

A Contamination by yeasts and moulds (Unacceptable quality) was noticed in 5% of L-GFP and in 18.2% of N-GFF. The latter category of foods was also contaminated by *Staphylococcus aureus*, faecal and total coliform in 13.6%, 13.6% and 5.4% of cases respectively. The gluten-free meals prepared at home were contaminated in prevalence of 11.7% mainly with *Staphylococcus aureus*. This food category was also contaminated by faecal coliforms, total coliforms and sulphite-reducing anaerobes. While, no contamination was observed in meals prepared in food services (Table 2).

DISCUSSION

There are many aspects related to the safety of gluten-free foods such as exact gluten content and contamination by physical or chemical substances [21, 22, 23]. Microbiological contamination of foods may be responsible for intestinal food poisoning in celiac patients whose intestinal villi are already damaged by atrophy [24]. Overall, among the sample analysed in our study, the majority of gluten-free foods displayed a satisfactory microbiological quality. These results are in accordance with those reported by similar studies conducted in Italy and Brazil [25, 26]. Contamination of gluten-free meals was particularly pronounced in home-prepared meals. It was mainly caused by *Staphylococcus aureus* and coliforms, which is probably due to poor hygienic conditions. Indeed, celiac patients give great importance to the gluten content in gluten-free foods and may neglect the contamination risk. No contamination of gluten-free meals prepared in food services was observed. This may reflect the importance that restaurants and bakeries place on microbiological safety during the preparation process of these foods. An Italian study conducted in a school catering facility reported similar findings [27]. Indeed, the non-detection of a serious microbiological risk in gluten-free and lactose-free foods prepared by the services of this school confirms the compliance with good hygienic practices following HACCP implementation [27].

Contamination of products labelled as “gluten-free” was almost absent and was noticed in less than 1% of the samples. This shows that hygienic practices have been followed during all the formulation processes of gluten-free products, in accordance to the HACCP system [28].

It was remarkable that naturally gluten-free foods were frequently contaminated with yeast and mould, which could be due to poor storage conditions. This can also be explained by the fact that these foods, dedicated mainly to patients on a gluten-free diet, are generally stored for a long time before being sold. Definitely, the longer the storage period of gluten-

free foods, the more the load of yeasts and moulds increases [29]. In contrast, as a naturally gluten-free food, quinoa is generally free of microorganisms [25]. In the N-GFF of our study, coliform contamination was observed in 13.6%, which is probably related to improper handling during the processes of harvest, storage and sale.

As a serious health hazard, the presence of *Salmonella* and *Listeria monocytogenes* in gluten-free foods is alarming. In fact, *Salmonella* and *Listeria monocytogenes* are among the major causes of food-borne disease outbreaks [30]. Fortunately, no gluten-free foods have been contaminated with these dangerous bacteria. Similar findings were reported by studies conducted on L-GFP [25, 26]. Similarly, such contamination was absent in gluten-free meals prepared in food services as reported by Petruzzelli et al. [27].

At the limit of our knowledge, this study represents the first one carried out in Morocco and Africa, highlighting the importance of the microbiological safety of GFF. Our study focused on three food categories at once (N-GF, L-GFP and gluten-free meals). Nevertheless, as limitations, the sample size of foods analysed remains relatively small to draw definitive and others conclusion, especially about some more virulent food poisoning microorganisms (*Salmonella* and *Listeria Monocytogenes*). In addition, the unavailability of the *Bacillus cereus* specific agar medium in the context of this study, limited our ability to investigate the risks associated with the said organism. It is noteworthy to report, that the study *Bacillus cereus* is recommended by food regulatory organizations due to their frequent presence in foods [31].

CONCLUSION

The results of our study showed a high prevalence of contamination in naturally gluten-free foods (8.3%) and gluten-free meals prepared at home (11.7%), predominantly with yeasts and molds for the first category, and with *Staphylococcus aureus* and coliforms for the second category of foods. While no contamination was observed in gluten-free meals prepared in food services. We also noticed the absence of contamination with some pathogens like *Salmonella* and *Listeria monocytogenes*, known for their extreme virulence. Therefore, rigorous hygienic practices and adequate corrective measures should be considered by celiac patients, especially regarding the naturally gluten-free and meals gluten-free prepared at home.

Conflict of interest

The authors declare that there are no conflicts of interest.

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