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RESEARCH ARTICLE

Flatbreads on the Rise, What about their Nutritional Quality? The Current State of the Mediterranean Market

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ABSTRACT
Flatbreads are increasingly attracting consumers, driving them to new eating ways. To define and evaluate the nutritional intake provided by these products, flatbreads market of seven Mediterranean countries (France, Spain, Italy, Croatia, Greece, Malta, and Lebanon) were considered. Flatbreads were available in both traditional and gluten-free versions, and in the single and doble layer variety. Wheat flour was the primary ingredient in both types, while sunflower and olive oil were the most used fats. Lebanese flatbread did not contain any fat. The Spanish market mostly featured one-layer flatbreads, such as *tortillas* and wraps, whereas *pita* appeared more frequently in Greece. Many Croatian flatbreads were not fermented. In comparison to gluten-containing flatbreads, the gluten-free version had a larger number of components listed on the labels. Blending flours with starches was the most common recipe. Hydrocolloids, emulsifiers, and fibers were added largely for technical reasons, but also to increase nutritional quality. Gluten-free flatbreads, on the other hand, were discovered to have lower fiber and protein content than their gluten-containing counterparts. Furthermore, their calorie value, as well as carbohydrate and salt content, were found to be lower.

1. Introduction

In the last decade, a growing change of the consumers' eating behavior is being imposed on the traditional food choices. To meet the demands of the consumers, who are becoming more and more concerned about short ingredient list, clean labels, functional ingredients and low environmental impact diet, the food industry is going through a deep reimagination. One of the first staple foods that is experiencing this change is bread. For many years, loaves and packaged sliced breads have represented the main choice available on the shelves of the grocery stores in Western countries. Lately, migratory flows increase, as well as the search for authentic and convenient foods have enabled the appearance of new products alongside traditional yeast breads. Among them, flatbreads (FB) are the most representative category; in fact, in 2019, the European flatbread market size was estimated at almost US 10 million dollars and is projected to reach more than US 16 million dollars by 2027 with a compound annual growth rate of 9.5% from 2021 to 2027 [1]. Probably, FB are the earliest form of bread made by mankind approximatively 14,400 years ago in northeastern Jordan [2]. The possibility of being produced from different grains other than wheat, their easier cooking techniques, the convenience of transport and the option of being filled with several other foods making them a complete dish, have allowed FB to successfully transit from rural to modern society [3]. Generally, the production of FB requires a flattened dough obtained through mixing and kneading flour, salt, water and yeast (optionally); then, dough can undergo a proofing step before shaping and cooking [4]. A conventional leavening, namely sourdough, was used until the apparition of baker's yeast in the 18th with the so called "Pain à l'Allemand" [5]. More recently, chemical leavening has been adopted by some baking industry. The natural sourdough leavening combined with the use of whole meal flour yields an enhanced presence of minerals in bread; according to Reinhard [6], it represents an important source of minerals for the rural Iranian population. Owing to their production process flexibility and their ingredient adaptability, a wide range of FB has been produced from different geographical areas of the world. To better define this broad panorama, FB have been classified into two main groups, the single-layered and the doble-layered [3,7]. Within the class of the single-layered, a further distinction is made between the unleavened and the leavened ones [8]. Among them, Italian *piadina* [3], Lebanese *saj* [9], and *tortilla* from Mexico [10] belong to the unleavened single-layered FB while *naan* from India [11], and *crescentina* [3] from Italy represent the leavened variants. Shifting the focus towards the double-layered FB, *khobz* from Lebanon [3], Italian *puccia salentina* [12], Greek *pita* and Sardinian *carasau* are the most known [3]. From a nutritional standpoint, FB have been prevalently produced from wheat, maize and rice but in Asia and India the use of barley, millet, oats, rye and sorghum is a well-established practice, which also makes them more nutritious [13]. In fact, an increased content of protein, minerals and fiber was found in flatbreads made by sorghum flour (up to 15%) compared to the control made only with wheat [14]. Same trend was reported when millet flour, raw and extruded, was added up to 30% to the wheat flour for *chapatti* flatbread production [15]. The partial substitution (6%) of a gluten-free (GF) formulation based on rice flour with amaranth flour led to a double-layered flatbread higher in protein and ash content with a greater polyphenol bioaccessible fraction [16]. Keeping with the pseudocereals category, *balady* FB with higher amount of protein and mineral (potassium, magnesium, calcium, iron, copper, manganese, and zinc) were carried out substituting wheat flour with quinoa flour (up to 30%). Nevertheless, panelists appreciated the flavor up to 15% substitution level while FB with 30% of quinoa flour were characterized by the typical bitter aftertaste [17]. When chia seed flour was combined (from 5 to 20%) with maize flour, *tortillas* higher in protein, lipid and dietary fiber with a reduced predicted glycemic index were developed [18]. Healthier FB have also been produced using wholegrains [19,20]. Owing to their higher nutritional value, pulses have always been used for the flatbread manufacture, especially in India where black beans are mixed with rice or maize flour for giving to *khocho* and *dosa* [21,22]. Despite the nutritional enhancement brought in by pulses, it is worth noting that a wheat replacement (above 15%) with kidney bean and black gram flours decreased color, taste, aroma, breakability, and overall acceptability score of the unleavened FB (*chapatti*) [23]. Their outstanding qualities as water binders and gelling agents have guaranteed that starches and fibers were employed as minor ingredients in flatbread formulations, especially in those GF [8]. Commonly, FB can include some vegetable oils in their formulations, they can be flavored with some spices (garlic, onion and ginger or chili powder) and the addition of sesame or black seeds participates to increase the content of minerals, vitamins, fiber, and unsaturated fatty acids [4,11].

As pointed out above, FB groups together many products with different formulations that deserve

further investigation to evaluate their nutritional quality. Therefore, delineating and evaluating the nutritional intake offered by the FB to the Mediterranean population represents the scope of this research. No other surveys have been carried out on the nutritional quality of FB in the Mediterranean area so far. Due to this, a deep assessment of ingredient formulations and nutritional composition of the commercial FB available in the Mediterranean market was carried out. In particular, the analysis concerned products sold in seven Mediterranean countries (France, Spain, Italy, Croatia, Greece, Malta and Lebanon).

2. Material and methods

2.1 Data gathering and statistical analysis

Data gathering was conducted from December 2021 to March 2022. With the only exception of Malta, where FB from artisanal bakeries were considered, nutritional data were taken from the labels of FB marketed at the major retailers in the surveyed countries. Samples were chosen not taking into account any topping or coating. From the nutritional labels, energy (kcal/100 g), total fat (g/100 g), saturated fatty acids-SFA (g/100 g), carbohydrates (g/100 g), sugars (g/100 g), fiber (g/100 g); protein (g/100 g), and salt (g/100 g) were extracted and recorded. The statistical analysis was performed using STATGRAPHICS CENTURION XVII software (Version 17.2, Virginia, USA). Marketed products were categorized for the gluten presence, type (single or double layer), type of flour (white, whole grain and blends), ingredients (fat, sugar), leavening agent (yeast, sodium bicarbonate), process aids (hydrocolloids, emulsifier), preservatives (sorbate or propionate salts or acids) and secondary ingredients. To describe significant differences ($p < 0.05$) among the different variables, MANOVA was employed. A principal component analysis (PCA) was created to describe the variability of the data.

