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# Practices of deep-frying processes among food handlers in social food services in Navarra, Spain

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ABSTRACT

Deep frying is one of the most used worldwide methods in food preparation, but controlling the oil quality (temperature and formation of polar compounds) is crucial. The main objective of this work was to assess the practices of food handlers with regard to the frying processes in social food services located in Navarra (a region of northern Spain). The study was performed in two phases: in the first one, a self-administrable questionnaire regarding the usual practices on food deep-frying processes was sent to the food services through the main social catering companies of Navarra participating in the study. In the second one, *in situ* monitoring of the frying practices was performed as verification tools of frying practices reported by food services and to check the oil quality. Almost half of the fryers exceeded the maximum recommended temperature to avoid the formation of toxic compounds (175 °C). Despite only one the fryers exceeded the maximum limit of polar compounds established by current Spanish regulation, the obtained values indicated that the oil had begun to degrade in 20% of the fryers. Oil temperature is an important factor that affects the quality of the oil. In addition, significant differences were found between the different frequencies of change or types of oils. We have noticed a lack of knowledge in relation to the risks associated to the bad management of frying oil. Therefore, it would be desirable to improve food handlers training in relation to this matter. Defining a periodic frequency of oil change according to its use and periodic controls of temperature and polar compounds (as part of the Hazard Analysis and Critical Control Point system), could be adequate tools to improve management of frying oil in food services.

## 1. Introduction

Deep fat frying is one of the most well-accepted methods in food preparation, especially in the Mediterranean area (Hampikyan et al., 2011). Fried food provides unique aroma, taste, golden colour and crispy texture that cannot be found in other cooking techniques (Aladedunye, 2015).

During deep frying, different reactions occur depending on factors such as replenishment of fresh oil, frying condition (i.e., time and temperature) and the original quality of the frying oil. Oil storage and cooking conditions can also produce a variety of chemical compounds due to oil oxidation and polymerization (Esfarjani et al., 2019). In addition, oil degradation is also affected by the type of oil and the nature of fried foods (Flores-Álvarez et al., 2012). Thus, food handlers should know all these circumstances related to frying practices and consequently, they must control the frying processes regularly to avoid chemical risks. This checking should include at least the frying temperature, the number of times the oil has been reused and the levels of polar compounds.

In order to produce a top quality fried product, oil temperature must be high enough to ensure that the centre is adequately cooked and the surface layer does not get overdone, in the time required to cook the product (McSavage and Trevisan, 2001). However, it is known that the extended use of oils at high temperatures and the lack of periodical replacements result in changes in the oils in terms of physical properties and an increased concentration of various chemicals, including peroxide and polar compounds (Manral et al., 2008; Takeoka et al., 1997; Wang et al., 2015). Therefore, controlling the quality of the consumed edible

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oils in catering establishments is essential to guarantee the health of consumers (Ahmadi et al., 2018). However, not all methodologies provide objective and reliable information on the oil degradation to avoid health risks. Thus, monitoring frying oil by visual inspection is an extended practice among food handlers, but it has been determined as not reliable enough to take decisions regarding when should be necessary the oil replacement (Fernandez-Gallardo et al., 2011; Yilmaz, 2020).

Hazard Analysis and Critical Control Point system (HACCP) (CAC, 1997) has become universally recognized and accepted as a useful tool to ensure food safety (FAO/WHO, 2004). European food businesses operators must implement food safety procedures based on the HACCP principles according to the Regulation (EU) No. 852/2004 (EC, 2004). In addition, the Spanish Regulation 3484/2000 establishes as mandatory the application of self-monitoring activities following the HACCP principles for the catering industry (BOE, 2001). The key point is to determine correctly the Critical Control Points (CCP) and the procedures to control them. Both the temperature and the production of polar compounds in frying oil are considered CCP to be taken into account to prevent some of the chemical hazards that could occur in catering services (Weisshaar, 2014).

Determination of the total polar compounds (TPC) is one of the most reliable methods for the continuous monitoring of the quality changes in oils during the frying process and it is accepted worldwide for the control of frying oils and fats (Hampikyan et al., 2011). In Spain, the current legislation establishes a maximum limit of 25% for polar compounds in frying oil (BOE, 1989).

