni, Sforza, Vittadini & Prandi, 2018). The addition of amaranth flour in gluten-free flatbreads significantly improved the doughs’ textural properties and resulted in flatbreads with improved color (Piga et al., 2021). However, during a storage period of 3 days, this incorporation reduced the quality (i.e., increased starch retrogradation, crumb firmness and extensibility properties) of these breads. This can be due to the high fiber content of amaranth flours causing water migration and thus accelerated staling. Quinoa addition increased protein content and improved amino acid profile as well as mineral contents (such as sodium, potassium, magnesium, calcium, iron, copper, manganese, and zinc). Increased protein and fiber resulted in higher water absorption, while starch increased dough development time. The addition of 20% quinoa flour resulted in doughs with high stability value (indicating high dough strength). Nevertheless, the obtained breads showed reduced specific volume and increased hardness due to the changes of gluten secondary structure and gluten dilution effect (Ctoovanu, Unguream-Iuga & Mironaeza, 2022). At 30% addition level, detrimental effects were observed in texture (gumminess and chewiness) resulting in a low acceptability of enriched breads (El-Sohaimy, Shehata, Mehany & Zeitoun, 2019). Flavor was appreciated up to 15% level and described as nutty, and no bitter aftertaste was perceived contrary to breads made with 30% quinoa flour. The use of pulses flours to make flatbreads is not a recent trend following the public recognition of their health benefits such as high protein and fiber contents (Boukid, Zannini, Carini, & Vittadini, 2019). Pulses were blended with rice or maize flours to make traditional flatbreads (e.g., Kocho made with beans in India) with higher protein content and lower starch digestibility compared to control flatbread (Ray, Ghosh, Singh & Chandra Mondal, 2016; Serka et al., 2019; Boukid, Rosell, & Castellari, 2021). From a rheological point of view, pulses addition increased dough water absorption due to increased protein and fiber contents. Sensory evaluation showed that adding more that 15% pulses flours decreased color, taste, aroma, breakability, and overall acceptability of enriched flatbreads (Wani, Sogi, Sharma & Gill, 2016). However, high addition level of pulses might result in reduced organoleptic properties due to off smells of some pulses. Advances in technologies and breeding aims to mitigate the components responsible of undesirable flavors and color and thus favor the addition of higher amounts of pulses (Boukid, Rosell, Rosen, Bover-Cid & Castellari, 2021; Santos et al., 2019). Grains/ seeds derived flours can be used refined or as whole flours (Boukid & Rosen, 2020). Wholegrains have gained much attention as health-beneficial ingredients in flatbreads making (Khalon, 2018; Liu, Hou, Cardin, Marquart & Dubat, 2017; Maya-Cortés et al., 2010). The quantity of water in flatbreads depends on the flour properties (protein content and water holding capacity) (Fayaz et al., 2021). Indeed, adding wholegrains to dough increased water absorption and dough development time. Incorporating high amounts of wholegrain flours increased crumb firmness and resulted in bread with medium acceptability (Kotetta, Irakli, Papageorgiou & Skendi, 2014). Yeast, sour dough, and baking soda are the main leavening agents, and they are optional ingredients depending on the type of flatbread (leavened or unleavened) (Fayaz et al., 2021). Flatbreads can be salty in which salt is used for flavoring and for increasing gas retention or sweet in which sugar or honey is added for improving the flavor, texture, and the color of flatbread. In salty flatbreads, sugar can be added at small amounts to serve as a substrate for the yeast.

2.2. Fortifying ingredients

Fortification is applied using additional ingredients for improving the functional, nutritional, or/ and creating new flavors and thus enriching the portfolios of flatbreads. These ingredients can be classified based on their source into animal- or plant-based materials (Patil & Arya, 2019).

Animal-based ingredients can be added in different forms including butter, milk, yoghurt, whey or egg. These ingredients are commonly used for improving the technological, nutritional quality, and sensory attributes of flatbreads. Protein rich ingredients also can ensure an improved protein network development ensuring dough stability (Benali et al., 2021). In milk protein concentrate, peculiar flavors have been identified that correspond with tortilla flavor, which may result from Maillard browning, lipid oxidation, or amino acid degradation (Carter, Cheng, Kang, Meletharyal & Drake, 2021). Eggs contribute into structure, leavening, richness, color, and flavor of flatbreads (Gellinas, 2021). Additionally, they are high-quality protein source beside other micronutrients such as vitamins (vitamin B12) and minerals (e.g., iodine, phosphorus, selenium, zinc, and iron) (Idamokoro, Falowo, Oyegu & Afolayan, 2020). Whey proteins are also commonly used to increase protein content specially in gluten-free flatbread formulations (Patil & Arya, 2019).