3. Results

3.1 Summary of the gluten containing flatbreads ingredients

As shown in Figure 1 (frequency figure), a total number of 232 FB were gathered in the Mediterranean market, 202 of which contained gluten. Considering the classification described above, single layer FB were the most present in the market (n=127), while the double layer ones occupied a smaller portion of it (n=75). It must be stressed that although the Greek *pita* is a single layer bread in Greece, it has been classified within the double layer breads to keep previously reported classification [3]. Figure 1 depicts the frequency of the raw materials utilized for the gluten containing FB. Three types were found and considered as the principal ones, white flour, brown flour and a blend of the previous two. Within the white flours type, wheat flour was the most abundant in both types of FB, double layer (n=60) and single layer (n=96), respectively. In this latter, spelt flour (n=13), durum wheat semolina (n=5), kamut wheat flour (n=4) and buckwheat flour (n=2) also took part in the ingredients list. In the double layer ones, the rest of the white flours were durum wheat semolina (n=7) and cocoa flour (n=1). Whole wheat (n=18), whole spelt (n=6) and whole kamut (n=3) flours represented the brown flours used for the single layer FB manufacturing, unlike those with double layers in which only whole wheat flour appeared (n=19). Regarding the blends, used as main ingredient, wheat and whole wheat flours appeared in the ingredient list of the double layer FB, while the other flatbread type included buckwheat flour (n=2) blended with the whole wheat one. Starch (n=7), corn flour (n=6), oat fiber (n=6), rice flour (n=6), malted flour (n=4), barley flour (n=3), bran (n=2) and rye flour were classified as "other cereal ingredients" and were the most frequently encountered in the formulations of the single layer FB. In the other FB group, in addition to the before-listed ingredients, wheat germ (n=2) and millet seed flours (n=2) were also used as "other cereal ingredients" while other seeds (n=4), activated charcoal (n=1) and soy protein were set aside as "other ingredients". Staying in the same ingredient category, the situation varied depending on the type of the product. In fact, potato flour or flakes (n=8), herbs and spices (n=5), pulses flour (n=5), pea protein (n=2), chia seeds (n=2) and flaxseeds (n=2) were the most present ingredients in the labels of the single layer FB.

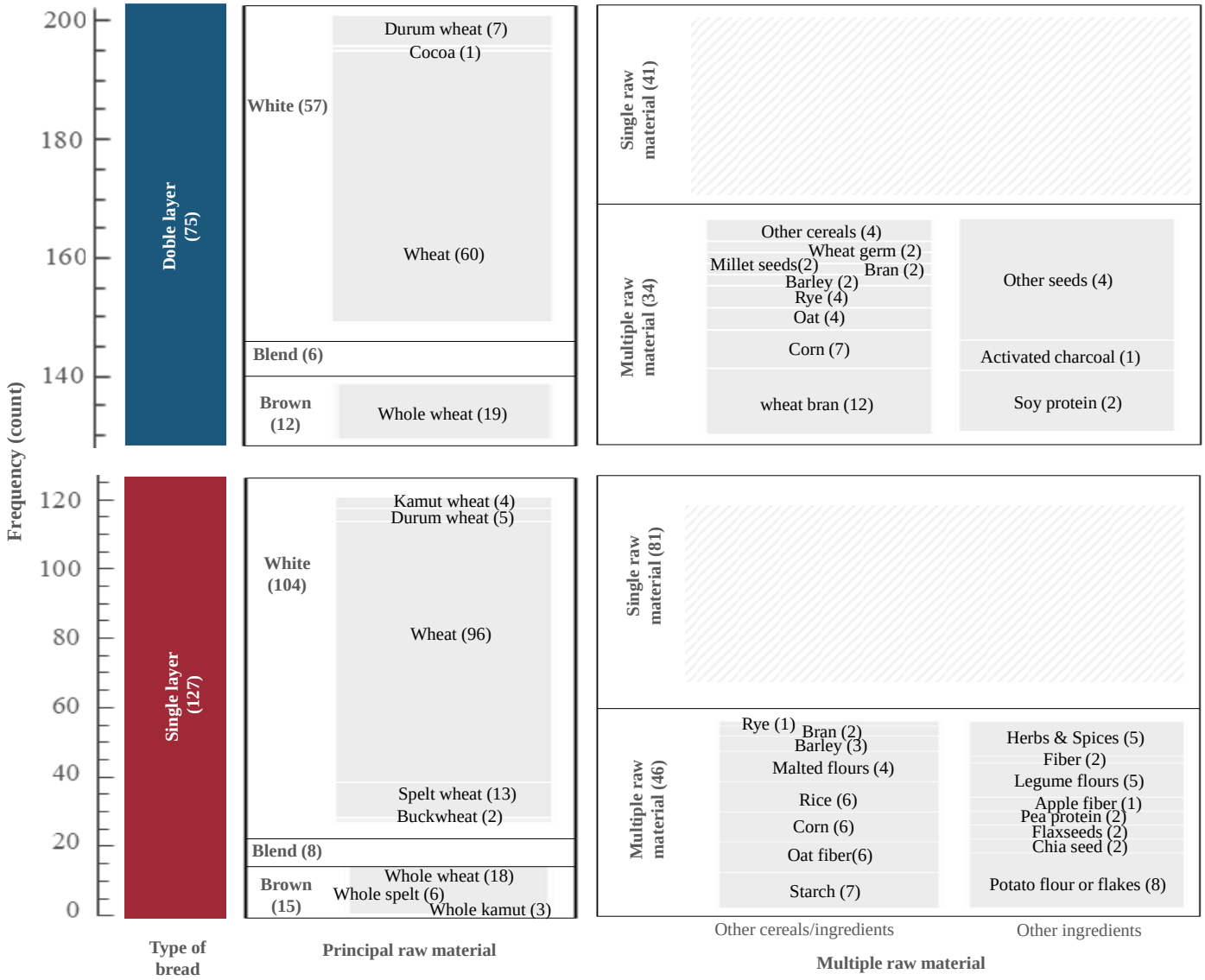


Figure 1. Appearance frequency of the main flours in the ingredient list of gluten containing flatbreads. The numbers in brackets indicate the number of products.

To better understand the impact of the ingredients on the nutritional quality of this increasingly demanded product, a detailed evaluation of the different types of fat, preservatives, leavening agents, processing aids, sugar and salt is reported in Figure 2. No fat addition was reported in most of the analyzed ingredient lists from single layer (n=44) and double layer (n=102) FB. In the case of these latter, 31 samples included fats in their formulations; in particular, oils from rapeseed (n=2), olives (n=5), sunflower (n=19) and mixtures of them (n=5) appeared more frequently. From the other hand, in addition to those cited before, vegetable fat from palm (n=3) and corn (n=1) were used on their own or in combination with animal fat, lard (n=8) to produce the double layer FB.