On the other hand, the high temperatures in frying processes is one of the factors that favors the formation of acrylamide in foods rich in hydrocarbons. This is a chemical processing contaminant classified by the International Agency for Research on Cancer as a Group 2A compound, which means a probable carcinogen for humans (IARC, 1994). In 2015, the European Food Safety Authority (EFSA) published that the presence of acrylamide in food potentially increases the risk of developing cancer for consumers in all age groups (EFSA, 2015). Later, in 2017, the European Commission established mitigation measures and benchmark levels for the reduction of the presence of acrylamide in foods (EC, 2017). In this sense, a report from the Scientific Committee of the Spanish Agency for Consumers Affairs, Food Safety and Nutrition (AECOSAN), currently AESAN, recommends avoiding frying temperatures above 175 °C (Cámara et al., 2017). Moreover, frying of meat products at high temperatures can produce an appreciable level of some potentially carcinogenic compounds such as heterocyclic aromatic amines (IARC, 2018).

Studies on frying practices and its impact on the quality and safety of frying oils have been carried out among street vendors and restaurants (Ahmadi et al., 2018; Karimi et al., 2017), but little information regarding these activities in the social catering sector is available (Fernandez-Gallardo et al., 2011). Considering the large amount of meals served each day in childcare, schools, hospitals, geriatrics and businesses (Gheribi and Bonadonna, 2018), it is critical to ensure food safety in social food services. In this context, the main objective of this study was to assess the practices of food handlers with regard to the frying processes in food services located in Navarra (a region of northern Spain), in order to determine risky situations. The study was carried out in two phases: the first one by using a self-administrable questionnaire to recover relevant information regarding frying processes, and the second one, by *in situ* monitoring of the frying practices as verification tools of the reported data by food services.

## 2. Materials and methods

### 2.1. Selection of food services

The criteria for the sample selection were food services operating at social level and providing daily menus that included fried products. Navarra is a small region of the North of Spain and we have considered the largest companies operating in the area. Therefore, a letter explaining the purpose of the study and requesting cooperation was sent to the main social catering companies that manage food services in Navarra (school and university canteens, university residences, geriatric centers and hospitals), ensuring participants the confidentiality of the information gathered. 12 out of the 15 contacted social catering companies agreed to participate in the study, allowing us the access to one or more of the food services managed by them. The companies themselves decided which of the food services could be included in the study according to the established criteria (basically, those that provided fried dishes regularly). Thus, the self-administered questionnaire was sent to the 30 food services selected by the participating companies, but only 20 responses were recovered. The remaining services refused to participate referring lack of time. Finally, the *in situ* monitoring of the frying practices was performed in 14 food services, due to the difficulties in establishing a visiting day in the remaining centers (lack of personnel, fryers out of use or staff work overload). The study was conducted from January 2019 to November 2019.

### 2.2. Documentation design

A self-administrable questionnaire was developed to recover information regarding the usual practices on food deep-frying processes (available upon request to the corresponding author). The questionnaire was designed having into account the research team experience on the implementation and audits of the HACCP system in social catering companies, as well as on the activities performed in previous studies (Garayoa et al., 2017). The questionnaire consisted of 16 questions (open answer of multi-choice options), covering general data of the food services (social catering sector, number of daily menus, etc.) and specific questions related to the deep-frying process (characteristics and capacity of the fryers, types of the fried foods and oils, temperature of deep-frying, quality controls carried on and frequency of these controls). Before distribution, the questionnaire was checked by experts and validated doing some tests with potential respondents.

In addition, a template was prepared to collect data during on-site inspection in the kitchens. The following information was recovered through visual inspection, direct questions to workers and *in situ* oil monitoring: types of the fried foods and oils, date of the last change of oil and/or the frequency of change, oil temperature and level of polar compounds.

### 2.3. Self-reported information on frying practices

The questionnaire was sent by email to the catering company managers and they distributed it to each of their food services. The questionnaires completed by manager of each food service were received within one month of being sent to the companies. In case of missing data, the food service was contacted by telephone to complete the information.

