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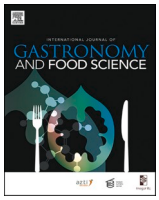

Haute cuisine: A mixed-methods approach to assess gastronomic offer nutritional adequacy and importance given by chefs to food and nutrition guidelines

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ABSTRACT

In recent years, a growing interest of society for out-of-home food experiences has been observed, concurrently with an increasing number of restaurants associated to haute cuisine. However, data on the nutritional adequacy of the meals offered in these restaurants is lacking. This study aimed to evaluate the perception of haute cuisine chefs in Portugal about the importance attributed to food and nutrition recommendations when planning their gastronomic offer and to assess the nutritional adequacy of the meals offered in these restaurants. A mixed-methods, cross-sectional study was conducted, in which all chefs from Michelin star-awarded restaurants in Portugal, in accordance to the Michelin Guide 2022 edition, were eligible and invited to participate. A qualitative content analysis of semi-structured face-to-face individual interviews (n = 11 chefs) and a quantitative assessment of the nutritional composition of appetizers, main courses and desserts (n = 29 recipes) were conducted between January and June of 2022. The majority of chefs reported giving much importance to nutrition principles while planning their menus, also showing positive attitudes and opinions towards healthy food practices and future partnerships with nutritionists. However, knowledge and perceptions regarding nutrition concepts were, in general, inconsistent and unobjective. Recipes' median energy contents ranged between 549 kcal/serving in meat courses and 1594 kcal/serving in desserts, with total fat contribution at around or above 40% of total energy value (TEV). Median saturated fat contents varied between 14% and 21% of TEV in appetizers and desserts, respectively. Sugar contents were the highest in desserts (median: 49% of TEV). Salt was particularly high in seafood dishes (median: 12.9 g/serving). The recipes evaluated showed an inadequate nutritional profile, with energy, total fat, sugar and salt contents frequently above maximum recommendations. Strategies aimed at improving chefs' culinary practices are needed, namely through the enhancement of their literacy and awareness regarding nutrition principles. Their openness to collaborate with nutrition specialists should be exploited as an opportunity for future interventions.

1. Introduction

In recent decades, there has been a growing interest in the area of gastronomy, both by the scientific community and the general population. Restaurants are one of the biggest economic contributors to the tourism sector, also being responsible for transmitting the culture and gastronomic heritage of a given country or region. These establishments provide gastronomic experiences, which have been

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increasingly valued by both locals and tourists (Henderson 2009). In terms of the typology, a variety of options are available, ranging from more popular (such as traditional restaurants) to more sophisticated concepts (as is the case of haute cuisine) (Canziani et al., 2016).

The term "haute cuisine" is defined by the Oxford Advanced Learner's Dictionary as "cooking of a very high standard, following the style of traditional French cooking" (Oxford University Press 2023). Contemporary haute cuisine can be characterized by confection and presentation methods that are differentiated, sophisticated and innovative (Beaugé 2012; del Moral 2020). The Michelin Guide, which was initially created as a compilation of handy information for travellers (e.g. maps, how to change a tyre, places to eat or sleep), started to use stars in 1926, in order to distinguish fine dining establishments (Michelin Guide 2023a). Today, this guide is inseparable from haute cuisine, and its awards are highly recognized as a mark of quality by all professionals in this sector worldwide. A growing number of restaurants associated with haute cuisine has been emerging, and nowadays, over 3000 restaurants are awarded with at least one Michelin star, globally (Michelin Guide 2023b), thus supporting the importance of studying this gastronomic concept. In addition, gourmet cooking has been gaining media attention, reflected in the presence of award-winning renowned chefs on television shows or as part of digital contents on social media, that way reaching thousands of followers (Villani et al., 2015).

Worldwide, a marked increase in the consumption of meals prepared away from home has been observed (Guthrie et al., 2002; Popkin 2006, Orfanos et al., 2007). A growing body of literature indicates that eating out-of-home food can be a factor influencing energy and nutrient intake, and consequently may have an impact on health (Bezerra et al., 2012; Lachat et al., 2012; Nago et al., 2014). Nevertheless, although haute cuisine restaurants are considered as part of the out-of-home food supply, they present very distinct and specific features, namely the types of foods used and the preparation methods, that can possibly cause significant differences in its nutritional composition when compared to other gastronomic concepts. In fact, according to the Michelin Guide, Michelin-awarded chefs are currently prioritizing healthful and nutritious ingredients, as for example seaweed, tempeh and millet, which are expected to be increasingly found in their tasting menus (Michelin Guide 2024). Accordingly, a literature review on luxury gastronomy described a growing movement among Michelin-starred chefs towards more healthy and environmentally responsible meals, in order to meet the expectations of increasingly conscious customers (Batat 2020). However, currently there is a lack of data on the nutritional adequacy of the meals offered in these restaurants, and to the best of our knowledge, no such studies have been conducted in Portugal.