In the case of cereal-based products, shelf-life takes on particular importance as it makes food more convenient while it can be improved by technological measures or by employing preservatives. A large number of double (n=44) and single layer (n=94) FB did not contain any preservative. Blends of calcium propionate-ascorbic acid (n=13), vinegar-calcium propionate-sorbic acid (n=6) were the most common in the formulations of the double layer FB followed by sodium acetate-calcium propionate-ascorbic acid (n=1) and calcium propionate-potassium sorbate (n=1), whereas in some FB calcium propionate (n=9) standalone. The latter was found in combination with potassium sorbate (n=11) and sorbic acid (n=3) in the ingredient list of the single layer FB alongside to sodium propionate-potassium sorbate

(n=7) and sodium propionate-sodium carbonate (n=6).

Figure 2 highlights that all the double layer FB were fermented by yeast (n=72) or its combination with chemical leavening agents (n=3). Different situation was noticed in the group of the single layer ones where almost the half of the products were unleavened (n=39). Chemical raising agents (n=46) were the most employed for a spongy texture achievement while their combination with yeast (n=12), yeast alone (n=29) or sourdough fermentation (n=1) represented the other alternatives.

With the primary scope of facilitating the food product handling and improving of its technological quality, processing aids have been largely used in the food industry. Fifty-one double layer FB and seventy-four single layered did not contain any processing aid. Nevertheless, xanthan gum (n=10), guar gum (n=8), mono and diglycerides of fatty acids (n=8), enzymes (n=7) and gluten (n=7) frequently emerged among the ingredients of the double layer FB. Glycerol (n=32), carboxymethylcellulose (n=11), guar gum (n=30), mono and diglycerides of fatty acids (n=35) represented the processing aids most employed for the development of the single layer FB.

In breadmaking, sugars are mainly used to increase the substrate content for the yeast activity and to facilitate non-enzymatic browning reactions associated with the typical color and flavor of the baked goods. Only 33 double layer FB contained sugars, in particular, sucrose (n=33) and dextrose (8); while, besides the ones already mentioned, in single layer flatbreads beet carrot sugar (n=1) was also reported.

Shifting towards the salt addition, all the products contained salt in their formulations. Only three double layer FB and 8 single layer ones did not contain salt. These were sold in Croatia and some others from Greek (n=2) and French (n=1) markets.

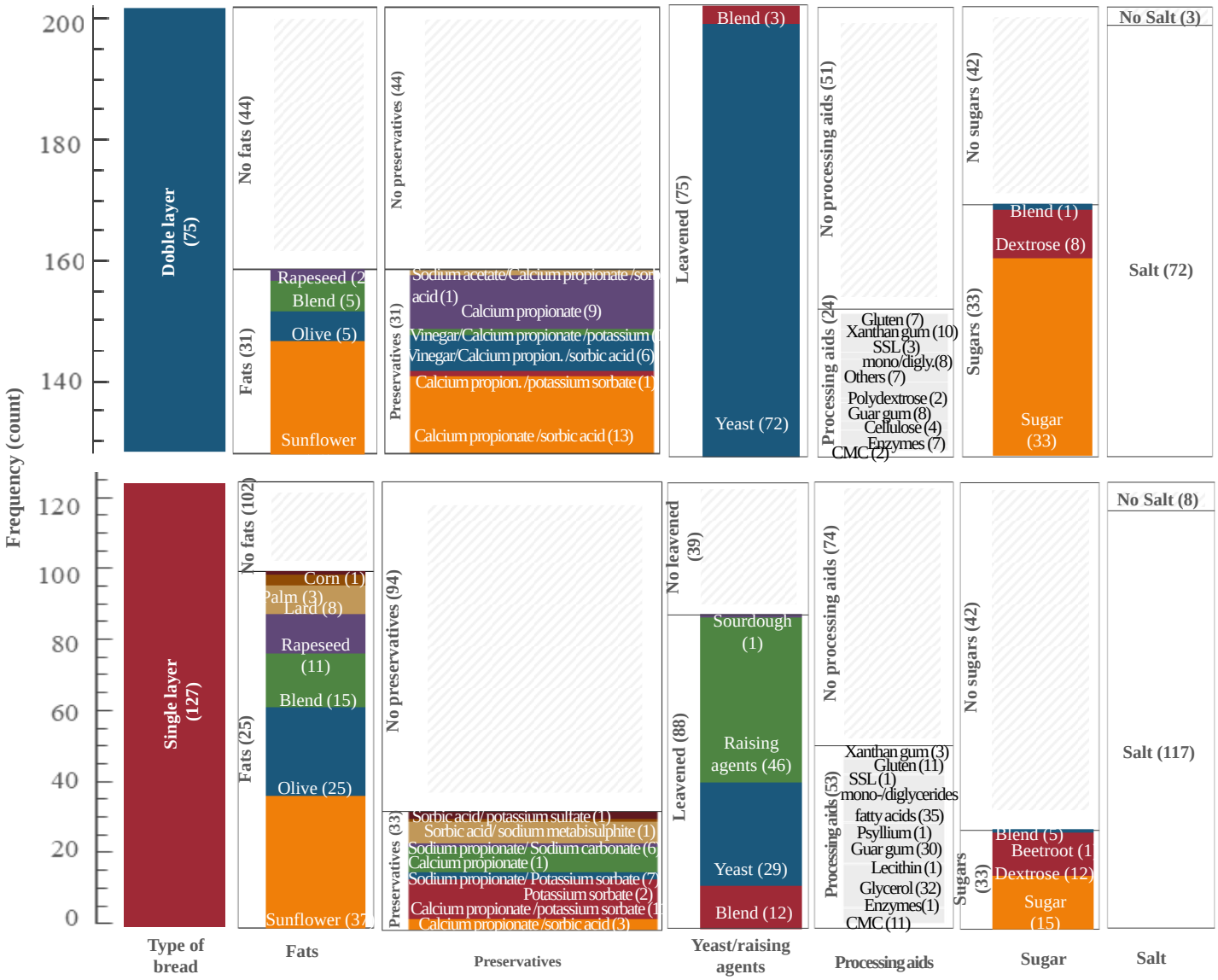


Figure 2. Appearance frequency of different types of fats, preservatives, leavening agents, processing aids, sugar and salt in the ingredient list of gluten containing FB. The numbers in brackets indicate the number of products.

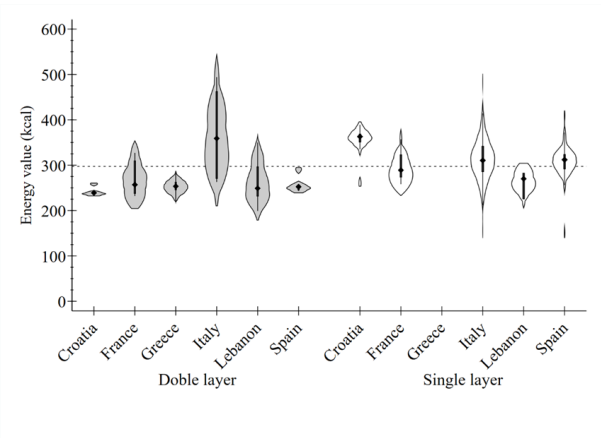
3.2 Nutritional quality of gluten containing flatbreads

Figure 3 highlights the results of the analysis for the energy value, fat, carbohydrate, protein and salt content, respectively. Regarding the energy value (Figure 3.a), single layer FB were energy denser than the double layer ones, but this difference was not significant ($p < 0.05$). The country of production had a significant ($p < 0.05$) effect on the final kcal content. In fact, FB from Italy, Croatia and Spain were those with the highest values while the Lebanese, the Greek and the French ones were placed to the opposite side. Given that fat is the most caloric ingredient (9 kcal/g), its presence increased calories of FB. In fact, the presence of lard in the *piadina* formulations, which is the prevalent flatbread in the Italian market, was responsible for the significant ($p < 0.05$) increase of the energy value and the total fat content of the FB.