### 2.4. Verification of frying practices

To verify the self-reported practices we made a visit to the food services 6 months after receiving the questionnaire. The same trained staff performed this work in all food services, interfering as little as possible with the routine kitchen work.

The information was obtained by visual observation and questions to the person in charge of the food service (monthly menu programs to verify the type of fried foods, records of changes of oil and type of oils that were currently in use). In addition, direct measures in the heated oil of the fryer (temperature and polar compounds) were made by triplicate. Food handlers were asked to fry a food as usual and when finished the process the measuring instrument FOM 320 (Ebro-electronic, Ingolstadt, Germany) was dipped into the oil and stirred in order to measure the temperature and the percentage of TPC.

### 2.5. Statistical analysis

Statistical analyses were performed by using SPSS 15 software (SPS Inc., Chigago, IL, USA). The means, percentages and averages were calculated for the analyzed samples. In order to find significant correlations between different attributes of oil (oil exchange frequencies and recorded temperatures) and levels of polar compounds, the chi square test was applied with a level of significance of $p < 0.05$.

## 3. Results and discussion

The self-administered questionnaire was sent to the 30 food services selected by the 12 participating companies and responses were received from 20 kitchens, with a majority managed by companies A ($n = 5$), B ($n = 3$), C ($n = 2$) and D ($n = 2$) (Table 1). *In situ* information regarding TPC and temperature of frying oil was obtained by visiting 14 food services (Table 2).

### 3.1. Deep-frying practices in food services: types of used oil and fried food

The self-reported questionnaire (Table 1) showed that sunflower oil is used in 9 of the kitchens, followed by high-oleic sunflower oil ($n = 8$). These two types of oils are the most frequently used in food service establishments in Spain (Mesias et al., 2019), although olive oil is typically the main source of lipids in the Mediterranean diet. Fundamentally, economic reasons have led this sector to use other types of oils for frying, such as sunflower oil or mixtures of refined vegetable oils, soybean oils and high oleic acid content (Casal et al., 2010), while olive oil is used to dress salads. With regard to the information collected on the visits to the selected food services (Table 2), we found that the information they provide us regarding the type of oil used did not coincide with that observed *in situ* in three establishments. In two of them we observed that they used special oil for frying, even though in the questionnaire they claimed to use oil high-oleic sunflower (a more expensive oil). In the third one, they used high oleic sunflower oil, instead of the sunflower oil referred to in the questionnaire. Significant differences were detected regarding levels of polar compounds and the two types of oil most frequently used ($p < 0.05$).

As shown in Table 1, frying is used as a cooking technique to prepare different types of food both of plant and animal origin. These foods include potatoes, chicken breast, sausages, hamburgers, battered fish, peppers, zucchini, onions or breaded products (data not shown). The effect of type of fried food on the quality of oil could not be evaluated since most fryers were used to prepared meals of different origin. It must be mentioned that differences regarding shelf-report answers and observed practices were found (Tables 1 and 2), with more types of food fried in the seven of the food services visited with respect to those indicated in the questionnaire. In this sense, Zanin et al. (2017) recommended using the observed practices in order to evaluate the food safety performance and the self-reported practices to assess perceptions and behavior.

Finally, we observed that seven of food services that have 2 fryers, used one of them exclusively for frying potatoes (Table 1). In this case, we observed lower polar compounds values when using high-oleic sunflower (<3) with respect to the using of sunflower (19.5). In addition, it was a usual practice to change oil from fryer 1 (potatoes) to fryer

