Challenges of teaching food microbiology in Brazil

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Abstract

Food Microbiology is included in majors such as Food Engineering, Food Science and Technology, Nutrition, Veterinary Medicine, Gastronomy, Pharmaceutical Sciences, among others. Food safety and hygiene are usually the focus, but the technological applications of microbes through fermentations are also covered. During an education symposium at the Brazilian Congress of Microbiology in 2017, a group of professors expressed their difficulties associated with teaching to new generations, the use of technology in the classroom, and the application of new learning tools. The objective of this study was to gather information about the educational practices among Brazilian professors who teach Food Microbiology throughout the country. The results indeed confirmed the diversity of careers in which food microbiology is taught. We verified that professors mixed traditional teaching strategies with modern active learning methods, even though some difficulties associated with lack of time, pedagogical training, and low adherence of students for adopting these modern methods were commonly highlighted. The preferred teaching approaches were dialogued or discussed lectures, seminars, homework, case studies, and field visits. It is noteworthy that most professors still use traditional teaching methods. It is crucial that awareness concerning the educational needs in different careers and the challenges and dilemmas facing education for the new generations should be dealt with by using effective teaching approaches in food microbiology education. We suggest that a more permanent discussion forum among faculty members dealing with food microbiology in the country should be launched and this work is a step towards this goal.

Keywords Education · Food hygiene · Teaching · Food safety · Higher education

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Introduction

Food microbiology teaching mostly deals with topics related to the role of microorganisms in food safety and hygiene, prevention of food spoilage, food production by means of fermentations and other microbial processes, and with the role of microbes in nutrition. The technological, sensorial, and nutritional aspects of foods influenced by foodborne microorganisms are also related [1]. Additionally, the role of probiotics and their possible effects on human and animal health has gained increased interest in recent decades [2].

Food microbiology is important for many careers such as Food Engineering, Food Science and Technology, Nutrition, Veterinary Medicine, Gastronomy, Pharmacy, among others. As diverse these curricula can be, the subject still plays an essential role in the production of safe, nutritious, and wholesome foods, gaining different meanings and focuses depending on the major, but part of the general umbrella of One Health and the farm to fork food safety framework [3, 4].

Data from the National Institute for Educational Studies and Research “Anísio Teixeira” (INEP) from the Brazilian Federal Government indicate that there are hundreds of undergraduate courses that potentially teach, at least in part, Food Microbiology subjects nationwide. For instance, throughout the country, there are 515 courses of Pharmacy, 456 of Nutrition, 247 of Veterinary Medicine, 94 of Food Engineering, and 94 of Food Science and Technology [5]. These numbers are high, but it is common for the same institution to offer a course in the morning and the evening, impacting the total numbers; besides the fact that many institutions have multiple campi spread at different cities, offering the same undergraduate major. Even though we were unable to verify if each of these courses teach Food Microbiology in their curricula, it is likely that there might be at least a discipline that is correlated and deals with the subject in the context of Food Safety, as verified in the national curricular guidelines of each of these careers [6].

One of the challenges in the teaching of food microbiology in this scenario is to determine what is the appropriate content and by which approach one can convey the knowledge to such a heterogeneous and complex group of professionals. A possible outcome is that professors may replicate their teaching methods according to how they were taught and miss on important new strategies that would engage more effectively the new generations [7]. Besides, students generally have alternative perceptions about the relationship between microorganisms and food from their daily routines, which are usually superficial and influenced by common sense [8–11].

The modernization of the educational process is necessary, especially considering that the twenty-first century has been marked by great changes and social transformations which directly affect all levels of education [12–14]. In higher education, the professor and the university face new challenges with the enormous scientific, technological, and pedagogical advances seen lately. All of these alter the skills and abilities that need to be developed by the students and require a change in the teaching methods and also in teachers’ attitudes [12, 15].

The modern university classroom should reflect the world and its technology that is constantly evolving. The use of smartphones, computers, notebooks, and tablets in higher education classrooms is becoming more prevalent, prompting a change in students and professors’ attitudes. State-of-the-art technology advancement is really fast, but this does not always translate to appropriate knowledge acquired by the students [11]. But according to Libâneo [16], technology cannot be separated from modern education. Thus, the need for a renewal in methodological strategies is clear, since each generation presents different abilities and needs [16]. This also asks for improvement of novel technical skills among teachers’ upgraded set of modern information teaching tools.