Plant sources are incorporated in different forms including flours, oils, starches, fibers, or proteins. Flours derived from pulses (chick-pea flour, cowpea flour), vegetables (fenugreek, cassava) and seeds (flaxseeds) are used for their nutritional and functional properties (Benali et al., 2021; Boers et al., 2017; Dankwa, Aisala, Kayiitesi & Kock, 2021; Pathania, Kaur & Sachdev, 2017). Composting different flours for flatbread production could improve the functional properties of dough or batter due to changes in protein-starch and protein-protein interactions compared to using the flours individually (Patil, Sonawane & Arya, 2021). Rheological properties of chapatti dough enriched with spinach powder showed an increase in water absorption and tenacity and a decrease in extensibility (Khan, Maheesh, Semwal & Sharma, 2015). Other emerging flours of hemp and microalgae are being used to enhance the nutritional value (i.e., protein, omega-3, and omega-6 fatty acids) (Sharma & Prabhhasankar, 2021). These ingredients are usually added at low amounts due to their strong flavors (microalgae) that might induce negative impact on the organoleptic properties of final products. Insect flours were also used as protein rich ingredients. It was reported that the addition of freeze-dried cricket flour/paste (10–15%) increased water absorption and dough consistency but weakened the strength of the gluten network. Increasing the addition level of these flours resulted in increased hardness and decreased extensibility. At a low level (5%), cricket flour supplemented chapatti had similar texture to that of the control (Khatun, Van Der Borght, Akhtaruzzaman & Claes, 2021). Starches (e.g., cassava starch, potato starch or tapioca starch) are widely used to improve the texture, appearance, and overall acceptability of flatbreads specially those gluten-free (Horstmann, Belz, Heitmann, Zannini & Arendt, 2016; Martinez & Boukid, 2021). This can be attributed to starches ability for water holding and network formation and air entrapment as well as they are characterized by a bland taste fitting conventional and emerging formulations of flatbreads (Siguenza-Andrés, Gallego & Gómez, 2021). Proteins isolates, hydrolysates or concentrates are also used to increase protein content and improve the amino acid profiles as well as to get advantages from their bioactivity (e.g., antioxidant peptides) (Acevedo-Martinez & de Mejia, 2021). Most commonly, vital gluten is incorporated in flatbread formulations to enhance the rheological characteristics of weak flours or to mask gluten dilution effect when gluten-free flours were used for partial substitution of wheat (Sharma & Prabhhasankar, 2021). The addition of protein isolates such as lupin increased the dough development time, stability and the extensibility of the dough (Paraskevopoulos, Provatidou, Tsotsiou & Kiosseoglou, 2010). It resulted in reduced bread volume due to gluten reduction but delayed bread staling. Sensory properties were appreciated, and high amounts of isolates can be added compared to flour without inducing changes in flavor (Boukid & Pasqualone, 2021). Fibers are added as pure extracts (β-glucan and hemicellulose) or rich fractions (e.g., husk, dried peel or bran) (Boers, MacAulay & Murray, 2016; Eshak, 2016). Fibers play an important role in flatbread rheological properties owing to their physical effects such as the interaction with water, stability and development time (Kaur, Boekhoff, & Stahl, 2017). These could be due to the fact that fibers increase dough plasticity, which results in an increased water absorption of dough and increased dough plasticity (Kaur, Boekhoff, & Stahl, 2017).

Application of food research in flatbread production provides the benefits that improve the quality of these foods, which are generally associated with the nutritional content and organoleptic quality.

Future research in flatbread development will provide potential benefits for the better understanding of the applications of new flours and novel ingredients.
ing to their ability for water holding and gelling beside having nutritional benefits such as weight management, satiety and insulin sensitivity (Barber, Kabisch, Pfeiffer & Weickert, 2020). Adding fiber rich ingredients such as barley husk (up to 30%) increased water absorption and decreased dough extensibility which in turn increased hardness of chapatti (Mehfuzz, Mohsin Ali, Arif & Hasnain, 2018b). Fruits such as dates, apple or banana are mainly added for flavoring motives in sweet flatbreads. Furthermore, these ingredients can import health beneficial compounds such as antioxidants, vitamins, and minerals (Dhalaria et al., 2020). Likewise, vegetables and spices (e.g., garlic, onion, ginger powder, or chili powder) are added for their flavor properties in salty flatbreads (Pathania et al., 2017). Seeds such as sesame and black seeds are commonly added intact on the surface of flatbreads such as Chinese sesame flatbread (called shaobing or huoshao). The seeds have several health benefits including anti-biotic, anti-inflammatory, antihistaminic, antibacterial, anti-bronchial and immune effects (Ahmad et al., 2021).

