DELIVERABLE 4: COMPARATIVE ANALYSIS REPORT WITH CASE STUDIES OF GOOD PRACTICE IN THE DEVELOPMENT OF NEW TECHNOLOGIES RELATED TO NDSS AND THEIR ROLE IN STIMULATING THE INNOVATION PROCESS IN THE EU FOOD INDUSTRY

A QUESTIONNAIRE-BASED STUDY

17 MAI 2024

CRA-W

1. Introduction

This document presents the work done to identify needs in term of sensors relevant to the SENSORFINT project. For this, the main activity included the development of a questionnaire-based study to collect information about current practices, applied standards and identify/confirm core needs/demands and challenges. The responses received from the questionnaires are analysed and presented within this document.

2. Objectives

The objective pursued along this task was to identify needs and users 'goals on the area of sensors through the SENSORFINT project.

3. Process design of the questionnaire

3.1 Strategy outline

The design of the questionnaire was based on a structure to allow efficiency and convenience for fast completion by users/stakeholders. The chosen questions were focused on avoiding too technical elements that may be difficult for responders to provide answers to. The questionnaire was developed using "EUSurvey application" (ec.europa.eu/eusurvey/home/welcome). This is a simple and easy to use platform provided by the EU for performing surveys. Anyone can register, create surveys, share the survey link and receive responses. It also offers the best processing tools with no restrictions on the number of surveys one can create or the number of questions in each survey, or the number of responses one can collect. The platform also offers automated in-platform results analysis and the data/responses collected can be easily downloaded/exported. Personal data were not required but could be filled as optional fields if wanted by participants.
The survey remains available and can be viewed at the following link: https://ec.europa.eu/eusurvey/runner/641bd045-1f7d-2fda-26d3-ba18a6b8db21.

3.2 Questionnaire language

Questionnaires were first developed in English language. Questionnaires in local language are needed since some end users are more comfortable with their national language. The EUSurvey application allows direct translations to other EU languages. A first version in French was developed and validated by the CRA-W and Wagralim.
Each translated questionnaire included the same questions, with the same number of possible answers as the original ones (in English). That was an important condition in order to analyse data results properly.

3.3 Survey dissemination

The survey was mainly sent via email to all different participants through the SensorFint list platform as well as Wagralim contact lists. Potential participants have been invited to participate in the survey by e-mail. Figure 1 shows the email sent to all the potential participants.

SENSORFINT QUESTIONNAIRE

Dear,

The objective of the sensorFINT COST ACTION (EU CA19145) is create a vibrant network, combining experience in research, manufacture, training and technology transfer in relation to non-destructive spectral sensors (NDSS). The Action will operate by developing generic solutions to existing and emerging problems in non-invasive food process control building an "smart food control system" as well as developing a cadre of well-trained young researchers who will convert scientific results into a reality that matches industrial needs.

I am writing to invite you to participate in a key element of the study, a survey gathering input from experts within the food, feed and other industrial sectors to gain first-hand insights on the real needs and on the potential interest regarding this sensor technology.

I would very much appreciate your insights and input from a European perspective on this important subject. Have your views and opinions voiced.

As a thank you, we will share the outcome of the whole foresight project with you when completed, which will encompass views of a large number of national and international experts on the future of the sensors which may be of interest to you.

Survey Link:

Please complete the survey latest by XXth XX 2023.

If you have any questions, please don't hesitate to get in touch with me.

Looking forward to receiving your response.

Best Regards

Figure 1 – invitation letter (in English) sent to all the potential participants

4. Survey – questions

Figure 2 shows all the questions included in the survey, including the different arborescences depending on the question.

Who are you *(possibility to stay anonymous)?*

From which country are you coming from? *(Free response)*

Do you consider yourself as a: *(possibility to tick several boxes)*

- Food/Feed industry
- Other industry
- Researcher/academic
- Sensor provider
- Sensor user
- Other *(Free response)*

For food/feed industry & other industry & sensor user

How many persons are working in the industry? *(Tick one box)*

- 1 to 10
- 10 to 50
- 50 to 200
- >200

What type of products are you processing? *(Possibility to tick several boxes)*

- Food
- Feed
- Other – which ones? *(Free response)*

Is your company using actually sensors for quality purpose? *(Yes/no)*

- No
- Yes
    - Which sensors? *(Free response)*

Is your company using sensors to check integrity/conformity of your raw materials and/or products? *(Yes/no)*

- No
- Yes

    - Which sensors? *(Free response)*

What are the key parameters that have to be followed in your process? *(Free response)*

- protein
- fat
- ash
- humidity
- sugar
- Other – which one? *(Free response)*

Does you quality control involve laboratory measurements (wet chemistry) of composition or other properties (contaminants, impurities …)? *(Yes/no)*

- No
- Yes
    - Which ones? *(Free response)*

Do you use rapid sensors such as NIR spectroscopy for some or all of these measurements? *(Yes/no)*

- No
- Yes

Are you interested in exploring the potential use, or further use, of such methods? *(Yes/no)*

- No
- Yes

Would you make such measurements if rapid and low cost methods were available? *(Yes/no)*

- No
- Yes

Which are the actual limitations to implement sensors in your company? *(Free response)*

Do you think that sensors are promising solutions for you? *(Free response)*

Where do you need implementation of sensors in your process?