**Table 1**
Self-reported information by food handlers regarding frying practices.

| Food service (Company) | Number of daily menus | Used oil | Fryer | Type of food | Selected T (°C) | Oil control | Frequency of oil change |
|---|---|---|---|---|---|---|---|
| 1 (A) | 220 | Sunflower | 1 | P; M; F; O | 180 | Yes[c] | Monthly |
| 2 (A) | 500 | Sunflower | 1 | P; V; M; O | 170–180 | Yes[c] | Weekly |
| | | | 2 | P; V; M; O | 170–180 | | |
| 3 (A) | 50 | High-oleic sunflower | 1 | P; F; O | NR | Yes[c] | Every 2 weeks |
| 4 (A) | 150 | Sunflower | 1 | P | 170–180 | Yes[c] | Weekly |
| | | | 2 | O | 170–180 | | Every 5 days |
| 5 (A) | 50 | High-oleic sunflower | 1 | P; MM; F; O | 170–180 | Yes[c] | Every 2 weeks |
| 6 (B) | 276 | High-oleic sunflower | 1 | V; O | 180 | Yes[b] | No defined frequency |
| | | | 2 | P; V; O | 180 | | |
| 7 (B) | 530 | Sunflower | 1 | P; M; F; O | 170 | No | Every 2 months |
| 8 (B) | 900 | Sunflower | 1 | P, V; M; MM; F, O | 180 | No | No defined frequency |
| | | | 2 | P, V; M; MM; F, O | 180 | | |
| 9 (C) | 20 | Sunflower | 1 | P | 180 | Yes[c] | Every 2 weeks |
| | | | 2 | O | 180 | | |
| 10 (C) | 20 | Sunflower | 1 | P; MM; O | NR | Yes[c] | No defined frequency |
| 11 (D) | 50 | High-oleic sunflower | 1 | P; O | 180 | No | Weekly |
| 12 (D) | 50 | High-oleic sunflower | 1 | P | 180 | No | Every 2 weeks[e] |
| | | | 2 | M; O | 180 | | |
| 13 (E) | 1100 | Sunflower | 1 | P; F; O | NR | Yes[a] | NR |
| | | | 2 | P; F; O | NR | | NR |
| 14 (F) | 200 | High-oleic sunflower | 1 | P | NR | Yes[a] | No defined frequency[e] |
| | | | 2 | V; F; O | NR | | |
| 15 (G) | 130 | Sunflower | 1 | P; V; M; MM; O | 170–180 | Yes[c] | Every 2 weeks |
| 16 (H) | 40 | High-oleic sunflower | 1 | P | NR | No | Monthly |
| | | | 2 | V; M; F; O | NR | | |
| 17 (I) | 45 | Special oil for frying | 1 | P | 180 | No | Monthly[e] |
| | | | 2 | V; M; F; O | 180 | | |
| 18 (J) | 400 | Special oil for frying | 1 | P; M; O | NR | No | Every 2 weeks |
| | | | 2 | P; M; O | NR | | |
| 19 (K) | 60 | Special oil for frying | 1 | P | 170–180 | Yes[d] | No defined frequency |
| 20 (L) | 80 | High-oleic sunflower | 1 | P | NR | No | Every 2 weeks[e] |
| | | | 2 | F; O | NR | | |

P (potatoes); V (vegetables); M (non-minced meat); MM (minced meat); F (fish), O (others); NR: Not reported.
[a] Digital polar compound meter FOM 320 (Ebro, Germany).
[b] Oxifrit-Test (Merck, Germany).
[c] OleoTest (Biomedal, Spain).
[d] 3M Low Range Shortening Monitor (3M, USA).
[e] The oil used in fryer 1 is changed to fryer 2 and continues to be used.