This is due to their rich composition of minerals (iron, magnesium, manganese, copper, and calcium), vitamins (B1 and E), unsaturated fatty acids and fiber. Food additives have been also employed in flatbreads to ensure a better quality (through the use of emulsifiers, crosslinking enzymes, levitating agents) and to standardize flatbread quality (Chhabra, Kaur & Kaur, 2018). Hydrocolloids such as guar gum and xanthan gum are added in small quantities to improve the rheological properties and reduce the glycemic index of flatbreads (Giri, Banerji, Lele & Ananthanarayan, 2017).

3. Categorization

Due to the composition and methods of preparation (Table 1), different classifications were suggested to typify flatbreads (Mansoor, Ali & Hasnain, 2021). Flatbreads can be classified in two different categories, i.e., single layered and double layered (Kumar, 2016).

Single-layered flatbreads can be divided in two subgroups, leavened and unleavened. Leavened flatbreads can be made from a semi-fluid batters or doughs (Ray et al., 2016). Various types of flatbreads are prepared using semi-fluid batters such as Ethiopian injera (Diddana et al., 2021). These batters are often obtained from gluten-free cereals like rice, sorghum, teff, maize, or black beans, which are usually fermented twice and then baked in a pan (Pasqualone, 2018). Grain flour mixture fermented by lactic organisms and yeast has probiotic and probiotic benefits. Flatbreads made from doughs are leavened, risen twice before baking and then baked in the oven at high temperatures. Unleavened single-layered flat bread such as roti, tortilla, and paratha are 12–25 cm in diameter and 1.3–3.0 mm thick (Diddana et al., 2021). Traditionally, these flatbreads are rolled and baked on a clay griddle (naan) or iron pan (roti) or shallow fried in a pan with oil (paratha) or deep-fried (poories). Fried flatbreads have peculiar organoleptic properties related to δ-decalactone (oily/peach), 2-acetyl-1-pyrroline (roasty/popcorn-like), 3-methylbutanal (malty), methional (baked potato-like), 2,3-butanedione (buttery), phenyl acetaldehyde (flowery), and (E,E)-2,4-decadienal (deep-fried) (Lasekan & Dabaj, 2020). Nevertheless, they are less recommended due to their high fat content. Three methods are currently applied for industrial production of flatbreads namely hot-press, die-cut, and hand-stretch (Bejosano & Aliwola, 2015).

Double-layered flatbreads such as and Arabic flatbread (pita) and baladi are risen twice and expand during baking at high baking temperatures (350–600 °C) which result in the formation of a balloon-like shape with separate upper and lower surfaces (Pahwa, Kaur & Puri, 2016; Pasqualone, 2018). The expansion depends on the viscoelastic properties of the flour (high gluten content). After baking, the balloon deflates due to cooling, resulting in a soft and flexible flatbread that can be stuffed with meat and/or vegetables (Pasqualone, 2018).

4. Nutritional facts of a selection of the most sold commercial flatbreads

Flatbreads are a versatile product and available with a wide variety of ingredients resulting in a nutritional composition that can largely differ. Based on Mintel’s data, more than 12,986 flatbreads are currently commercially available. An overview of the nutritional composition of the most popular flatbreads (i.e., tortillas, pita bread, naan, parathas, and focaccias) launched between 2015 and 2021 in the global market is summarized in Table 2. In general, flatbreads have a high carbohydrates content irrespective of the type due to the high use of starchy ingredients. The average sugar content does not exceed 5 g and thus can be classified as “low in sugar” (Regulation (EC) No 1924/2006). Parathas have high fat content since they are fried in oil (Sudha, Eipson, Khanum, Naidu & Venkateswara Rao, 2015), while pita bread had the least fat due to the low amount of oil used in the formulation. Tortilla has the highest mean fiber content probably due to the use of wholegrains like maize. Overall, on an average of all flatbreads exceed 3 g of fiber per 100 g and thus can be classified and claimed as “source of fiber” (Regulation (EC) No 1924/2006).

5. Trends in the development of value-added flatbreads

5.1. Healthiness

Healthiness is a major trend in the food sector due to increased consumers’ awareness towards what they eat as outlined in Table 3. Vegetables, grains and seeds contain healthful phytonutrients and they have low cholesterol compared to animal sources (Boukidi et al., 2021). Different vegetables (beside those usually used) were incorporated in flatbreads to improve their nutritional value (Dankwa et al., 2021; Li, Kahlon, Wang & Friedman, 2021). Raising niche markets such as vegan and vegetarians also boosted this market growth in which 37% of total launches of flatbreads (2015–20121) were claimed suitable for vegan/vegetarian. Consuming plant-based food was further reinforced during the COVID-19 pandemic. Consumers associated healthy plant-based foods with lower risk and severity of COVID-19 (Neira, Godinho, Rincón, Mardones & Pedroso, 2021). Substituting 10% of wheat flour with soy flour improved protein and mineral contents (Khan, Anjum, Pasha, Sameen & Nadeem, 2012). Defatted soybean (Glycine max L.) flour has been incorporated up to 5% to improve both nutritional and sensorial qualities of tortillas (Elias-Orozco, Castellanos-Nava, Gaytrín-Martínez, Figueroa-Cárdenas & Loaiza-Piña, 2002). Adding soybean and amaranth flours improved tortilla quality and protein content (Joshi, Kushwaha & Kulshrestha, 2019). Substituting 40% of wheat flour with amaranth flour increased minerals (iron, calcium, and magnesium), fat, protein, and lysine and improved in vitro protein digestibility of chapatti (Banerji, Ananthanarayan & Lele, 2018). Incorporating pulse flours such as kidney bean, cowpea and black gram (up to 20%) increased the protein uptake and improved the protein quality (Balasharan