- At the harvest time
- At the reception stage
- In the process
- At the final product
- At the packaging stage
- In the store distribution

Should the sensor be fully automated? *(Yes/no)*

- No
- Yes

    - If Yes, is real-time prediction necessary? *(Free response)*

        - *No*
        - *Yes*

Do you have an interest for a portable technology to analyse the physico-chemical composition/quality of your products?

(scale 0 to 10, 1 being no interest and 10 being extremely high interest)

- If > 5: How much time could you spend to do one analysis (including time to wash the instrument)? *(tick one box)*
    - Less than 1 minute
    - 1 minute
    - 3 minutes
    - 5 minutes
    - 10 minutes
- What price are you willing to pay for such instrument? *(free response?)*

Importance of following criteria *(scale 0 to 10; 0 being no importance and 10 being extremely high importance)*

- Low price
- Robustness
- Accuracy of the measure
- Easy-to-use information
- User friendly interface
- Information delivered on smartphone

For researchers/academic + sensor provider + other

What is the main field of your research? *(Free response)*

What are the bottlenecks for the use of sensors in the food sector? *(Free response)*

What are the challenges in the sensing devices? *(Free response)*

Are sensors a solution to tackle food integrity issue? *(Yes/no)*

- No
- Yes
    - How? *(Free response)*

Do we need new sensors? *(Yes/no)*

- No
- Yes
    - Which sensors? *(Free response)*

Do we need new platforms? *(Yes/no)*

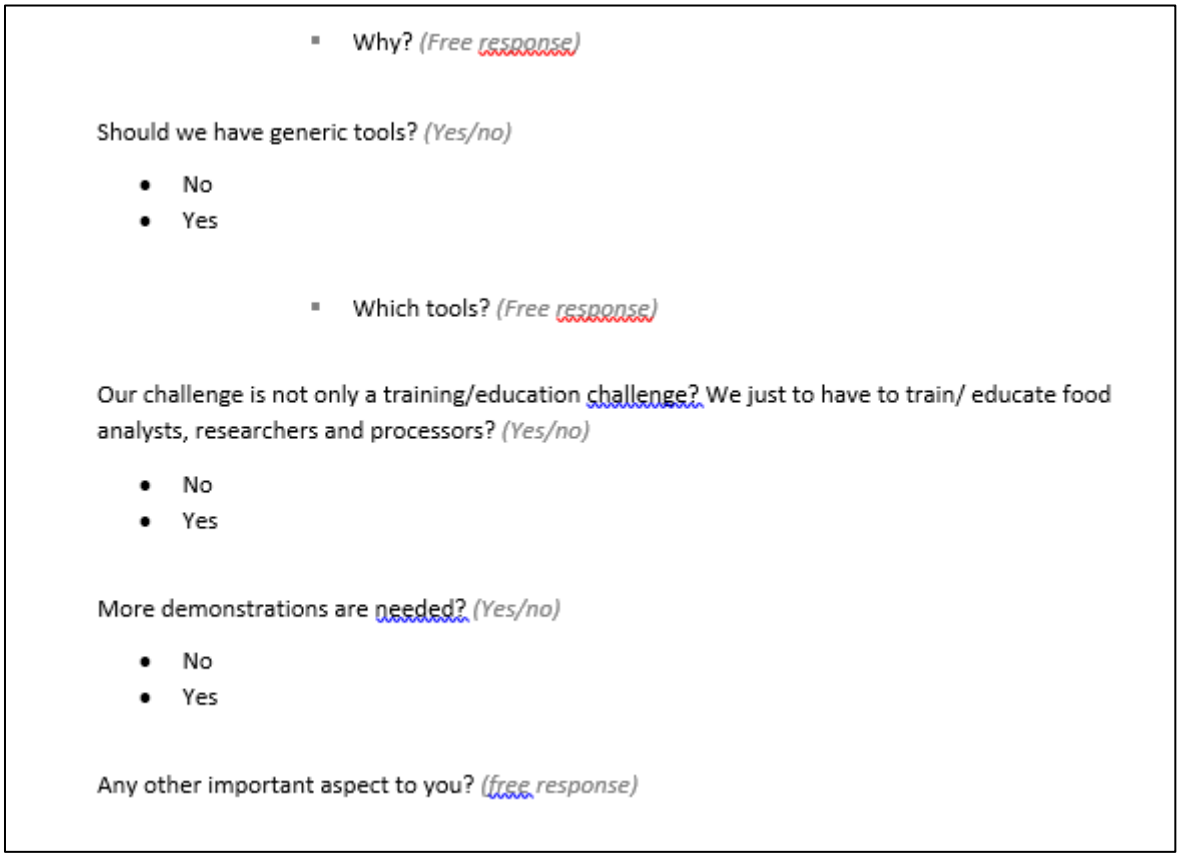
- No
- Yes
    - Which platforms? *(Free response)*