The professor is one of the actors in the modernization of the university, since their mission is based on the advancement

of knowledge, demanding more active and effective forms of education for the student’s knowledge construction [17]. This process requires a modern and innovative teaching methodology [18–20].

Faced with new educational dynamics, the norm nowadays is that the teacher loses the centrality in the classroom and becomes a mediator through collective reflections, arousing interest, criticism, and providing more meaningful instructions, which come to be consolidated by different methodological strategies [21, 22].

What is also of concern is the fact that proper training for teaching food microbiology may not have been correctly addressed in the careers of new generations of professors. Based on our experience, professors working with food microbiology do not have specific pedagogical training that allies the particular technical knowledge and the pedagogical presuppositions of the teaching-learning process. Thus, it is crucial that the process of qualification of professors be continuous so that proper adjustments can be performed according to the needs of the classroom [23].

The present study aimed to investigate the technical training, the pedagogical practices adopted by Brazilian Professors, and their perceived difficulties when teaching Food Microbiology in Brazil for different undergraduate majors.

Materials and methods

This research is characterized as an exploratory, cross-sectional, and quantitative approach aiming to identify the current scenario of Food Microbiology teaching, assessing the academic and pedagogical training adopted by professors in the classrooms throughout Brazil. The use of technology and different teaching methods in the classroom as well as their relevance are also explored.

The target audience of the research was composed of professors who approached the Food Microbiology theme in several undergraduate courses in Brazil offered by public and private higher education institutions.

Data collection took place during the months of July, August, and September 2018 through an online questionnaire developed in the platform Google Forms, available at the link <https://goo.gl/forms/U6uR77OznVJ0Q9yp1>. We created thirty-one objective and subjective questions and grouped them into the following topics: personal data, institution and work regime, teaching strategies, and means to overcome the challenges in teaching.

In order to reach the target audience, an invitation to fill out the form was sent to the e-mail addresses of several professors that belong to the Food Microbiology Teachers Brazilian Network, part of the Food Microbiology Teachers Global Network launched in 2016 by Professor Peter Raspor from

the International Committee on Food Microbiology and Hygiene (ICFMH) during the Food Micro Conference in Dublin (Ireland). The link was also made available by the Brazilian Society for Microbiology (SBM) through their e-mail directory. Additionally, a link of the survey was made public via several groups in social media outputs and which contained potential professors that teach Food Microbiology, in addition to professionals we knew and contacted personally.

Once the data were collected, they were organized in electronic spreadsheets, using the Microsoft Office Excel 2007 and analyzed by simple descriptive statistics and the qualitative data through the technique of content analysis, which allows one to consider the data both in the textual structure and in the implicit subjectivity of words and their inferences in each subject's messages [24].

It should be noted that the ethical and legal aspects were considered according to the provisions of Resolution 510/2016 of the National Health Council, and the voluntary participation in research and anonymity of the participant were guaranteed [25]. No personal data from the respondents were shared during the survey. The free and informed cooperation of the participants in the study, as well as the most relevant information such as objectives, methods and contact of those responsible for the research were presented in the questionnaire itself. A copy of the questionnaire is presented as [supplemental material](#). Thus, ethics committee's approval was not required both as per our institution's guidelines as well as per national regulations. Please see the "Ethical aspects of this research" section for additional information.

Results and discussion

Profile of professors who participated in the study

A total of 117 professors responded to our online questionnaire. All of them teach Food Microbiology (or a related course/subject) to several different undergraduate majors such as Nutrition, Food Engineering, Food Science and Technology, Veterinary Medicine, Pharmacy, Gastronomy, among others (for a detailed list of all courses, please see Table 1). The majority of the respondents teach Food Microbiology to Nutrition (48.7%), followed by Food Engineering (23.9%), Pharmacy (16.2%), Food Science and Technology (15.4%), and Veterinary Medicine (12.8%).