From the other hand, lower calories were significantly ($p < 0.05$) associated with the absence of fat (especially for the products from Lebanon) in the ingredient list, as well as the presence of rapeseed and sunflower oils. Nevertheless, the combination of different types of fats and the use of lard led to a significant ($p < 0.05$) increase of the saturated fat content, whereas the opposite tendency was observed when no wheat ingredients (wheat bran) were included in the formulations. The average of the saturated fat content slightly exceeded 1 g/100 g of product.

As depicted in the Figure 3.c, the average of the carbohydrates content was just above 44 g/100 g. FB without any addition of salt and sugar resulted in significantly ($p < 0.05$) higher carbohydrate content that was significantly ($p < 0.05$) reduced in the case of the brown wheat FB, because of its higher fiber content. Depending on the home market, significant ($p < 0.05$) differences were also found among the different FB. In particular, in Croatia and France, FB had the highest carbohydrate content as opposed to Greek and Spanish markets that offered products with the lowest carbohydrate amount. With respect to sugar, the average content was around 3 g/100 g and the presence of seeds in the FB was significantly ($p < 0.05$) related to a greater sugar load; Italian and Lebanese products showed the smallest value. Significant ($p < 0.05$) differences were discovered among the dietary fiber contents of the two categories of FB; indeed, doble layer products were the highest. In this regard, a significant ($p < 0.05$) association was found between the inclusion of brown wheat and other non-wheat cereals in increasing the final dietary fiber content. Lebanese, Spanish, and Italian FB significantly ($p < 0.05$) stood out for their higher fiber amount.

Same trend was observed for the protein content, in which the three afore-mentioned countries showed the highest content, but no significancy ($p < 0.05$) was found. The average protein content of the Mediterranean FB was around 9 g/100 g.



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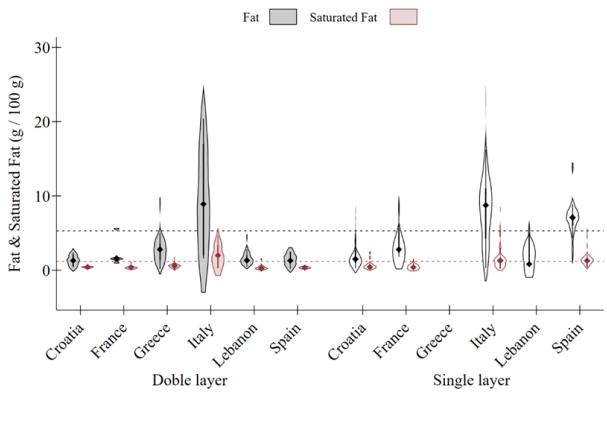
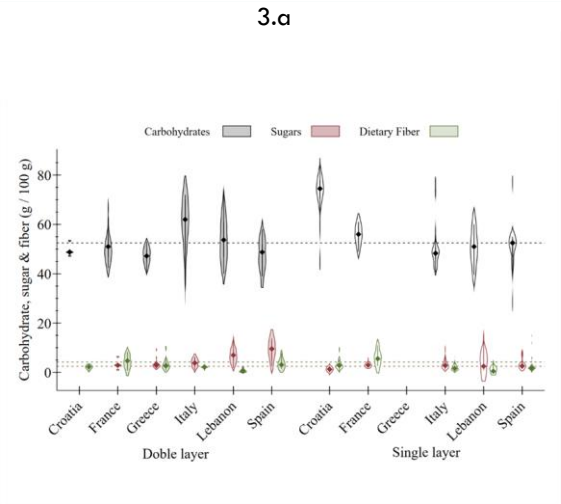


3.b



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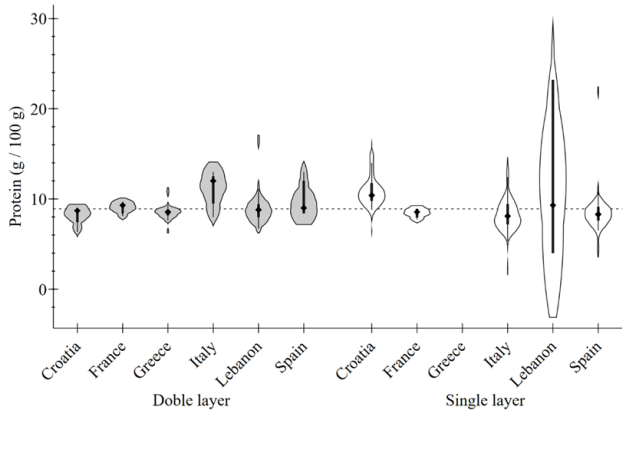

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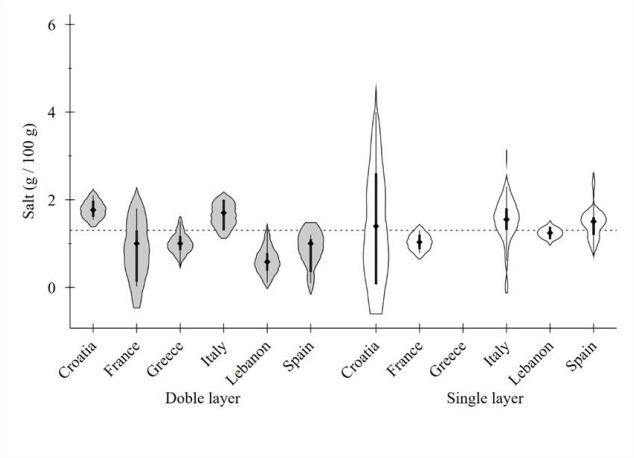


3.e

Figure 3. Nutritional composition of the gluten containing flatbreads sold in the Mediterranean market. 3.a: Energy values, 3.b: Total fat and saturated fat content, 3.c: Carbohydrate, sugar and dietary fiber content, 3.d: Protein content, 3.e: Salt content.

Owing to the large datasets, a principal component analysis (PCA) was employed to improve the exploration of the FB Mediterranean market. Principal component 1 (PC1) was able to explain the 32.3% of the data variability and products were mainly separated by their fat content. In fact, samples higher in total fat, saturated fat and salt are located in the right upper quadrant and principally represent products from Spanish and Italian markets. Only 20.5% of the data variability was described by the principal component 2 (PC2) which was mainly influenced by carbohydrates and protein content. France and Greece were the countries in which marketed FB had lower sugar contents.