Do we need new algorithms? *(Yes/no)*

- No
- Yes
    - Which algorithms? *(Free response)*

Is calibration a challenge? *(Yes/no)*

- No
- Yes



- Why? *(Free response)*

Should we have generic tools? *(Yes/no)*

- No
- Yes

- Which tools? *(Free response)*

Our challenge is not only a training/education challenge? We just to have to train/ educate food analysts, researchers and processors? *(Yes/no)*

- No
- Yes

More demonstrations are needed? *(Yes/no)*

- No
- Yes

Any other important aspect to you? *(free response)*

Figure 2 – the survey

5. Survey outcome

The output of each questionnaire was collected as an Excel spreadsheet exported from the platform. This platform allows extracting the results in form of graphs and tables, including values in terms of number of participants and percentages.

6. Participants

In total 98 people have completed the questionnaire. The profile of the participants is as indicated in Figure 3.

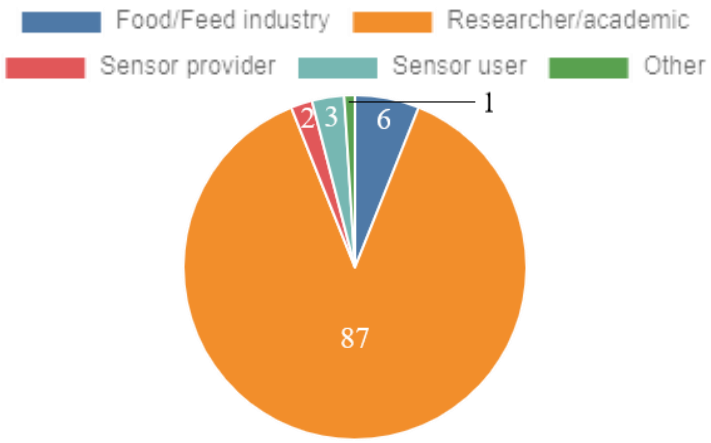


Figure 3 – Profile of the different participants

As expected, the vast majority of the participants (87.88 %) come from the research/academic area. Around 6.06 % of the participants come from the food and feed industry. The remaining 6.07 % are split between sensor users (3.03 %), sensor providers (2.02 %), and others (1.01 %).

These participants mostly come from European countries most represented countries are Spain (26.92 % of participants), Italy (14.42 %), and Turkey (8.65 %). The majority of the participants come from European countries but other continents are represented as well as represented in Figure 4.