As such, we aimed to: (1) evaluate the perception of chefs from Michelin-awarded restaurants in Portugal regarding the importance they attribute to food and nutrition recommendations when planning their gastronomic offer, as well as facilitating and hindering factors to nutritional adequacy; and (2) to assess the nutritional adequacy of the meals offered in these restaurants.

2. Methods

A cross-sectional study of Michelin-awarded restaurants and respective chefs was conducted in Portugal. A mixed-methods design was employed, in which a qualitative assessment of chefs' perceptions was complemented with a quantitative evaluation of the nutritional composition of their menus. All chefs from Michelin star-awarded restaurants in Portugal, in accordance to the Michelin Guide 2022 edition (Michelin Guide 2023c), were eligible for this study and were invited to participate.

Semi-structured face-to-face interviews were carried out individually, in order to qualitatively assess chefs' perceptions and opinions regarding the importance given to nutritional aspects when planning their menus, as well as facilitating and hindering factors to nutritional adequacy. Interviews were conducted at distance via *Zoom*®, and recorded for subsequent transcription. The interviews conducted intended to assess the following dimensions: chefs' priorities when planning the restaurants' food offer; perceptions regarding customers' demands/expectations and their effects on the meals planned; level of participation of a nutritionist in the preparation of the menus; knowledge regarding the term "healthy eating" and importance attributed to this concept; nutrition principles perceived as more relevant and put in practice, and how these may influence customers' acceptance; awareness regarding the components of a nutritionally adequate meal; perception regarding whether the meals their restaurants offer are nutritionally adequate; perception regarding whether or not the Michelin Guide takes into account nutritional adequacy when assessing restaurants; opinion regarding whether Portuguese gastronomy facilitates or hinders compliance with healthy eating principles; and opinion regarding the possibility of a future synergy between nutrition and haute cuisine. Further comments were also registered. After transcription of all interviews using the *NVivo*® software, inductive content analysis was performed (Strauss and Corbin, 1998).

Chefs were also asked to select one or more recipes from the tasting menus offered in their restaurants. These menus tend to be the most popular options as they represent a set of courses specially selected and prepared by the chef to provide a gastronomic experience of excellence. A quantitative analysis of the recipes provided was conducted through the assessment of the food and nutritional composition of their technical sheets. The *Movelife*® software, an online food and nutritional assessment tool adapted to bakeries, hotels, catering, restaurants and similar sectors, was used. This software enables the creation of technical sheets from the input of recipes data such as list of ingredients, quantities and preparation methods used. In these technical sheets, information such as the nutritional declaration, list of allergens, food costs, among others, is systematized and presented. The recipes' components were classified into food groups: (1) fruit; (2) vegetables; (3) meat, seafood and eggs (which were further sub-categorized into red meat, white meat, processed meat, fish, shellfish, and eggs); (4) cereals and tubers (which were further sub-categorized into whole cereals, refined cereals, and tubers); (5) pulses; (6) dairy products; (7) oils and fats (which were further sub-categorized into virgin olive oil, extra virgin olive oil, lard, butter, sunflower oil, and other vegetable oils); (8) algae; (9) nuts; (10) seeds; (11) vegetable proteins; (12) spices (i.e., dried non-leafy aromatic parts of plants such as black pepper, cinnamon, etc.); (13) herbs (i.e., leafy green fresh aromatic parts of plants such as fresh parsley, basil, etc.); (14) added sugar; (15) added salt; and (16) alcoholic beverages. The portions of each food group (in grams per capita) were calculated by dividing the total quantity of each food group used in a specific recipe and the number of portions yielded by that recipe. The proportions of each food group, in accordance with the groups listed in the Portuguese food guide (Direção-Geral da Saúde 2023), were also calculated. The confection method used for each recipe's component was registered. For the nutritional evaluation of the dishes, this software uses data from the Portuguese food composition table (Instituto Nacional de Saúde Doutor Ricardo Jorge 2021). However, when data was not available from that source (which was the case of processed ingredients), food labels were used taking into account the brands reported by the chefs. The following parameters were analyzed: energy, protein, total fat, saturated fatty acids, carbohydrates, free sugars, dietary fiber and salt. The edible portion of each ingredient was computed for all recipes.