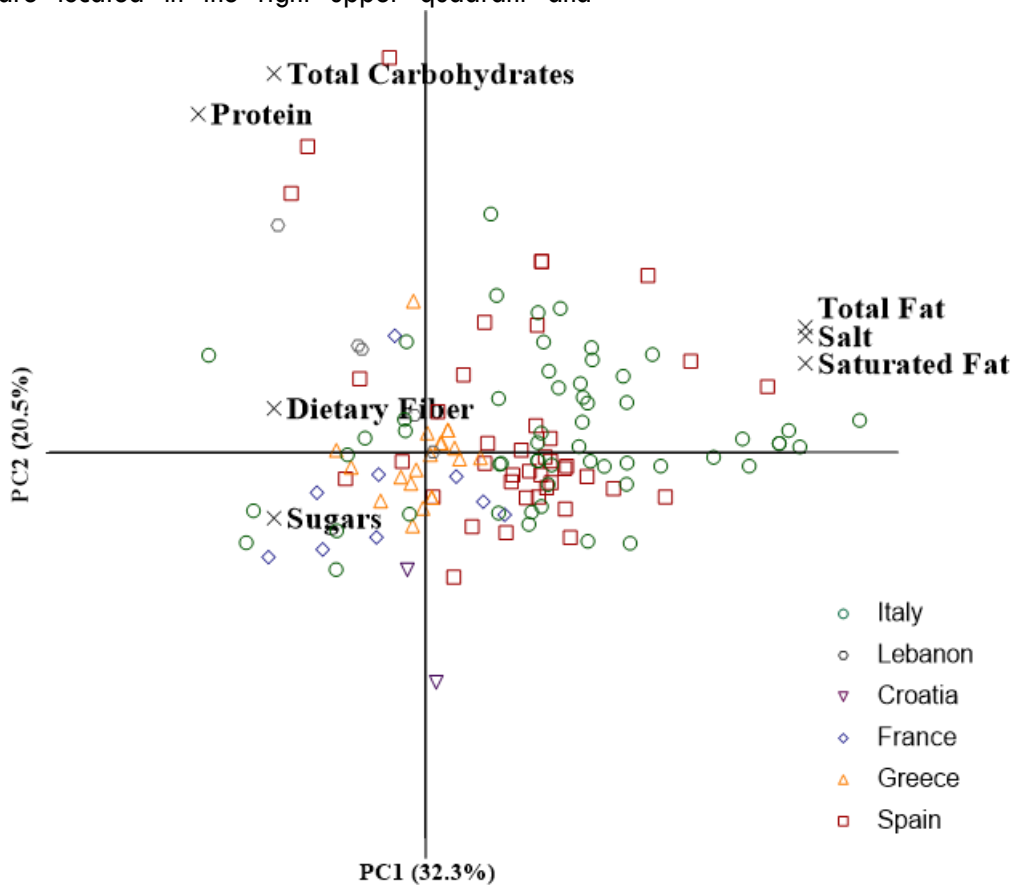


Figure 4. Principal Components Analysis of the gluten containing flatbreads sold in the Mediterranean market

3.3 Summary of the gluten-free flatbreads ingredients

Among the countries bordering the Mediterranean basin, considered in this study, only France, Italy, Malta and Spain provided GF FB in their respective markets; only one product belonged to the double layer category, while the rest were of the single layer type. Looking at Figure 5, which provides the ingredients information about the GF FB, their larger average number of ingredients (30) was immediately noticeable, with respect to the gluten-based samples (15). Generally, a blend of flours with starch (n=12) or its mixture with fiber (n=13) or protein (n=9) were the most adopted technological choices for the GF FB manufacturers. The presence of flour sources (n=3) or starch (n=1) was limited to only 4 products in total. Among the cereal flours, those from rice (n=32), buckwheat (n=14) and corn (n=12) appeared with higher frequency in the ingredient labels, while peas (n=4), yellow lentils (n=4) and chickpeas (n=4) were the sources of the most used legume flours. GF formulations also included flours from carob bean (n=4), quinoa (n=4) and flaxseed (n=2). Starch was the key component in almost every GF structure, mainly sourced from corn (n=29), potato (n=18), tapioca (n=17) and rice (n=11). In the case of the minor ingredients, potato (n=7) and apple (n=6) represented the main sources of fiber for nutritional enrichment. The most common proteins in the GF ingredient package were those from soy (n=9) and pea (n=3).

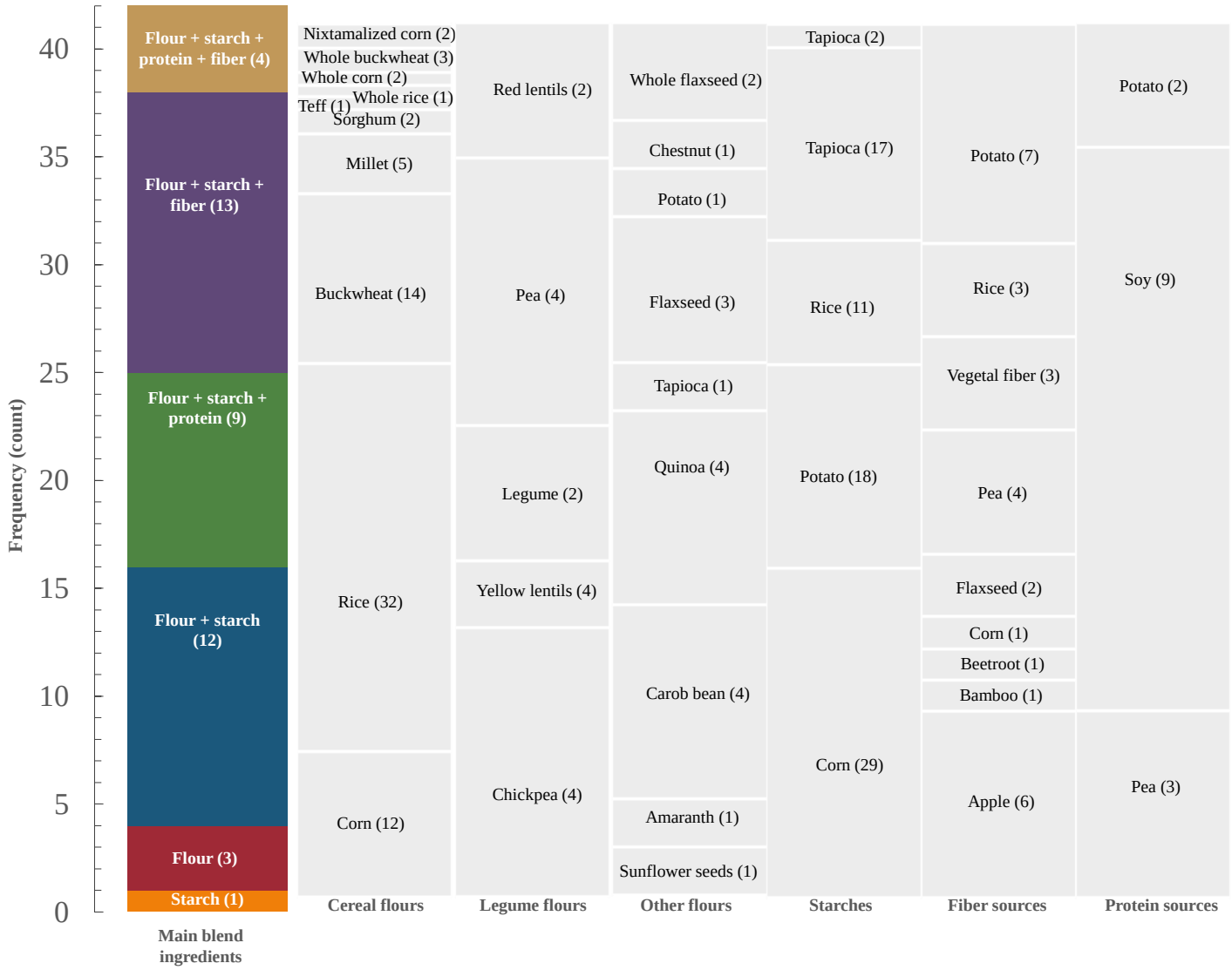


Figure 5. Appearance frequency of the main flours in the ingredient list of gluten containing flatbreads. The numbers in brackets indicate the number of products.