We found that 80.3% of the respondents in this survey are women. This could be due to chance, but it could also mean an increased interest of women to the Food Microbiology area in addition to reflecting an increased interest of women for higher education in general. Even though we cannot discard any of the hypotheses, it is tempting to favor the latter as the INEP (National Institute of Educational Studies and Research) census of higher education shows that undergraduate courses

Table 1 List of courses mentioned in the questionnaire in which Food Microbiology is taught in Brazil

Courses	%
Nutrition	48.7
Food Engineering	23.9
Pharmacy	16.2
Food Science and Technology	15.4
Veterinary Medicine	12.8
Gastronomy	5.1
Agronomy/Zootechny	4.3
Agribusiness Engineering	0.9
Biological Sciences	0.9
Biomedicine	0.9
Chemical Engineering	0.9
Consumer Sciences	0.9
Dairy Science and Technology	0.9
Domestic Economy	0.9
Hospitality	0.9
Technical Course in Agroindustry	0.9

in Brazil are occupied by nearly 60% of woman [5]. Interestingly, Francesconi and Parey [26] used data from college graduates in Germany to assess the extent of gender disparities. In that country, men and women enter college in roughly equal numbers, but more women complete their degrees. Clear increases for women in graduation rates can be observed in health sciences (including medicine and pharmacy), social sciences (including law, business studies, economics, and psychology), and agricultural studies (including nutrition) [26]. In Brazil, more women occupy the careers of Nutrition and Pharmacy, possibly reflecting the number of professors in these areas as well [27]. Nearly half of the respondents teach Food Microbiology to Nutrition, which might explain the shift towards more women in our survey.

Another trend we observed is that the majority of professors who participated in our research (69.3%) are relatively young, being under 45 years of age, while 19.7% are in the group between 46 and 55. A minority of the respondents (11.2%) were older than 56 years. Likewise, 57.2% of the respondents reported having less than 10 years of experience, while only 16.2% were at least 20 years into their careers (Table 2). This result seems to be a response to the program adopted by the Brazilian Federal Government for expansion and restructuration of the Federal Universities, popularly known as *Programa Reuni*. The program started in 2003 and the data indicate that back then, there were 114 municipalities with public universities in Brazil. By 2011 there were 237 contemplated towns, including the creation of 14 universities and the expansion of more than 100 new campi, which enabled the creation of many new undergraduate courses and the hiring of thousands of professors across all areas in the

Table 2 Features of participating professors

Professors' characteristics	%
Academic background	
Post-doctoral	19.7
Doctorate degree (Ph.D. degree)	49.6
Academic Master	29
Specialization or MBA	1.7
Institution that they work	
Public School	64.1
Private School	35
Both	0.9
Current work regime	
Exclusive dedication (full time)	63.2
Full time (non-exclusive)	11.1
Part-time	8.5
Paid by the hour	17.1
Teaching experience	
Less than 5 years	23.9
6 to 10 years	33.3
11 to 20 years	26.5
More than 20 years	16.2

years that followed the implementation of the program. One of the aims of the program was to expand free higher education in the country [28]. It is not the objective of this study to discuss the political issues regarding the program nor are we in the position to criticize or recommend it. However, it is tempting to speculate that the results observed here could, at least, be partially explained by the increase in the number of universities and positions available for new professors.

Half of the respondents work in the Southeast region of Brazil which encompasses the states of Sao Paulo, Minas Gerais, Rio de Janeiro, and Espirito Santo (please see Fig. 1 for a distribution of respondents across the country). This is also the most populated and industrialized region in Brazil, concentrating most of the higher education institutions [5]. The Northeast region (composed of nine states) contributed with 25 questionnaires, and the Southern region of Brazil (composed of the states of Parana, Santa Catarina, and Rio Grande do Sul) contributed with 21.

For this survey, professors belonged mostly to public institutions with a work regime of 40 h, with full dedication to the university and its activities (similar to a tenure track career). It is worth mentioning that students from public universities in Brazil do not pay fees or tuition, with completely free access to nearly all activities developed by the university. Additionally, a tenure track career in the country is characterized by research, teaching, extension, and administrative activities, and in most public universities, a minimum of 8 to 12 h dedicated to undergraduate teaching is required (authors' experience).