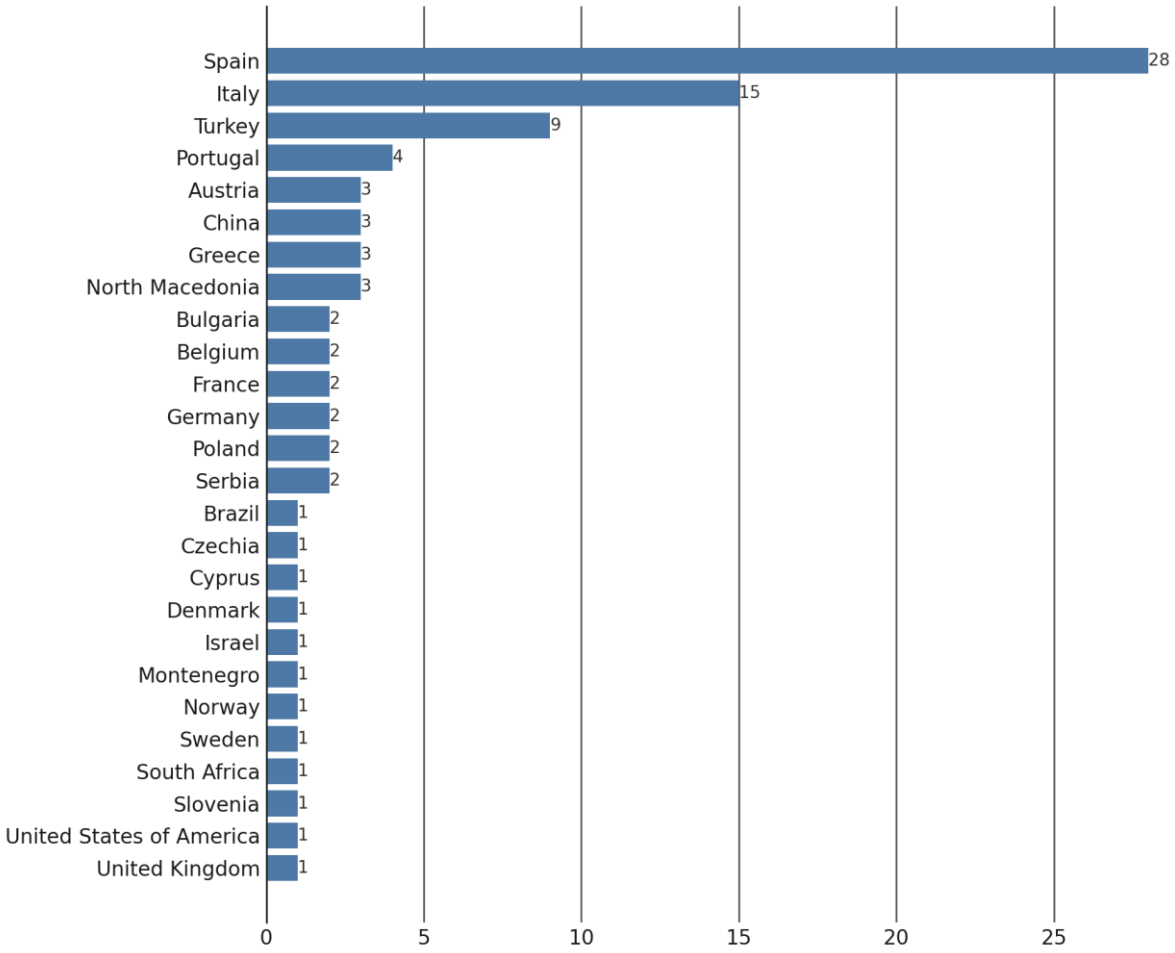


Figure 4 – Country of origin of the different participants

7. Data analysis

7.1. Research/academic

7.1.1. Sensors

The research and academic area gathered a wide range of participants (Figure 5). Among those 87 participants, 32.18 % work in R&D, 40.23 % are professors, 16.09 % are students, and the remaining 11.49 % are considered “others”.

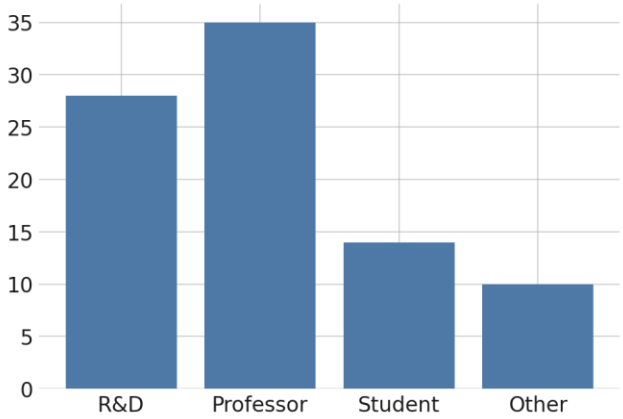


Figure 5 – Professional profile of the different participants

According to 93.10 % of them (Figure 6), sensors represent a solution to tackle food integrity issues, 3.45 % consider that this is not an appropriate solution, and 3.45 % did not answer this question.

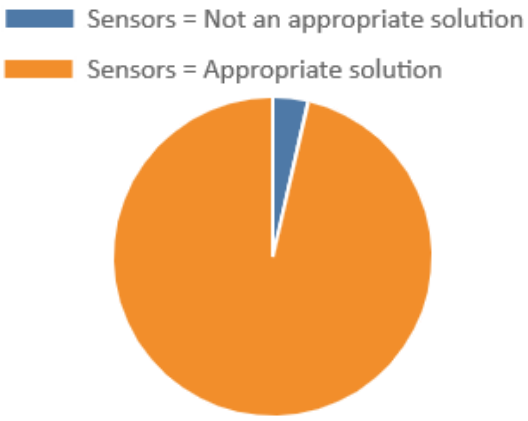


Figure 6 – Results regarding the question on the possible use of sensors on food integrity issues

To do so, the majority (82.76 %) consider that new sensors are needed, but 14.94 % consider that this not (Figure 7). Again, a small percentage (2.30 %) did not provide any answer.