Table 1

<table>
<thead>
<tr>
<th>Types</th>
<th>Yeast</th>
<th>Proofing</th>
<th>Consistency</th>
<th>Thickness</th>
<th>Diameter</th>
<th>Examples</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single layered</td>
<td>Leavened</td>
<td>1</td>
<td>Dough</td>
<td>1.5 – 2mm</td>
<td>20cm</td>
<td>Naan</td>
<td>(Kumar, 2016)</td>
</tr>
<tr>
<td></td>
<td>Unleavened</td>
<td>2</td>
<td>Batter</td>
<td>3–6 mm</td>
<td>60 cm</td>
<td>Ethiopian injera</td>
<td>(Neela &amp; Fanta, 2020)</td>
</tr>
<tr>
<td>Double layered</td>
<td>Leavened</td>
<td>No</td>
<td>Dough</td>
<td>1.3–3.0 mm</td>
<td>12–25 cm</td>
<td>Tortilla</td>
<td>(Diddana et al., 2021)</td>
</tr>
<tr>
<td></td>
<td>Unleavened</td>
<td>2</td>
<td>Dough</td>
<td>4–20mm</td>
<td>20cm</td>
<td>Pita</td>
<td>(Quall, 2016)</td>
</tr>
</tbody>
</table>
Table 2

<table>
<thead>
<tr>
<th></th>
<th>Tortilla</th>
<th>Pita bread</th>
<th>Naan</th>
<th>Parathas</th>
<th>Focaccias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of products</td>
<td>965</td>
<td>635</td>
<td>729</td>
<td>379</td>
<td>773</td>
</tr>
<tr>
<td>Average values of nutrients (g/100 g)</td>
<td>295.10</td>
<td>262.35</td>
<td>262.98</td>
<td>306.39</td>
<td>286.10</td>
</tr>
<tr>
<td>Energy</td>
<td>6.84</td>
<td>2.44</td>
<td>6.36</td>
<td>11.37</td>
<td>8.81</td>
</tr>
<tr>
<td>Fat</td>
<td>1.98</td>
<td>0.53</td>
<td>1.45</td>
<td>5.23</td>
<td>2.03</td>
</tr>
<tr>
<td>Of which saturated</td>
<td>49.63</td>
<td>50.67</td>
<td>48.1</td>
<td>44.97</td>
<td>43.68</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>2.82</td>
<td>2.59</td>
<td>3.74</td>
<td>4.41</td>
<td>2.70</td>
</tr>
<tr>
<td>Of which sugars</td>
<td>5.06</td>
<td>3.90</td>
<td>3.12</td>
<td>3.96</td>
<td>3.20</td>
</tr>
<tr>
<td>Fiber</td>
<td>8.48</td>
<td>9.31</td>
<td>8.13</td>
<td>6.92</td>
<td>8.00</td>
</tr>
<tr>
<td>Protein</td>
<td>573.43</td>
<td>467.41</td>
<td>522.97</td>
<td>371.28</td>
<td>569.22</td>
</tr>
<tr>
<td>Sodium</td>
<td>8.81</td>
<td>7.91</td>
<td>8.13</td>
<td>6.92</td>
<td>8.00</td>
</tr>
</tbody>
</table>

* Table based on Mintel’s GNPD database, using the following criteria: food category “Bread & Bread Product”; launched from January 2015 to December 2021.