Most respondents (69.3%) have a doctorate degree (equivalent to a Ph.D.) with 19.7 of those having a post-doctorate experience. A full characterization of the professional activity of the respondents is presented in Table 2. This result evidences the continuing education of university professors which is regulated by the Brazilian Education Guidelines and Law (Lei de Diretrizes e Bases da Educação Brasileira 9396/96) [29]. It may also reflect an increase in graduate programs since 2005. Nóvoa [30] emphasized the importance of graduate training but criticized the fact that there is no sufficient pedagogical practice during graduate school. Thus, Veiga [31, 32] stressed that higher education institutions should support graduate programs that ensure adequate technical and pedagogical training of its candidates.

Concerning pedagogical training, 74.4% of professors reported having participated in at least a short course on the subject, while 25.6% did not participate in any training of the sort. Short courses (ranging from 2 to 60 h) and graduate disciplines were the main reported activities. As it can be observed, one of the great challenges faced by higher education teachers refers to the lack of pedagogical training specifically directed at developing teaching skills. Aiming to improve their qualification, some of these professors join Graduate Programs. However, these programs are focused on research, directly aiming at scientific production, with an insufficient appreciation for developing teaching skills [31, 32]. The deficiency in training of university teachers can negatively impact the learning process, affecting a professor's performance [33, 34]. More importantly, studies show that the selection of university professors usually undervalue their pedagogical skills [35, 36] as compared to research skills. Fernandes [37] adds that what is typically evaluated is the competence in specific areas (undergraduate and graduate levels) in which professors will work.

Teaching practice in the area of food microbiology

74.4% of the professors reported teaching the subject of Food Microbiology while other related courses were also reported. For instance, Food Hygiene was reported by 40.2% of the respondents, while 20.5% reported teaching Foodborne Diseases, 11.1% Microbial Biodiversity in Foods, 7.7% Food Safety, and 7.7% Microbiology of Dairy Products. On average, these courses are 60 h per semester. The same professor, at times, can teach several of these related courses.

When questioned about their work schedule, professors reported spending, on average, 14 h teaching in the classroom, 8 h on planning the activities before the class, and 8 h with other activities such as grading exams and home works.

Since the career of university professors usually include teaching, research, extension, and administrative work, we attempted to identify how each professional participated in these activities. The majority of the respondents (50.4%)

Fig. 1 Distribution of the professors who responded to the survey, by state and region in Brazil. The map was created using an online service (<https://mapchart.net/>)

participate in the four activities above mentioned, while 16.2% carry out teaching, research, and administration; 15.4% perform teaching, research, and extension; and only 5.1% deal exclusively with teaching. Some other professionals reported a combination of teaching with administrative work (4.3%); teaching and research (4.3%); teaching with extension work (3.4%), and lastly teaching, extension, and administration (0.9%).

We also asked how each professor organized their weekly routine taking into consideration each of the activities mentioned above. Most professors dedicate more time to teaching, ranging from 11 to 15 h a week, on average, and from 1 to 5 h each to research, extension, and administration. When asked about their preference, they tended to choose teaching first, then research, over administrative work, and extension.

The activities of teaching, research, extension, and administration are part of the attributions of research

university professors in Brazil. This broad scope of activities requires multiple skills, even though it could increase the workload and hinder the development of adequate pedagogical strategies. For good performance, professors need to have knowledge beyond the conceptual domain of the discipline and apply methodologies that are appropriate for people at different age groups and social backgrounds. However, we believe that graduate school in Brazil does not specifically train its candidates on these pedagogical principles. Certainly, the production of knowledge through research can improve a professor's understanding of the conceptual domain [38, 39]. According to Veiga [31, 32], the inseparability of teaching, research, and extension activities is an important integrating characteristic of the teaching practice.