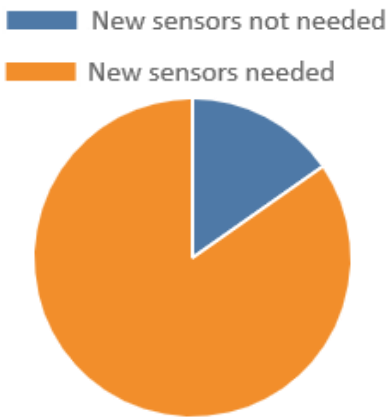


Figure 7 – Results regarding the question on the possible development of new sensors on food integrity issues

In Figure 8 it is shown that these new sensors should rather be for new applications (useful for 68.97 % of voters) than for new sensors that measure parameters already measured by sensors (useful for 43.68 % of voters). 18.39 % of the participants did not answer this question.

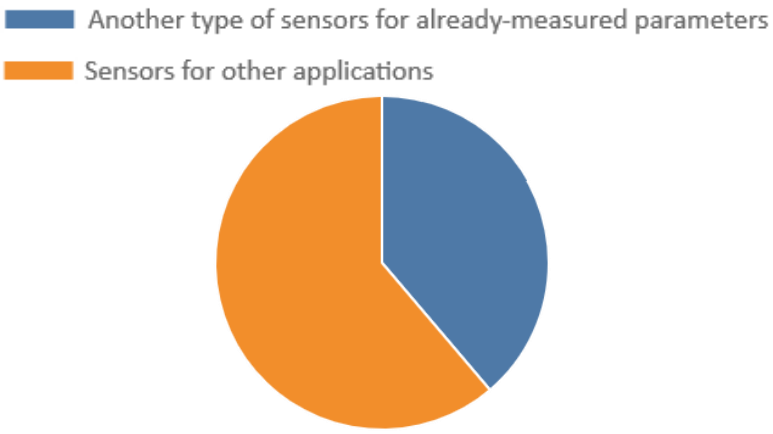


Figure 8 – Results regarding the question on the possible use of sensors for new applications

7.1.2. Models

For these sensors to be useful, we asked the participants if new prediction models were needed. As indicated in Figure 9, 88.51 % answered yes, 10.34 % of the voters no, and 1.15 % did not answer.

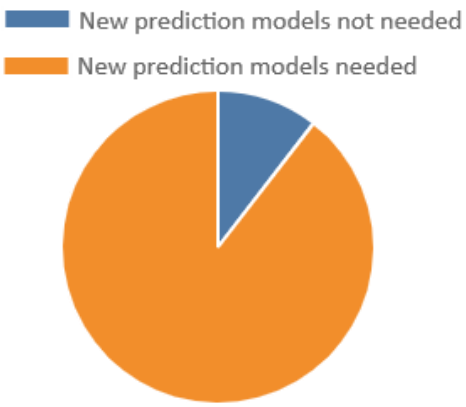


Figure 9 – Results regarding the question on the possible need of new prediction models

These models could be based on basic chemometrics tools (50.57 % of the voters) or sophisticated ones (50.57 % of the voters as well), as shown in Figure 10. 21.84 % of the participants do not care as long as these models provide quick answers. 12.64 % did not answer.

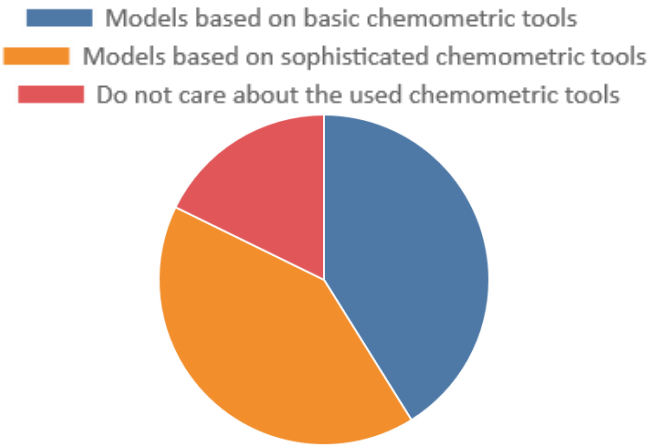


Figure 10 – Results regarding the question on the possible need of chemometric based prediction models

Calibrating new models, however, represents a challenge for 68.97 % of the researchers as shown in Figure 11. Only 28.74 % of them feel comfortable to carry out this process.