Table 3

<table>
<thead>
<tr>
<th></th>
<th>Tortilla</th>
<th>Pita bread</th>
<th>Naan</th>
<th>Parathas</th>
<th>Focaccias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of products</td>
<td>965</td>
<td>635</td>
<td>729</td>
<td>379</td>
<td>773</td>
</tr>
<tr>
<td>Healthiness</td>
<td>19% (N = 187)</td>
<td>5% (N = 34)</td>
<td>44% (N = 318)</td>
<td>67% (N = 253)</td>
<td>14% (N = 108)</td>
</tr>
<tr>
<td>Vegetarian</td>
<td>16% (N = 159)</td>
<td>6% (N = 40)</td>
<td>5% (N = 34)</td>
<td>2% (N = 8)</td>
<td>5% (N = 38)</td>
</tr>
<tr>
<td>Vegan/no animal</td>
<td>5% (N = 53)</td>
<td>1% (N = 9)</td>
<td>0% (N = 0)</td>
<td>0% (N = 0)</td>
<td>6% (N = 50)</td>
</tr>
<tr>
<td>Gluten-free</td>
<td>13% (N = 127)</td>
<td>18% (N = 117)</td>
<td>4% (N = 29)</td>
<td>8% (N = 32)</td>
<td>1% (N = 9)</td>
</tr>
<tr>
<td>Wholegrain</td>
<td>7% (N = 72)</td>
<td>15% (N = 97)</td>
<td>12% (N = 84)</td>
<td>23% (N = 86)</td>
<td>5% (N = 38)</td>
</tr>
<tr>
<td>Low/no/reduced trans fat</td>
<td>5% (N = 53)</td>
<td>21% (N = 134)</td>
<td>4% (N = 26)</td>
<td>11% (N = 41)</td>
<td>1% (N = 9)</td>
</tr>
<tr>
<td>Low/no/reduced cholesterol</td>
<td>4% (N = 37)</td>
<td>12% (N = 76)</td>
<td>3% (N = 21)</td>
<td>3% (N = 10)</td>
<td>1% (N = 4)</td>
</tr>
<tr>
<td>Low/no/reduced fat</td>
<td>1% (N = 6)</td>
<td>3% (N = 17)</td>
<td>2% (N = 13)</td>
<td>0% (N = 1)</td>
<td>0% (N = 1)</td>
</tr>
<tr>
<td>Low/no/reduced sodium</td>
<td>1% (N = 5)</td>
<td>2% (N = 12)</td>
<td>0% (N = 0)</td>
<td>0% (N = 0)</td>
<td>1% (N = 0)</td>
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<tr>
<td>No added sugar</td>
<td>1% (N = 6)</td>
<td>3% (N = 17)</td>
<td>2% (N = 13)</td>
<td>0% (N = 1)</td>
<td>0% (N = 1)</td>
</tr>
<tr>
<td>High/added fiber</td>
<td>1% (N = 6)</td>
<td>3% (N = 17)</td>
<td>2% (N = 13)</td>
<td>0% (N = 1)</td>
<td>0% (N = 1)</td>
</tr>
<tr>
<td>High/added protein</td>
<td>1% (N = 6)</td>
<td>3% (N = 17)</td>
<td>2% (N = 13)</td>
<td>0% (N = 1)</td>
<td>0% (N = 1)</td>
</tr>
<tr>
<td>Vitamin/mineral fortified</td>
<td>0% (N = 3)</td>
<td>1% (N = 4)</td>
<td>0% (N = 0)</td>
<td>0% (N = 0)</td>
<td>0% (N = 0)</td>
</tr>
<tr>
<td>Naturalness</td>
<td>17% (N = 164)</td>
<td>11% (N = 71)</td>
<td>31% (N = 226)</td>
<td>54% (N = 205)</td>
<td>10% (N = 81)</td>
</tr>
<tr>
<td>No additives/preservatives</td>
<td>10% (N = 93)</td>
<td>4% (N = 25)</td>
<td>10% (N = 76)</td>
<td>24% (N = 90)</td>
<td>2% (N = 19)</td>
</tr>
<tr>
<td>Free from artificial preservatives</td>
<td>1% (N = 13)</td>
<td>0% (N = 1)</td>
<td>9% (N = 66)</td>
<td>11% (N = 42)</td>
<td>1% (N = 4)</td>
</tr>
<tr>
<td>Free from artificial colorings</td>
<td>1% (N = 11)</td>
<td>0% (N = 2)</td>
<td>9% (N = 65)</td>
<td>9% (N = 34)</td>
<td>1% (N = 4)</td>
</tr>
<tr>
<td>Sustainability</td>
<td>1% (N = 9)</td>
<td>2% (N = 14)</td>
<td>5% (N = 34)</td>
<td>5% (N = 19)</td>
<td>2% (N = 19)</td>
</tr>
<tr>
<td>Environmentally friendly package</td>
<td>13% (N = 128)</td>
<td>6% (N = 41)</td>
<td>5% (N = 36)</td>
<td>2% (N = 6)</td>
<td>6% (N = 43)</td>
</tr>
<tr>
<td>Recycling</td>
<td>12% (N = 120)</td>
<td>5% (N = 29)</td>
<td>4% (N = 30)</td>
<td>0% (N = 0)</td>
<td>3% (N = 27)</td>
</tr>
<tr>
<td>Organic</td>
<td>13% (N = 130)</td>
<td>5% (N = 29)</td>
<td>4% (N = 30)</td>
<td>0% (N = 0)</td>
<td>3% (N = 27)</td>
</tr>
<tr>
<td>Convenience</td>
<td>13% (N = 130)</td>
<td>5% (N = 29)</td>
<td>4% (N = 30)</td>
<td>0% (N = 0)</td>
<td>3% (N = 27)</td>
</tr>
<tr>
<td>Microwaveable</td>
<td>59% (N = 572)</td>
<td>13% (N = 80)</td>
<td>27% (N = 198)</td>
<td>5% (N = 20)</td>
<td>4% (N = 31)</td>
</tr>
<tr>
<td>Ease of use</td>
<td>13% (N = 130)</td>
<td>5% (N = 29)</td>
<td>4% (N = 30)</td>
<td>0% (N = 0)</td>
<td>3% (N = 27)</td>
</tr>
<tr>
<td>Convenient packaging</td>
<td>13% (N = 130)</td>
<td>5% (N = 29)</td>
<td>4% (N = 30)</td>
<td>0% (N = 0)</td>
<td>3% (N = 27)</td>
</tr>
<tr>
<td>Time/speed</td>
<td>5% (N = 57)</td>
<td>4% (N = 25)</td>
<td>6% (N = 44)</td>
<td>8% (N = 31)</td>
<td>5% (N = 29)</td>
</tr>
</tbody>
</table>