As for the teaching strategies, each professor could choose from a list of predetermined approaches and the following were the most prevalently selected: discussed lectures

(95.7%, $n = 112$); seminars (76.1%, $n = 89$), guided study (64.1%, $n = 75$), and case study (59%, $n = 69$). Technical visits, teaching using a research activity, problem-based learning (PBL), and project development were also pointed out as teaching strategies, as shown in Table 3. A discussed lecture is understood as a regular lecture with the incentive for students to ask questions during the class and those questions may be answered by the professor right away. In essence, we consider this strategy as a traditional teaching approach, not falling in the category of active-based learning or “inverted classroom.” Therefore, Brazilian professors still largely use traditional teaching approaches to food microbiology. Given the diversity of learners, not all students can be equally successfully involved through a single teaching approach, it is necessary to explore and adopt alternative and creative approaches [40, 41].

Regarding the didactic resources, the majority of teachers reported the use of slides (99.1%), practical classes in the laboratory (88.9%), whiteboard (87.2%), textbook (57.3%), and computer (56.4%) (Table 4). The sense of inverted classroom is still in its infancy in the area of food microbiology as suggested by these results.

When asked about the technological tools or computer programs in the pedagogical practice, the data indicate that most professors (60.7%) use videos, virtual learning environments (moodle/stoa/solar/tidia) (32.5%), and social networks (26.5%) to improve the learning outcome by the students. Only 18.8% of the interviewees do not use any of these technological tools. Regarding the use of social media to strengthen the professional relationship with

students, 36.8% reported that they did not use these resources and 48.7% reported using WhatsApp and 36.8% Facebook. The activities performed in these social networks were related to the distribution of course materials (pdf files, research articles, related websites), case studies, and discussion groups.

The exploration of technologies as well as the use of new approaches based on partnership and co-responsibility between teacher and students can create a stimulating environment in the classroom [42]. In addition, engaging students in getting information from different sources and constructing their own knowledge can contribute to achieving more meaningful learning goals [43]. Certainly, there is room for additional use of technology in the teaching of food microbiology in Brazil.

When asked about the preference to teach traditional (expositive) lectures instead of using active learning resources, 79.5% of the interviewees reported the preference to merge traditional classes with teaching in the active methodology, instead of electing one or the other. The rationale for this, according to them, is that the combination of the two methods provides greater involvement and learning on the part of the student.

However, the current conception of teaching is related to the process of mediation, aimed at the construction of knowledge and not mere transmission of it, with the teacher working as a mediator. However, student’s participation and methodological diversification, enabling reflection and criticism of the students, are necessary [44]. Our data suggests that Brazilian professors working with

Table 3 Teaching strategies adopted by Brazilian professors dealing with Food Microbiology

Teaching strategies	%	Total number of responses
Discussed lectures*	95.7	112
Seminars	76.1	89
Directed study	64.1	75
Case study	59.0	69
Technical visits	43.6	51
Teaching with research activity	41.9	49
PBL/TBL	39.3	46
Project development	28.2	33
Teaching with extension work activity	20.5	24
Exposed dialog class	17.9	21
Conceptual map	15.4	18
Brainstorming	11.1	13
Workshop	11.1	13
Resolution of online questionnaire	11.1	13
Discussion lists	10.3	12
Group of verbalization and observation	9.4	11
Portfolio	4.3	5

*Discussed lecture are regular lectures with question and answers

Table 4 Didactic resources employed by Brazilian professors in food microbiology

Didactic resources	%	Total number of responses
Slides/projection	99.1	116
Laboratory for practical class	88.9	104
Whiteboard	87.2	102
Textbook	57.3	67
Computer	56.4	66
DVD—movies/documentaries/short films	30.8	36
Smartphone or tablet	24.8	29
Computer lab	17.9	21
Educational games	11.1	13
Educational software	5.1	6
Plickers and the like	3.4	4
Smart screen	1.7	2

food microbiology seem to be on the right track since they see the combination of different methodological strategies as beneficial for learning. For Anastasiou and Alves [45], the use of the active methodology presumes that specific contents are treated through the practical view of the student, allowing a level of reflectivity on the subject being addressed. In addition, Farias, Martin and Cristo [46] support that active learning methodologies have features that provide meaningful learning, group work, interdisciplinarity, and application of knowledge in the student's reality. These features may improve learning outcomes especially considering the great social and cultural differences in Brazil.