Information about the fats, preservatives, yeast and raising agents, hydrocolloids, processing aids, sugars and salt concerning the GF formulations are collected in the Figure 6. Only eight GF FB did not contain any fat; among the fat containing FB (n=34), sunflower oil (n=14), a mixture of the latter with olive oil (n=10) and margarine (n=4) were the most employed ones. Predominantly, GF FB did not involve the use of preservatives (n=27) for their production, nevertheless, fifteen samples mostly included sodium propionate (n=4), potassium sorbate (n=3) and a combination of them (n=2). A fluffy GF structure was created mainly by using raising agents (n=17) and yeast alone (n=5) or in association with sourdough (n=3), while 16 of the total samples did not involve any yeast/raising agent for the production process. In this study, hydrocolloids were present in almost all the formulations (n=41) except for one tortilla product made by nixtamalized corn. Guar gum (n=25), xanthan gum (n=20), psyllium (n=19) and hydroxypropylmethylcellulose (n=8) led the ingredient lists. As to the emulsifiers category, in 23 products no presence was reported, whereas in 19 products, mono- and diglycerides of fatty acids (n=12) and lecithin (n=9) were largely used. Glycerol (n=11), inulin (n=4), sorbitol (n=3) and enzymes (n=3) were classified as other processing aids. No sugars were found in 20 GF samples while in the remaining 22, dextrose (n=13) appeared most frequently. Concluding, the vast majority (n=39) of the GF FB included salt in their formulations, while only 3 samples were salt-free.

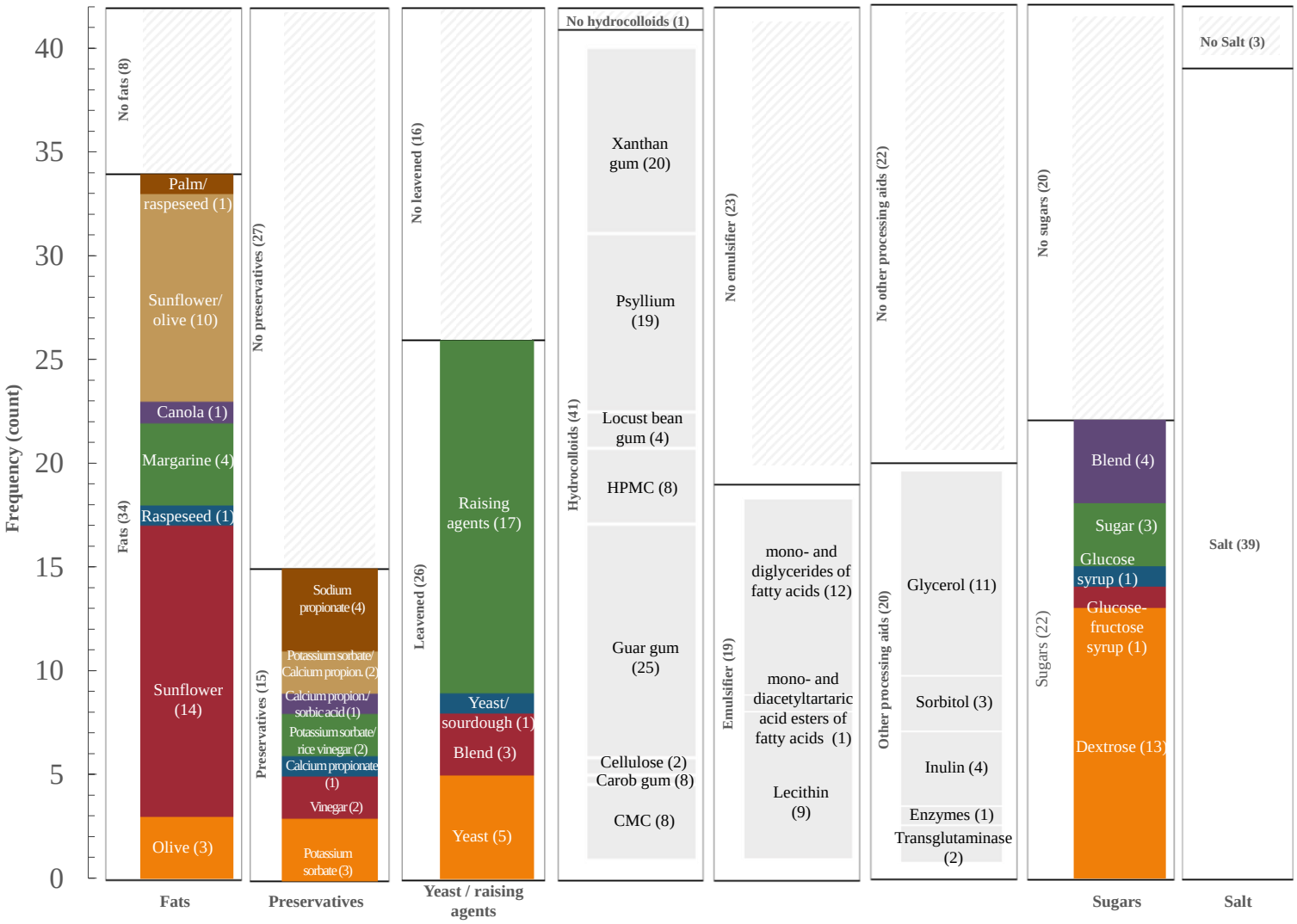


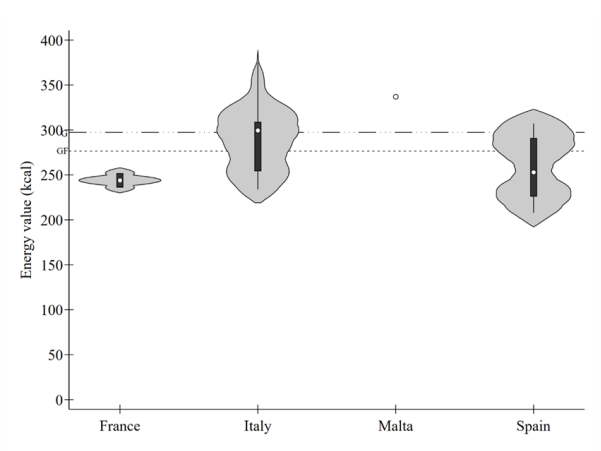
Figure 6. Appearance frequency of different types of fats, preservatives, leavening agents, processing aids, sugar and salt in the ingredient list of gluten-free flatbreads. The numbers in brackets indicate the number of products.