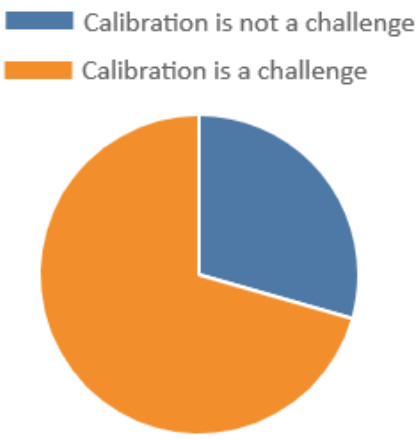


Figure 11 – Results regarding the question on the challenge when performing calibration

Accordingly, 72.41 % think that demonstrations are needed (Yes), 24.14 % that they are not necessary (No) and 3.45 % did not answer. Figure 12 shows the results.

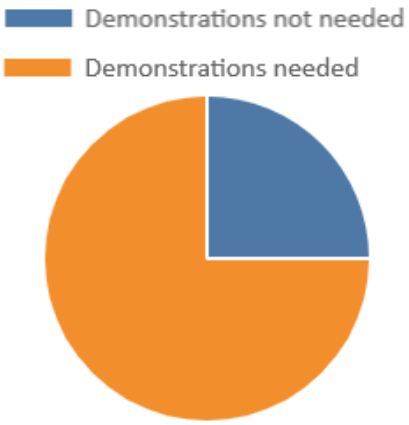


Figure 12 – Results regarding the question on the need of demonstration activities

Conclusion Researchers/academic: Researchers consider that sensors represent a solution to food-integrity-related issues. However, new sensors are needed and they should preferentially target new applications. Another constraint is the calibration, which is needed but represents a challenge for many participants.

7.2. Industry

The six industrials who answered this study were all from the food/feed industry. Most of them are R&D managers (4 people out of 6) but a quality manager and a technician also participated in this survey.

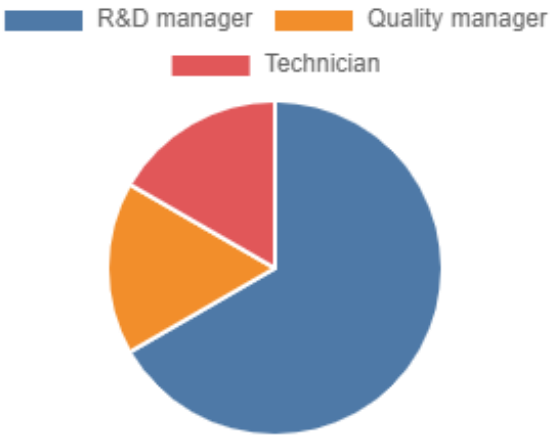


Figure 12 – Profile of the different industry participants

Half from them work in industries with 50-200 people, and the other half in industries with more than 200 people (Figure 13).

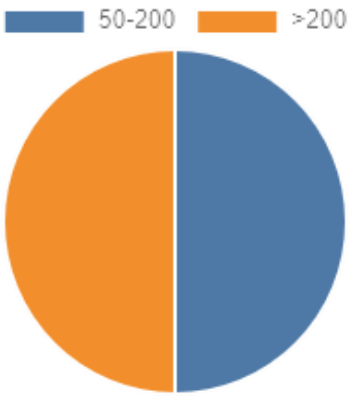


Figure 13 – Average size of the industries participating

They all use sensors for quality purposes. As shown in Figure 14, the categories of products are food, processed by 5 of their industries, feed processed by 2, and other categories of products which are processed by one.

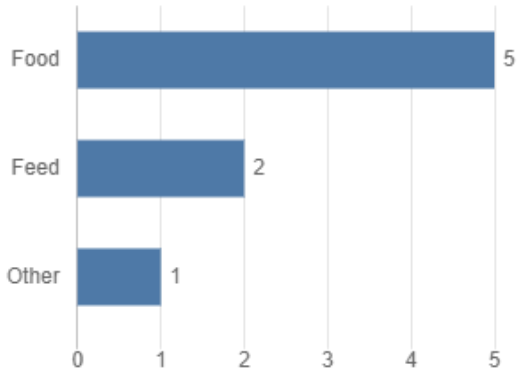


Figure 14 – Area of work of the industries participating

Even though the six industries use sensors for quality purposes, only half of them use them to check the integrity/conformity of the raw materials and/or products (Figure 15).