We also noticed from this study that professors are prone to the use of social media and this may have been encouraged by the university's environment and availability of resources. However, there is no progress in the use of more interactive and collaborative assets in food microbiology in the country such as educational games or simulators, aimed at greater impacts on student learning through research, analysis, and criticism. This fact is corroborated by the studies of Moran [47], Valente [48], and Soares [49], adding on the limitations and the challenges of the teachers regarding the collaborative learning and the use of media that can promote the interaction between teacher and student.

The professors were questioned about the limitations in the development and application of alternative teaching methodologies in their pedagogical practice, and 53.8% pointed the lack of time to devote to learning and applying new teaching methods, followed by lack of student's adherence (36.8%) and lack of knowledge on new methods by the professors themselves (35.9%) as the main hindrances.

In a related question, professors pointed out some of the difficulties they face in implementing changes in their

current pedagogical practice. Many of them indicated students' lack of motivation (61%), followed by professors' work overload (50.4%) and lack of time (42.7%), lack of adequate structure (36.8%), and low salary (17.1%). Some respondents also mentioned lack of training during academic preparation and difficulty in integrating resources with course syllabus. These results indicate that a change in the pedagogical practice is not easy and does not depend solely on the teacher's will.

For an innovative pedagogical practice, student participation is paramount, since interested and engaged students stimulate the teacher, favoring communication, and meaningful learning. However, it is necessary that the instructor persists in the change, seeking to accomplish it gradually [23]. Moran [47] explained that it is important for the teacher to show to the students the advantages of this new process, aiming at the partnership that will be established and the results that can be achieved for a better learning and professional formation. This "student-centered" approach to teaching shifts the focus away from what the teacher is doing and places it in what the student is learning. The strategies of active learning in the classroom ensures that the students engage in learning by discussing, writing about it, and solving problems [50].

We caution, however, that the fast development of new devices and new platforms can end up being a hindrance for some professionals since it can be quite time consuming to learn how to use all offered possibilities. Understandably, this fast technological development may hinder some teachers to become updated with the development flow in multimedia and computer technology especially because it does not always translate into novelty on the most efficient way to the teachers' environment.

Lack of time to plan different teaching strategies and excessive work were some of the main difficulties for professors

to invest in new pedagogical practices. The proper allocation of time should be reviewed by higher education institutions in order to provide better conditions for professors to invest in studying and perfecting educational practices [50]. It is also important that universities give more value to teaching in their career advancement options since promotions and tenure track positions usually give more value to research in comparison to teaching skills [51, 52]. Only then could institutions demand more effective and qualified teaching and overall academic production. In fact, professors and higher education institutions must overcome together the challenges and dilemmas that hinder innovative actions, and this should be a shared responsibility [23]. The promotion of education of quality is related to good teacher's training, continued professional growth, work organization, and the institution's involvement. It is a joint effort, in which all society stakeholders are benefited [53]. According to Bradforth et al. (2015), it is time to value teaching and to improve the quality of university education [52]. These authors also cite active learning initiatives as good ways to improve students' achievements and help to create a population that is science-literate and able to debate complex issues such as health, energy, security, and environmental matters.

Faculty and institutions of higher learning need to keep up to date to innovations in teaching practices as a way to engage the students and provide authentic educational experiences. Alternative and creative approaches need to be incorporated into the curricula for an undergraduate to a professional level, in alignment with industry trends and drivers [40].

To better address the limitations that Brazilian professors of Food Microbiology face, as well as to improve learning outcomes for different undergraduate majors, we believe that a set of principles and ideas can be derived from the ASM (American Society for Microbiology) Task Force on Curriculum Guidelines for Undergraduate Microbiology, from the Association of American Universities and the Research Corporation for Science Advancement Cottrell Scholars, as highlighted in several articles [50–52]. The first is the implementation of the “Backward design” when creating a course. The goal here is for students to develop a conceptual understanding and this design is good for that. In this approach, the professor designs the learning outcomes and assessments first. Then, he/she decides which resources and instructional activities should be used. Traditionally, we do the opposite as we get a predetermined syllabus and then we follow through with the course.