* Table based on Mintel’s GNPD database, using the following criteria: food category “Bread & Bread Product”; launched from January 2015 to December 2021. N: number of products.

& Selvi, 2021; Ochoa-Martínez et al., 2016; Wani et al., 2016). The addition of white beans improved the nutritional, physicochemical, and textural properties of tortillas (Maya-Cortés et al., 2010). Tortillas made with chickpea hydrolysates showed increased dipeptidyl peptidase (DP-IV) activity which is related to inhibitory effects towards type 2 diabetes (Acevedo-Martínez & de Mejia, 2021). Gluten-free grains ensured the production of high-protein flatbreads to offer a healthier option for gluten-sensitive individuals (Kahlon et al., 2019). These flatbreads were found also low in fat and contained all essential minerals (usually lacking in gluten-free breads). Sprouted seeds/grains were reported to have a high nutritional value and reduced amounts of antinutrients and epitopes (Boukid et al., 2018; El-Sohaimy et al., 2019; Boukid, Prandi, Vittadini, Francia & Sforza, 2018). Sprouted wheat and germinated legumes were used instead of wheat flour as a source of nutrients (protein, fiber, iron, calcium, and carotenoids) and showed higher accessibility compared to untreated wheat flours (Kahlon et al., 2019). Minimized barley flour-supplemented chapatti showed increased protein and minerals contents and acceptable sensory properties with an addition level up to 20% (Abdullah et al., 2021). Vegetables such as broccoli improved the antioxidant properties of flatbreads without hindering their organoleptic properties (Kahlon et al., 2019). Tortilla fortified with tomato, spinach, potato and other vegetables resulted with improved nutritional composition and peculiar flavors (Amin & Zubair, 2020; Crawford, Kahlon, Wang & Friedman, 2019) and reduced postprandial glucose (Akhtar et al., 2019). The demand for flatbreads high in fiber is increasing due to increased awareness about the health benefits of fibers in lowering the risks towards hypertension, diabetes, and colon cancer, among others (Arya & Sonawane, 2016). Increasing fiber (β-glucan) and ingredients rich in fiber (e.g., millet flour, wheat bran, barley bran, fenugreek seed powder and chickpea flour) resulted in increased slowly digestible starch and resistant starch, and reduced rapidly digestible starch and conse-
quenty resulted in reducing the glycemic response and index of flatbreads (Boers et al., 2017; Gujral, Sharma & Khatri, 2018; Robert, Ismail & Rosli, 2016; Sharma & Gujral, 2019). Furthermore, the use of wholegrains, claimed in 9% of commercial products (Table 3), was reported to be associated with several health benefits due to their high fiber as well as vitamins, minerals, and phytochemicals (Kahlon et al., 2019). The use of wholegrain sorghum flour reduced rapidly digestible starch and lowered glycemic index (Yousif et al., 2012). Beside increasing fiber content, wheat bran addition increased the total and bioaccessible pheno-
olics and flavonoids (Oghbaei & Prakash, 2019). Recently, improving the nutrient density and bioavailability in flatbreads is a recommended strategy for combatting nutrients deficiency (Bhavya & Prakash, 2021).

Combined incorporation of whole wheat flour and minerals resulted in the increase of protein in vitro digestible protein and iron bioaccessibility (Oghbaei & Prakash, 2018b). The simultaneous combination of carrot juice, soy, and whose malt content increased the carotenoids content (α- and β-carotene) and total antioxidant capacity and reduced glycemic index (Scaczinia, Del Río, Serventi, Carini & Vittadini, 2008). Multigrain (i.e., whole-wheat, finger millet, pearl millet and fenugreek) chapatti resulted with improved nutritional properties and desirable texture, color and aroma (Walde, Agrawal & Mittal, 2021). Wheat-millet composite flours-based chapatti had improved nutritional properties and rheologi-
cal properties and bread properties compared to wheat flour-based flatbreads (Nasir et al., 2021).