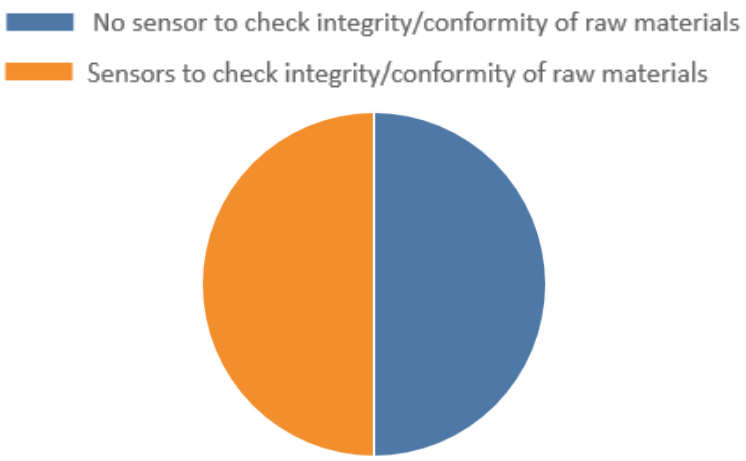


Figure 15 – Ratio of industries participating using sensors

The key parameters that have to be followed in the process are the fat content for 66.67 % of the industries, the humidity for 50 % of them, the proteins for 33.33 %, and then the ash and the sugar for 16.67 % each. 83.33 % consider other key parameters, such as the salt and polyurethane content (Figure 16).

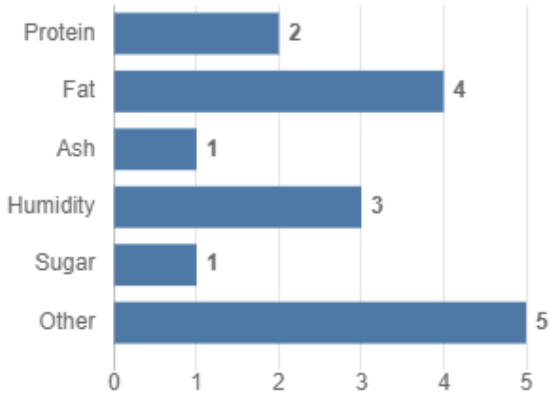


Figure 16 – Key parameters for the industries participating

In 83.33 % of the cases, quality control involves laboratory measurements of compositions or other properties (Figure 17). Those measurements target the proteins, humidity, fat, acids, nitrites, nitrates, pigments as well as microbiological contamination (salmonella) and the response time of the measurement methods ranges from seconds to hours.

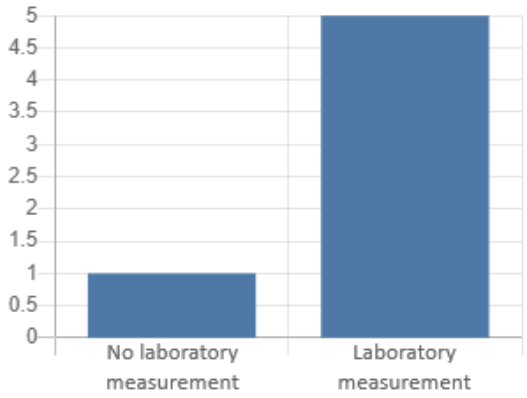


Figure 17 – Involvement of laboratory measurements in the industries participating

Again, 83.33 % of them use rapid sensors such as NIR spectroscopy for some or all of these measurements, as indicated in Figure 18.

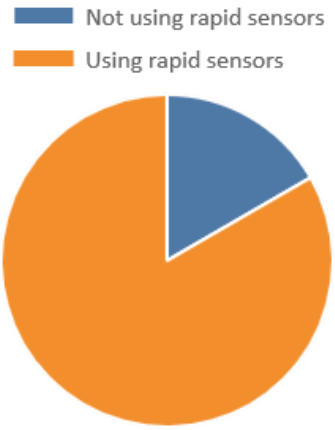


Figure 18 – Use of rapid sensors in the industries participating

All of them were interested in exploring the potential use of such methods. They would all make such measurements if rapid and low-cost methods were available. For now, the main limitations in sensor implementation are the cost, speed, accuracy, integration, and miniaturization of such instruments. Quick, possibly online, and cheap measurements would encourage all of them (5 yes - 1 no answer) to measure more batches/samples, allowing for more in-depth analyses.

Real-time predictions seem to be a necessity. As shown in Figure 19, only 33.33 % of them could spend 10 minutes for the analysis of one sample (time to clean the instrument included), 50% 5 minutes, 83.33 % 3 minutes, and 100 % 1 minute.