3.4 Nutritional quality of the gluten-free flatbreads

Under the energy value standpoint, GF FB sold in the Mediterranean market were less dense than their conventional counterparts. In general, French products were those with a lower caloric profile as opposed to the Italian and the Spanish ones (Figure 5.a). Compared to flour, starch addition significantly ($p < 0.05$) increased the energy value profile of the GF products. Figure 5.b shows the outcomes relative to the fat and saturated fat content, which followed the same pattern observed for the energy value. GF FB had lower fat content than those containing gluten, nevertheless this difference resulted reset when the saturated fat amount was analyzed.

As depicted in the Figure 5.b, the average of the carbohydrate content was higher compared to that of the gluten-based products. However, including starch in the formulations of the GF FB significantly ($p < 0.05$) contributed to a rise in carbohydrate content, while protein incorporation inverted that trend. No significant ($p < 0.05$) differences were observed about the sugar content of the samples coming from the different markets, as well as the fiber amount declared in the nutritional labels (Figure 5.c). In the latter, the average amount was lower in the GF products in comparison with the gluten containing counterparts. The comparison of the average protein content between the two product categories showed a dramatic difference with GF FB being characterized by a lower content (Figure 5.d). Generally, protein content was higher for the FB sold in Spain and it resulted significantly ($p < 0.05$) increase when the GF products included different flours rather than starches.

Regarding salt, GF FB class had a lower average level versus the conventional ones. Italian market seemed to be the country in which GF FB contained higher salt concentration (Figure 5.e), but this difference was not significant ($p < 0.05$).



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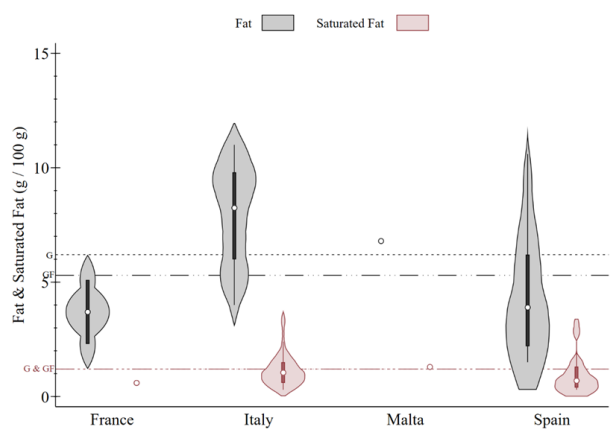

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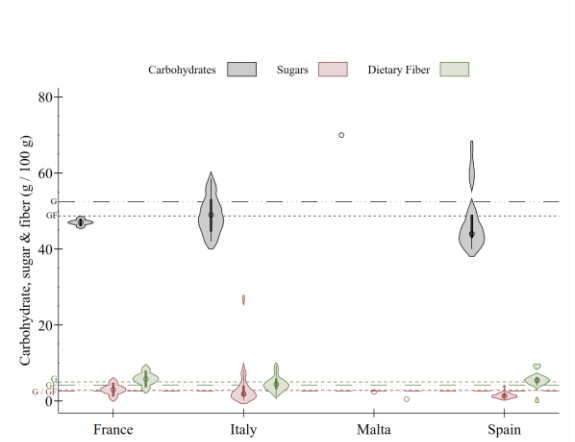

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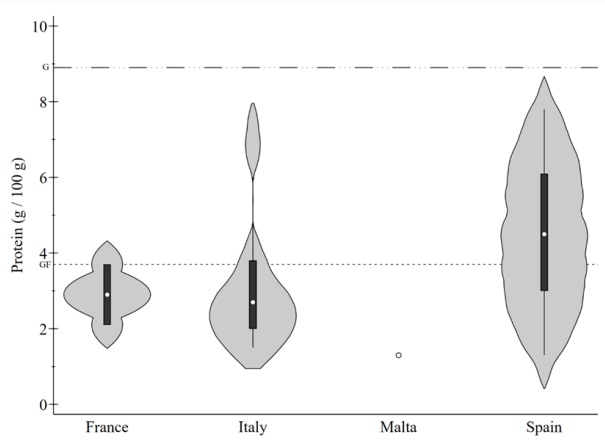
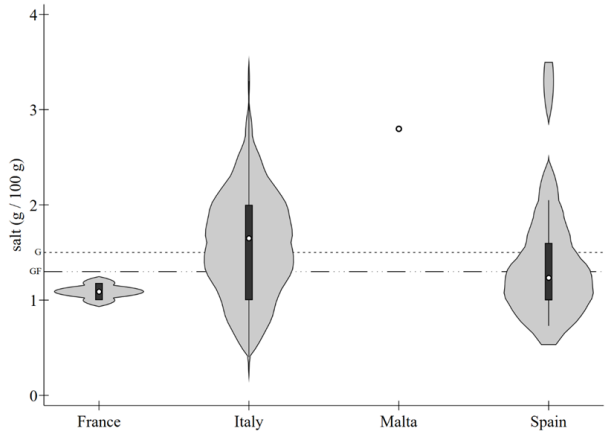


7.d



7.e

Figure 7. Nutritional composition of the FB sold in the Mediterranean market. 7.a: Energy values, 7.b: Total fat and saturated fat content, 7.c: Carbohydrate, sugar and dietary fiber content, 7.d: Protein content, 7.e: Salt content.

PCA of the nutritional data showed that two principal components explained 29.2% and 23.3% of the variation. Hence, the model described 52.5% of the total data variation (Figure 8). At the positive axis, the first principal component (PC1) weight was characterized by the dietary fiber, protein and the saturated fat content; here GF FB from the Spanish market have been found. From the other hand, GF FB sold in Italy had higher carbohydrate content.

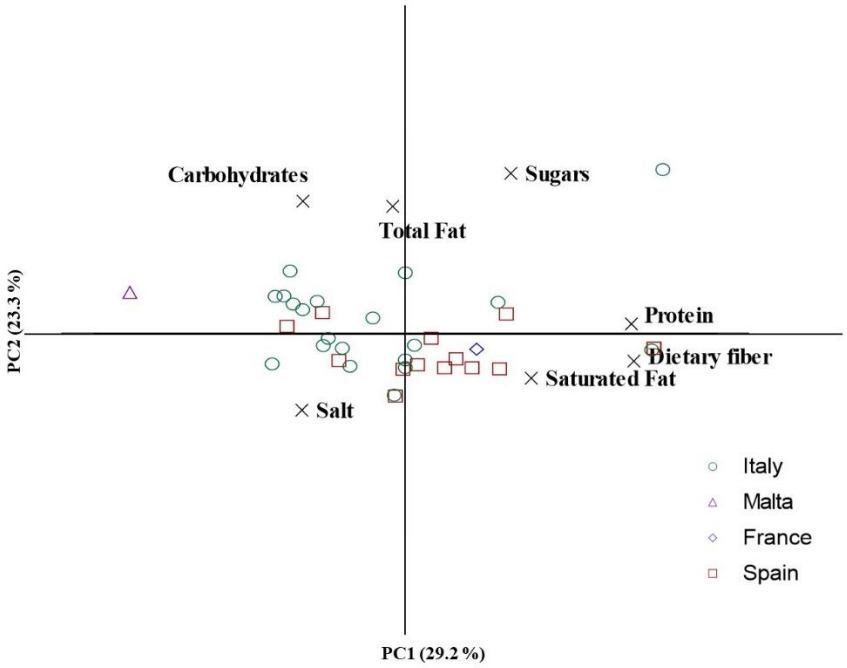


Figure 8. Principal Components Analysis of the gluten-free flatbreads sold in the Mediterranean market

4. Discussion

Despite the higher nutritional values of the gluten FB, whole meal flours were less employed when compared to white flours. In this regard, epidemiological studies have pointed out inversely associations between the risk of chronic diseases (obesity, type 2 diabetes, cardiovascular diseases, and cancer) and the whole wheat intake that provided higher quantities of fiber and bioactive components [24]. Behind that, there is a purely technological explanation; in fact, whole meal flours are more challenging raw materials to produce

baked goods. Specially for this product category, in which a certain rollability level is appreciated, both insoluble and soluble fiber interfere with the hydration of gluten and starch, worsening the technological quality of the final products [25]. The addition of legume flours to the cereal-based formulations would allow the obtention of a well-balanced product, from the aminoacidic point of view. In fact, the cereal lysine deficiency is complemented by the legumes and in the same way, the legumes lower levels of cysteine and methionine are enhanced by the cereals [26].