Incorporation of ingredients rich in minerals and vitamins such as green leafy vegetables in flatbreads is a way to increase the content of essential elements such as iron, calcium, ascorbic acid, folic acid, and riboflavin (Bhavya & Prakash, 2021). Targeted iron supplementation through the use of yeast enriched with iron also increased the bioavail-
ability of iron in flatbreads from 11 to 388 mg/100 g (Nowosad & Su-
jkja, 2021). Compared to refined wheat-based deep fried flatbreads, the incorporation of wheat bran and minerals resulted in flatbreads with higher mineral content and comparable protein digestibility (Oghbaei & Prakash, 2018a). Biofortified wheat flour with zinc improved the nutri-
tional quality of bread depending on the particle size of the flour. Increasing flour particle size (355 μm) increased ash, fat, fiber, phytic acid, antioxidant activity, and total phenolic content (Bassi, Kaur, Singh & Kaur, 2021). Biofortified colored wheat (black, blue, and purple) increased fibers, protein content, anthocyanins and phenolic acid compounds of flatbreads (Kumari et al., 2020; Sharma et al., 2022). These breads also resulted with low carbohydrate content that might be related with a low glycemic index compared to white flatbreads. The use of high amylose wheat mutant increased resistant starch and thus might be related to several benefits to human health (Rahim et al., 2020). The use of blue corn flour also increased phenolic and antho-
cyanins compounds of tortillas (Herrera-Sotero et al., 2017). Blue corn was also reported to potentially have anti-inflammatory, antioxidant, anti-
adipogenic, and anti-diabetic properties owing to their content of an-
thocyanins (Zhang et al., 2019).

The use of free-from and reduced claims of some nutrients such as sugar, fat and sodium are perceived by consumers as a positive indication of the nutritional quality of a product. Fat reduction claims were exhibited using claims such as low/no/reduced trans-fat (12%), low/no/reduced cholesterol (8%) and low/no/reduced fat (4%) (Table 3). In Europe, flatbreads claimed to be “low in fat” should not contain more than 3 g of fat per 100 g of product, while those claimed to be “fat-free” should not contain more than 0.5 g of fat per 100 g (Regulation (EC) No 1924/2006). Therefore, trying to reduce fat con-
tent as much as possible while preserving the sensory acceptability is an important challenge depending on the formulations of flatbreads. Sugar reduction claims are increasingly used by many brands to attract health-conscious consumers. The intake of dietary sodium has received huge attention due to its association with health problems such as hy-
pertension, cardiovascular diseases, gastric cancer, renal diseases, osteo-
porosis and kidney stones (Choi, Brandeau & Basu, 2016). As illustrated in Table 2, the sodium content of a selection of marketed flatbreads ranged from 371.28 to 573.43 mg/100 g, which was considered high based on European Regulation (“low in sodium” (<0.12 g of sodium per 100 g), “very low in sodium” (<0.04 g of sodium per 100 g) and “sodium-
free” (<0.005 g of sodium per 100 g) (Regulation (EC) No 1924/2006).

World Health Organization (WHO) and European Union (EU) have rec-
commended the reduction in sodium content of staple products such as flatbreads (Webster, Trieu, Dunford & Hawkes, 2014). Several strategies are being applied such as the gradual reduction of sodium or the use of salt replacers such as potassium (Fayaz et al., 2021).

5.2. Naturalness

Consumers have a strong preference towards foods made with natural ingredients and free from additives and preservatives (Román, Sánchez-Siles & Siegrist, 2017). Naturalness can be perceived from product labeling using terms such as “natural products” and “free-from additives/preservatives”. Commercial flatbreads (Table 3) re-

cflected this trend by using claims such as no additives/preservatives (25%), free from added/artificial preservatives (10%), free from added/artificial colorings (4%) and free from added/artificial flavor-
ings (4%). The presence of artificial colors and flavors, additives, and ingredients with chemical names were reported to negatively influence consumers’ perception of naturalness (Mintel, 2020).