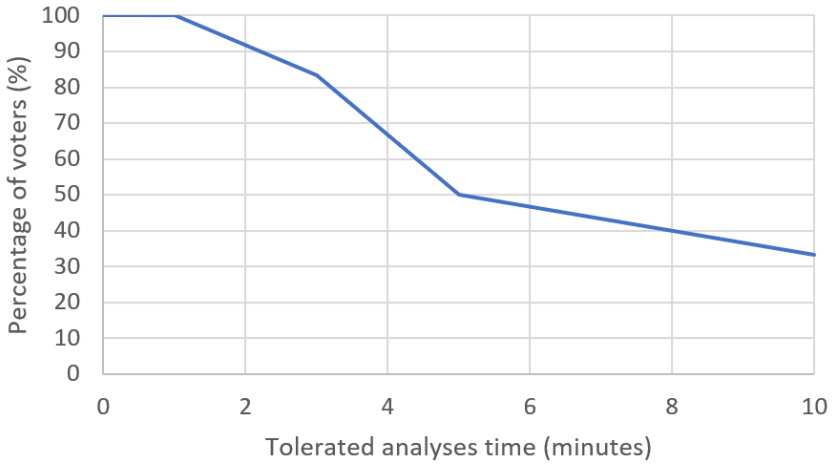


Figure 19 – Tolerate time per analysis for the industries participating

The implementation of such sensors seems needed at various stages of the product chain according to the participants (Figure 20). However, it seems like using these sensors on the final products and during the process are the preferred options (83.33 % of the voters selected these stages).

Figure 20 – Stages of the product chain where sensors are more needed for the industries participating

As indicated in Figure 21, 83.33 % would implement these sensors on the production line (e.g. continuously on the conveyor belt) rather than upon uploading/receiving the product.

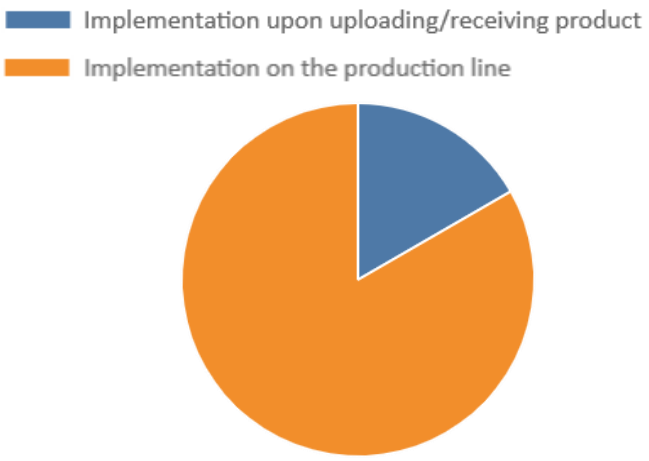


Figure 21 – Use of rapid sensors at the reception or at the production line for the industries participating

The same percentage consider that such sensors should be fully automated (Figure 22).

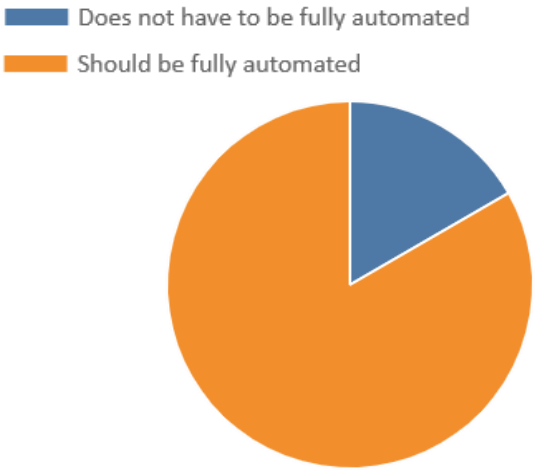


Figure 22 – Need of fully automated sensors for the industries participating

Eventually, the importance of several sensor criteria has been assessed. As shown in Table 1, among all the cited criteria, the robustness and the accuracy of the instruments seem to be the most important criteria. Having the results of the analyses directly on a smartphone is the criteria with the lowest priority.

Table 1- Most important criteria for the industries participating and their range of importance

Criteria	Average of the importance (/10)	Range of the importance (/10)
Interest in portable technology	9.33	7-10
Price	8.83	6-10
Robustness	9.50	9-10
Accuracy	9.50	8-10
Easy-to-use information	8.50	7-10
User-friendly interface	8.50	7-10
Information on smartphone	7.50	5-10

Conclusion Industrials: Industrials consider that sensors could represent a solution for validating the integrity and conformity of their products. Right now, such an implementation is made complicated by the cost, speed, quality, miniaturization, and implementation of such instruments. Real-time prediction (as fast as possible) represents a necessity. The robustness and the accuracy of the sensors are also critical.