According to Merkel (2016), it is important to set priorities in order to teach core concepts instead of voluminous contents, which can be overwhelming [50]. The idea is that with less material to be taught, the students can get a deeper understanding, developing the skills they need to analyze and investigate information. When talking about learning outcomes, it is important to clearly define the desired results for

each unit or class. Merkel exemplifies that a good way to perform this is by stating the outcomes that are expected such as: “By the end of this course, students should be able to” One way to know if students are actually reaching the desired outcomes, according to her, is to use more frequent, informal, and low-stakes assessments.

According to Bradforth et al. 2015, there are separate roles that senior university administrators, individual faculty members, and the departments can play in order to improve science education to undergraduate majors [53]. For faculty members, which they call “the bottom-up approach,” the idea is to shift their perspective from “What did I teach?” to “What have my students learn?”. This can only be performed by increasing students' engagement. On the other hand, senior administrators are considered in the position to implement changes from “Top-down.” The way they can achieve this is by recognizing and rewarding good teaching practices, encouraging departments by offering funds and awards and, centralizing and making data and analytics more readily available so that results on students' success can be shared and efforts made to improve it overall. Finally, the changes at colleges and departments are considered “middle-out.” In essence, departments and colleges should foster a team culture and develop learning objectives by identifying the core concepts in the disciplines. Then, faculty members should align the curricula with these learning objectives taking into consideration the content and skills to be developed. It is important that time and resources be provided in order to improve teaching methods and assessment techniques. The allocation of time to learn new methods and assess their effectiveness should be promoted and departments should allocate funds for that. They should also encourage discussion among departments on teaching practices, evaluate teaching outcomes with meaningful metrics that value learning and not instructor's popularity, and make teaching count for career advancement.

Implementation of these changes requires institutional support. We believe that Brazilian professional societies such as SBM (Brazilian Society for Microbiology), SBCTA (Brazilian Society for Food Science and Technology), and SBAN (Sociedade Brasileira de Alimentação e Nutrição) could help following the example set forth by ASM, as described previously. We recommend that these societies should provide educational courses and ongoing support for networking in their Annual Meetings, besides promoting education workshops, webinars, and some space in their journals and websites for articles, good practices, and perspectives in the area. The Food Microbiology Teachers Brazilian Network should also play an important role within these societies. The network should start thinking about the goals for the next 5–10 years on what can be done to

improve teaching in the area as well as to create a core curriculum on Food Microbiology and the set of skills that are to be developed by the students in the different careers. The exchange of ideas in conferences and meetings should naturally point towards a more defined set of short-, mid-, and long-term goals for the field.

Conclusion

Food microbiology is taught in several different careers in Brazil such as Nutrition, Food Engineering, Food Science and Technology, Veterinary Medicine and Pharmacy. Brazilian professors combine traditional teaching strategies, such as lectures, with modern active learning methods. Other teaching approaches commonly adopted by food microbiology professors in Brazil are laboratory classes, seminars, homework, and case studies. However, some difficulties associated with lack of time, excessive work overload, and insufficient pedagogical training for adopting new teaching methods were reported. Another difficulty related to implementing novel teaching approaches was the low adherence by the students. We conclude that most professors in the area of food microbiology in Brazil still use traditional teaching methods, and their reluctance to change is related to lack of training, time, and student's adherence. A clear trend was observed for mixing active-based learning methodologies with traditional teaching approaches. The authors would see focused training courses for advanced teaching methods for food microbiology teachers as very relevant approaches to overcome some specific obstacles in current teaching practices in Brazil.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical aspects of this research According to Resolution 510 of April 07, 2016, from the Brazilian Health National Council (*Conselho Nacional de Saúde*), and considering the ethics, history, social, and cultural aspects related to research in the Social and Human Sciences, registration or evaluation of this research with the ethics committee of the University is not required. The first paragraph of the Resolution 510 states that “research of public opinion in which the participants are not identified” does not need to be registered nor evaluated by the ethics committee. Additionally, the informed consent from participants was obtained in the first step of the online questionnaire (please see [supplemental material](#)—online questionnaire). We start by explaining the terms of the

research and emphasizing that the participant's information will remain anonymous and the system will not register the names of the respondents. Then, we formally ask the participants if they are willing to partake in the study.

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