**Table 2**
Recorded information on the visited food services (n = 14).

| Food service (Company) | Fryer | Measured data (media ±sd) | | Data provided by food handlers *in situ* | | | |
|---|---|---|---|---|---|---|---|
| | | Temperature (°C) | Polar compounds (%) | Used oil | Type of food | Frequency of oil change | Time since last oil change |
| 1 (A) | 1 | 184.9 ± 0.36 | 13.5 ± 0.12 | Sunflower | P; F; O | No defined frequency | 1 day ago |
| 6 (B) | 1 | 179.0 ± 0.29 | 4.0 ± 0.06 | High-oleic | P; V; F; O | No defined frequency | 5 weeks ago |
| | 2 | 183.7 ± 0.29 | 3.5 ± 0.29 | sunflower | P; V; F; O | | |
| 7 (B) | 1 | 192.1 ± 0.50 | 11.5 ± 0.26 | Sunflower | O | Every 1–2 months | 5 weeks ago |
| 8 (B) | 1 | 182.0 ± 0.46 | 21.0 ± 0.15 | Sunflower | P; V; M; MM; F; O | Every 4–5 weeks | 2 weeks ago |
| | 2 | 182.4 ± 0.21 | 17.5 ± 0.31 | | P; V; M; MM; F; O | | |
| 10 (C) | 1 | 160.2 ± 0.21 | 2.5 ± 0.12 | Sunflower | P; O | Every 2 weeks | 1 day ago |
| 12 (D) | 1 | 174.0 ± 0.59 | 3.0 ± 0.00 | High-oleic | P | Weekly[a] | 4 days ago |
| | 2 | 164.0 ± 0.21 | 3.0 ± 0.12 | sunflower | M; O | | |
| 13 (E) | 1 | 164.5 ± 0.31 | 16.5 ± 0.15 | Sunflower | P; V; MM; F; O | No defined frequency | 18 days ago |
| | 2 | 194.9 ± 0.41 | 13.0 ± 0.11 | | P; V; MM; F; O | | |
| 14 (F) | 1 | 172.9 ± 0.31 | 2.0 ± 0.05 | High-oleic | P | Weekly[a] | 3 days ago |
| | 2 | 166.9 ± 0.47 | 3.5 ± 0.21 | sunflower | V; M; F; O | | |
| 15 (G) | 1 | 161.0 ± 0.31 | 13.5 ± 0.21 | Sunflower | P; F; O | Every 2 weeks | 1 day ago |
| 16 (H) | 1 | 175.9 ± 0.21 | 2.3 ± 0.12 | High-oleic | P | Every 3–4 weeks | 3 weeks ago |
| | 2 | 135.6 ± 0.17 | 7.5 ± 0.31 | sunflower | V; M; MM; O | | |
| 17 (I) | 1 | 152.2 ± 0.26 | 12.0 ± 0.17 | High-oleic | P; V | Monthly[a] | 6 weeks ago |
| | 2 | 130.4 ± 0.29 | 19.5 ± 0.15 | sunflower | M; MM; F; O | | |
| 18 (J) | 1 | 155.1 ± 0.42 | 14.5 ± 0.20 | High-oleic | P; V; M; MM; F; O | Every 2 weeks | 4 days ago |
| | 2 | ND | ND | sunflower | P; V; M; MM; F; O | | |
| 19 (K) | 1 | 120.0 ± 0.21 | 31.5 ± 0.21 | Special oil for frying | P; V; O | Every 2 months | 6 weeks ago |
| 20 (L) | 1 | 179.8 ± 0.31 | 19.5 ± 0.06 | Sunflower | P | Every 2 weeks[a] | 8 days ago |
| | 2 | ND | ND | | M; F; O | | |

P (potatoes); V (vegetables); M (non-minced meat); MM (minced meat); F (fish); O (others).
ND: Not done because the fryer was turned off.
The shaded information does not match the questionnaire.
[a] The oil used in fryer 1 is changed to fryer 2 and continues to be used.

2 to extend the use of oil with a reduction in costs (four of the aforementioned kitchens).

### 3.2. Temperature in deep-frying processes: referred and measured data

Seven out of the twenty food services did not report the usual temperature during the deep-frying process, but the measured data *in situ* showed that 3 kitchens exceeded 175 °C (maximum recommended frying temperature, (Cámara et al., 2017), reaching 194.9 °C ± 0.41 in one of the fryers (Table 2). On the other hand, the rest of the kitchens (65%) already indicated a maximum temperature of 180 °C in the questionnaire. However, 5 fryers (belonging to 4 kitchens) exceeded 175 °C in our visit to the service, reaching over 190 °C in one of them. It should be noticed that both of the fryers of kitchen number 8 have recorded a temperature of 182 °C. The statistical analysis performed comparing the ranges of recorded temperatures (<160 °C, 160-175 °C and >175 °C) and the ranges of polar compounds (<10% and >10%), not showed significant differences. Taking into account the relationship between high temperatures and toxic compounds formation, strategies have been put in place to reduce acrylamide formation mainly at the industrial sector, where the measures are easier to apply due to well-controlled and more standardized processes. However, culinary practices in other settings such as public establishments, catering services, restaurants or private homes are not routinely controlled (Mesias et al., 2020). In the present study, 50% of the visited food services would not comply with the AECOSAN's recommendations on avoiding frying temperatures above 175 °C. In this sense, it is important that food handlers receive specific training on the deep-frying processes to minimize acrylamide formation.