Looking at the ingredients' labels from the countries' standpoint, it is worth noting that in most cases, when the wheat flour was combined with other raw materials or in the presence of the whole wheat flour, gluten was added to the formulations, while water was frequently holding the second place in the ingredients list. Only one product found in Malta did not present the nutritional label, because it was directly sold from artisanal bakeries. In this country, nutritional labels are mostly found for gluten free products, while both artisan and industrial bakers sell their bread unpackaged and unlabeled (for flat bread). Most FB from Lebanon did not contain any leavening agent, sugar or fat. Likely, because in the Middle East country considered in the study, FB are mainly sold in local bakeries and consumed daily, owing to that, products do not require a complex ingredient list. In Croatian FB, common findings among the ingredients were eggs, while sweet potatoes represented a novel ingredient for new products. In several FB (*Zagorje mills* and *Mills*), no leavening agent or fat were found, but traditionally, *Mills* are rehydrated, softened and greased before consumption. Shifting the attention to the French market products, rapeseed oil and hydrated sourdough were used more frequently compared to those from the other countries. Regarding Greece, *pita* was considered as a double layer flatbread, although both categories of pita are marketed. Pita is the only traditional flatbread type sold in Greece, and most of the products contained vinegar and colorants (mainly curcumin). Hydrocolloids were used more frequently than emulsifiers and sunflower oil resulted the most employed fat. A different situation is featured in Spain where single layer FB (tortilla and wrap) represented the highest market share. Apart from *cenceña*, all the Spanish marketed FB use chemical leavening agents. Wheat flour was the basic flour utilized in more than half of the products and even if olive oil was used, sunflower oil was the most frequently occurred in the ingredients lists. Dextrose appeared very often in the recipes of the FB, mainly because it serves as substrate for yeast fermentation [27]. The formulations of the double-layer FB seemed to be simpler than those reported for their one-layer counterparts. In Italy, kamut wheat and spelt flours were often reported as main ingredients and olive and sunflower oils, as well as their combination were the most popular fat; while in the *piadina romagnola* type, lard prevailed. No added sugar and leavening agents were observed in most of the Italian FB while a combination of yeast and chemical leavening agents were found in a smaller part of them. In general, the presence of preservatives is lower compared to the other countries. Salt content was significantly ($p < 0.05$) different, with Croatian and Italian FB showing higher salt levels as opposed to the Lebanese and French FB in which the salt concentration was the lowest ($p < 0.05$). About that, World Health Organization recommends that keeping the daily salt intake below 5 g (approximately 2 g of sodium) per person is key to prevent cardiovascular diseases, the leading cause of death globally [28].

GF FB are still a challenge and numerous ingredients and additives are present in the recipes to keep up the consumer expectations regarding this type of product. This outcome was expected because the creation of a gluten-like network involves a larger number of processing aids and a combination of multiple flours [29]. The large use of starch in GF product making is due to its ability to hold water and to form a matrix in which air bubbles and non-gluten protein are entangled, improving the viscoelasticity of the system [30]. The role of starch in the GF field, is not purely technologic but it is also pivotal in determining the final glycemic index of the GF products.

Different strategies have been implemented for mimicking the gluten behavior in the GF products. Among them, hydrocolloids, emulsifiers, and enzymes have shown the most encouraging results. The need for making these GF products rollable, in order to be easily served with vegetables, meat or seafood finds the hydrocolloids a great alliant to achieve the target. These water-soluble polysaccharides control the rheology in aqueous systems through the stabilization of emulsions, foams and suspensions [31]. Their use is not only relegated to technological improvement, but it also contributes to increase the content of the soluble fiber that regulate the appetite making the GF products healthier [32]. Regarding the inulin, a polysaccharide with a great number of hydrophilic groups, it is mainly used for technological improvements, owing to its high-water holding capacities [33]. Under a nutritional standpoint, inulin is also classified as soluble fiber with prebiotic activity. In fact, it is not hydrolyzed by the enzymes of the upper intestinal

digestive tract but once arrived in the colon, it is fermented by the intestinal microbiota producing short-chain fatty acids (mainly acetate, propionate, and butyrate) [34]. Therefore, fibers have a dual effect on the GF FB, in addition to the nutritional benefits, the use of fibers has different effects on the technological profile of the GF products, depending on the ratio of their soluble and insoluble components [35,36].

Due to the lower contribution in terms of protein content provided by the main GF raw materials, adding protein in the form of isolate or concentrate is a common practice set up by the food industry. In the case of soy and pea protein, particular relevance has their high biological value (higher in lysine and methionine) and their water absorption and foaming capacities that influence the rheological properties of the batters as well as the physicochemical features of the final GF products [37]. In the case of the polyalcohols, they are mostly employed as humectant agents, preserving moisture and decreasing water activity [38], as well as sweeteners in place of sucrose [39].

5. Conclusions

The convenience and flexibility of the flatbreads are more and more driving the consumers' attention towards new eating habits. The analysis of the Mediterranean market revealed that flatbreads can be found in the conventional form and in that gluten-free. Among them, two principal types are sold in the market of France, Spain, Italy, Croatia, Greece, Malta, and Lebanon, named the single and doble layers. The main commodity used to produce both types was wheat flour. Regarding fat, sunflower and olive oil were the most employed ones. Nevertheless, rapeseed oil was the preferred fat in the FB of the French market, while in Italy, *piadina* included lard. Different situation was found in Lebanon, in which the ingredient lists did not contain any fat. Spanish market offered principally one-layer flatbreads, in particular tortillas and wraps, whereas in Greece, *pita* appeared with more frequency. Many Croatian flatbreads were not fermented, and they did not contain any yeast or leavening agent. Compared to the gluten containing flatbreads, a greater number of ingredients appeared on the labels of their gluten-free homologous. In the latter case, blending flours with starches was the most widespread practice. Hydrocolloids, emulsifiers and fibers were incorporated primarily for technological improvements but also for nutritional enhancement. However, as opposed to the gluten containing ones, gluten-free flatbreads were proved poorer in fiber and protein content; from the other hand, their energy value was found lower, as well as the carbohydrate and salt content. With a view to achieving continuous nutritional and technological improvement of these products, an increased incorporation of pulse flours, vegetables powders, the implementation of sourdough fermentation and the salt reduction could offer even more healthy alternatives to consumers.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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