5.3. Sustainability

Sustainability-minded consumers are actively looking for foods that adhere to planet-friendly, sustainability, and recycling principles (Mintel, 2020). The producers of flatbreads are increasingly using eco-
friendly packaging, while others are supporting the use of renewable energy and upcycled ingredients (Mintel, 2020). The “organic” claim rein-
force the concept of sustainability (Mie et al., 2017). Organic farming is widely considered to be a far more sustainable (Uhunamure, Kom, Shale, Nethengwe & Steyn, 2021) and this explains the mounting organic flat-
bread (4% of products). Currently, plastic (such as polypropylene, and low-density polyethylene) is the main packaging material (up to 95%) of commercial flatbreads followed by paper plain, metallized film and solid white board. Many packaging companies are putting efforts to increase packaging sustainability. The use of environmentally friendly packaging reached 6% out of all products. Special attention has been also at-
tributed to the valorization of by-products, where the use of recycled ingredients was found in 5% of total launches. Researchers also inves-
tigated several byproducts for improving the quality of flatbreads in a sustain-
able way. For instance, barley husk, a by-product of starch extrac-
tion, increased fiber content in unleavened flatbread without affecting the sensory properties (Gujral et al., 2018; Mef zoo et al., 2018a). Par-
tial replacement of wheat flour with banana peels (5 and 10%) increased fiber, protein, potassium, calcium, sodium, iron and manganese of Egyptian balady flatbread (Es hak, 2016) and total phenolic and flavonoid contents, along with antioxidant properties, and improved texture and pliability (Kurhade, Patil, Sonawane, Waghamare & Arya, 2016). Peanut paste or oil cake resulted in a flatbreads rich in proteins (Kahlon et al., 2019).

5.4. Convenience

The convenience of flatbreads has been shown through claims such as microwavable (22%), ease of use (15%) and speed/time (6%) (Table 3). The preference for on-the-go food products boosted the mar-
et of flatbreads due to their suitability for modern eating habits and busy lifestyle (Allied Market Research, 2021). For instance, availability of various ready to eat flatbreads in the market to make sandwiches at home contributed towards the growth of the flatbread market (Research & Markets, 2019). Flatbreads are also commercialized as relatively in-
expensive, convenient, palatable, and versatile portable snacks or meal replacements. Various fast food chains, food markets and airlines have
introduced flatbread wraps and sandwiches (Kahlon et al., 2019). Furthermore, easy availability of frozen flatbread in the market, saves time and efforts of consumers (Allied Market Research, 2021). The commercial flatbread products can have a stable shelf life (64.3% of total commercial products) at room temperature up to 18 weeks, chilled (22.9% of total commercial products) with a shelf life up to 4 weeks or frozen (12.9% of total commercial products) with a shelf life up to 18 months offering different options to consumers.

5.5. New flavors

Research on innovative and unusual ingredients intends to offer consumers a traditional product (i.e., flatbread) with a modern twist (i.e., new flavors). Microalgae was used as innovative ingredients in wheat tortillas to increase their sustainability and promote the health benefits of microalgae (Hernández-López et al., 2021). This substitution increased protein, fat, phenolic and carotenoids contents as well as antioxidant capacity in microalgae-enriched tortillas. From a sensory perspective, tortillas made with Nanochloropsis sp. and Tetraselmis sp. had acceptable flavor and texture with scores close to 7 (like moderately) and overall acceptability with scores close to 6 (like a little bit) despite the intense “marine” flavor of these microalgae. This might be due to the lower addition level (up to 3%) that did not induce significant changes in acceptability score (up to 75%) compared to the conventional product (Hernández-López et al., 2021). Although there was a substantial change in color, consumers showed acceptable purchase intention of these products owing to the raising awareness about microalgae health benefits. Tortillas were also made with meringo flour and resulted with higher protein content, antioxidant activity and total phenolics content compared to the control tortilla (Páramo-Calderón et al., 2019). The use of proteins isolated from the scarlet runner bean and huazontle flour at levels up to 2.5% increased the nutritional value of the tortilla without affecting rheological, textural, and sensory properties (Sánchez-Villa, Zepeda-Bautista, Ramírez-Ortiz & Corzo-Ríos, 2020).

6. Conclusion

Increased demand towards flatbreads such as naan, pita, and focaccia are driven by their affordability, convenience, versatility, and authenticity. In recent years, health-conscious consumers keep seeking for healthier options of flatbreads compared to those traditional. This is boosting food developers to upgrade traditional foods to respond to consumers’ expectations (nutritional benefits, flavor, and texture). In this light, several studies are focusing on improving the nutritional value of flatbreads through fortification or substitution/reduction. The availability of various healthy alternatives in the market with health (e.g., satiety and slimming) and nutrition claims (e.g., high fiber and high protein) are expected to fuel the market growth in the upcoming years. The surge in demanding natural products is orienting flatbreads development to the use of natural ingredients and to avoid the use of additives. Furthermore, environmentally conscious consumers are requesting planet-friendly products and processing. Even though flatbreads have their peculiar long known flavor, the use of new innovative ingredients might provide a wider spectrum of flatbreads to attract consumers seeking new flavor experiences.

Compliance with ethics requirements

This article does not contain any studies with human or animal subjects.

Data availability

Not applicable.

Declaration of Competing Interest

None.

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