### 3.3. Quality control of TPC

Only twelve kitchens indicated that they used any of the tests or systems available for the quality control of the frying oil (Table 1). To verify the effectiveness of these controls, we proceeded to measure the percentage of TPC in all the available fryers when visited the kitchens (Table 2), with the exception of 2 of them that were off at the time of visiting because the kitchen staff was changing oil and cleaning the equipment. It is worth mentioning that levels of 31.5% ± 0.21 of polar compounds were detected in one fryer, despite they reported the regularly use of the 3M Low Range Shortening Monitor test (3M, Bedford, United Kingdom). This kit measures the quality of frying oils by analysing the free fatty acid (FFA) content. According to Tseng et al. (1996), FFAs are not considered a reliable indicator for the quality of deep-frying oils. Also, this test is subjective and rather difficult to interpret (Bansal et al., 2010). In addition, 23.8% of the measurements reported values above 15%, indicating that the oil started to degrade, although seven of the visited kitchens carried out a periodic control of the oil quality. Oxifrit-Test (Merck, Darmstadt, Germany) is another test based on the principle of colorimetry by detecting oxidised fatty acids (OFAs), by means of a colour indicator. This test provides more qualitative information on the oil quality rather than quantitative one, based on the oxidative degeneration (Paul and Mittal, 1997). Also, it is subjective to compare the colour of the resultant solution with the provided colour chart. However, the only food service that used this test in our study obtained adequate results when checking fryers *in situ* (4% ± 0.06 and 3.5% ± 0.29 of TPC, respectively).

The most used method to control the quality of frying oil was the OleoTest (three of visited kitchens) (Biomedal Diagnostics, Sevilla, Spain). It is a mix of chemical reagents for the evaluation of polar compounds formed during frying processes, and similarly to Oxifrit-Test, it is a colorimetric test that depends on the interpretation of the obtained colour. This method is valid with seed oils (sunflower, corn, peanut, etc.) and coconut oil, while it does not work with olive oil because it interferes with the colour of the test. The three kitchens that reported to use this test obtained correct levels of TPC when we checked the oils (between 2.5% and 13.5%).

The Digital Polar Compound Meter FOM 320 (Ebro), which provides the amount of TPC in percentage as well as the oil temperature, was used by the 14.3% of the kitchens. It is the only method that provides quantitative and objective data, thus we selected it to perform the quality control of frying oil in the visited kitchens. The measured data *in* *situ* showed correct TPC values in the both kitchens that used this methodology.

Regarding the seven food services that do not control the quality of the frying oils in any way (50% of establishments), they indicated, at the time of the visit, that a visual check was periodically carried out. The performed measurements in the fryers of these kitchens showed that they all complied with the current regulations, since the percentage of TPC was <25%. However, values above 15% were found in 4 of them, evincing that the oil was not in optimal conditions. In this sense, visual observation could be complemented with periodic surveillance of TPC by experimental procedures in order to obtain real-time information for a proper management of oil (Weisshaar, 2014). In a previous research, we found that visual observation can be a valuable tool for the quality control of frying oils, but it must be accompanied by periodic and adequate training of food handlers to be able to recognize risky situations and to control the main critical points (Garayoa et al., 2017). The HACCP system can help food handlers to integrate the objective control of frying oils among the mandatory activities established in the food service, establishing an oil management plan well defined, specifying maximum temperature in fryers, frequency of oil change and method and frequencies for polar compounds measures. However, catering establishments did not have established specific control measures to avoid frying oil degradation, as reported by Fernandez-Gallardo et al. (2011). By contrast, in the study carried out by Soriano et al. (2002) in university canteens, it was found that the implementation of guidelines included in the HACCP system produced an improvement in the quality of the frying process and all establishments reduced their polar compound values to less than 25%.

### 3.4. *Frequency of oil change: shelf-reported information and in situ verification*

Another important aspect that influences the proper management of frying oils is the oil renewal. Taking into account the variety of foods that are cooked in the studied fryers, it is important to establish an adequate frequency of oil change. In fact, the 75% ($n = 15$) of food establishments carried out the oil change with a previously established frequency (Table 1), which was variable according to the characteristics of each kitchen. Significant differences have been determined between weekly and monthly frequencies of change and percentage of polar compounds ($p = 0.038$) or weekly and every two weeks renewal ($p = 0.017$). On the other hand, the 25% of kitchens that had 2 fryers and one of them exclusively used for frying potatoes, the used oil coming from the potatoes fryer served for the renewal of oil in the second fryer. This practice is carried out because the oil degrades to a lesser extent when frying potatoes, as evidenced in the study carried out by Flores-Álvarez et al. (2012), in which it was found a faster degradation of oil during repeated frying of fish nuggets than when frying potatoes, as higher values of TPC were recorded.

Comparing the data provided by the food services and those recorded when visiting kitchens, it was found that the frequencies of oil change were not coincident in six of the food services (Table 2). Despite these differences, the quality of the oil complied with current regulations in all food services with the exception of one. This food service established the oil renewal every 2 months and, after using the oil for 6 weeks, the TPC reached the 31.5% ± 0.21. In this sense, some authors found that frying oils were used for a long time without being replaced and they committed to self-monitoring as a good strategy for ensuring that the frying oils meet the quality standards (Ahmadi et al., 2018; Karimi et al., 2017).

Training of food handlers in food safety is one of the pillars of the social catering companies. Various authors have reported that the acquired knowledge not always modifies workers attitudes and practices (Al-Kandari et al., 2019; Lestantyo et al., 2017; Osaili et al., 2018; Zanin et al., 2017). However, training is still lacking in key aspects, especially in the handling and control of food temperatures (Teffo and Tabit, 2020). In this sense, good practices and periodic controls of the deep-frying processes should be included in the training programs of the food services in order to minimize the chemical risks that may appear.

## 4. Conclusions

The surveillance performed in a sample of Spanish social food services located in Navarra highlighted the need to improve the frying processes with regard to frying temperatures and oil control procedures. Despite correct TPC levels were found in the majority of kitchens, temperatures higher than 175 °C were recorded in several fryers, which represent a risk of acrylamide and other toxic compounds formation. Therefore, it would be desirable to establish an oil management plan in the framework of the HACCP system, defining periodic objective checks of TPC and temperature, as well as oil change frequencies based on the recorded data. On the other hand, food handlers must be aware of the importance of maintaining oil in optimal conditions to avoid risks and this knowledge should be considered in the regular training programs. Finally, it was found a mismatch between some self-reported practices and those obtained directly when visiting the kitchens, highlighting the importance of verifying the information collected in questionnaires through *in situ* observations and measurements.

### 4.1. *Study limitations*

The main limitation of the study has been the low number of recruited food services and not being able to visit all the selected kitchens, with the subsequent reduced available data. In addition, it would also have been interesting to carry out a preliminary survey among food handlers to assess their training regarding frying oil management, to determine knowledge gaps.

Despite these limitations, the results obtained constitute a starting point to improve the training of handlers on this subject to achieve good handling practices of frying oils.

## Implications for gastronomy

The supervision and management of the frying oils used by food services is not considered in many of them as part of the established HACCP system, despite it is a key to guaranteeing their quality and subsequently, the health of consumers. To avoid the early degradation of oils and the formation of chemical hazards such as acrylamide and polar compounds, monitoring the frying temperature and levels of polar compounds should be included as Critical Control Points. In addition, it is important the election of the type of oil and the number of frying performed with the same oil must for good frying practices. In this sense, the training of food handlers in relation to this matter should be improved in order to transform knowledge into appropriate behaviors.

## Declaration of competing interest

The authors declare that there are no conflicts of interest.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijgfs.2021.100432.

## Author contributions

R.G. designed the questionnaire, contacted the social catering companies, made the visits, analyzed the data and wrote the manuscript. J.S. distributed the questionnaires and collected the data. A.V., A.L.C. and A. A. participated in the design of the questionnaire and reviewed the manuscript (A.A. is the main researcher of the BIOGENSA project). A.I. V. made some visits to food services, analyzed the data and reviewed the manuscript.

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