Data collection was performed between January and June of 2022. Descriptive statistics (i.e., absolute and relative frequencies, median and range) were used to summarize the chefs' characteristics and the recipes' composition.

3. Results

From a total of 33 chefs invited (corresponding to all Michelin star-awarded chefs in Portugal in 2022), 11 (33.3%) accepted to participate in the study. Table 1 describes the sociodemographic characteristics of

Table 1
Sociodemographic characteristics of the participants (n = 11).

	n	%
Gender[a]		
Male	11	100.0
Age (years)		
≤29	0	0.0
30-39	6	54.5
40-49	2	18.2
50-59	3	27.3
≥60	0	0.0
Nationality		
Portuguese	10	90.9
French	1	9.1
Country Region		
North	3	27.3
Centre	1	9.1
Lisbon and Vale do Tejo	3	27.3
Alentejo	0	0.0
Algarve	2	18.2
Azores islands	0	0.0
Madeira islands	2	18.2
Educational level		
Incomplete secondary education (<12 years)	1	9.1
Secondary education (12 years)	7	63.6
Higher education - bachelor's degree	1	9.1
Higher education - master's degree	2	18.2

[a] Up to the date of the study, all Michelin-awarded chefs in Portugal were male.

the participants. All chefs were men, and most of them were aged between 30 and 39 years (54.5%), portuguese (90.9%) and completed secondary education (63.6%). They operated in different geographical areas, mostly in the North region (27.3%) and Lisbon and Vale do Tejo (27.3%).

3.1. Qualitative evaluation of chefs' perceptions

When asked about the priorities when planning their restaurant's food offer, chefs referred three main dimensions: the quality of the products (E5 - *"(…) mainly the quality of the ingredients"*), the representation of the Portuguese gastronomy (E9 - *"based (…) on what is the local gastronomy"*; E11 - *"we want to show the 'portugueseness' of the dishes*"; E8 - *"the basis is our culture, our gastronomic tradition (…) using all types of Portuguese products to the maximum"*) and the seasonality of foods (E3 - *"we focus a lot on the seasonality of products"*).

Regarding the consumer's demands and expectations, chefs referred tradition (E1 - *"more and more value is given to the cooking of grandmothers, of mothers"*), creativity (E4 - *"our customers expect a lot of creativity"*), connection between the local and the global (E7 - *"fusion between the world cuisine, but with products from the local territory"*), and a remarkable gastronomic experience (E3 - *"to have more than a simple meal, to have an experience, to live a moment that marks you for the rest of your life"*; E9 - *"the customer does not come looking for dinner, the customer comes looking for an experience"*). The majority of chefs (81.8%) agreed that clients' expectations may vary according to their characteristics, specifically age, nationality, or the fact of being occasional or usual customers. When asked if the customers' expectations influence the planning of their gastronomic offer, 9 chefs responded "yes".

When asked about what they understood to be the concept of healthy eating, chefs referred aspects such as variety (E4 – *"a varied diet"*), balance (E3 – *"eat everything in a controlled way"*; E9 - *"the balance between what you can eat and how much you can eat"; "a balanced diet (…) not overeating every day*") and happiness/well-being (E10 - *"healthy is what make us happy"*). Some chefs also mentioned the consumption of specific food groups (E4 - "*fish, meat, carbohydrates, fat, sugar in the right amounts*"; E7 - "*eliminate all industrial foods and ingredients as much as possible"*). When asked to classify the importance given to the healthy eating concept on a 0–10 scale (0 being "not important" and 10 "extremely important"), most of them (90.9%) responded ≥8, and only one attributed 4.

Regarding the nutrition principles perceived as relevant and put in practice, chefs considered features such as freshness (E2 - *"relevant principles include freshness"*), quality (E7 – *it is not the quantity of things, but the quality"*; E1 - *"using the best possible products"*), healthiness/balance (E11 - *"a healthy and balanced diet"*; E8 - *"in a dish or in a tasting menu there has to be (…) balance"*), natural cooking (E5 - *"the use of natural fats"*; E1 - *"cook as naturally as possible"*), meal timing (E3 - *"respect the times of meals"*), diversity, seasonality and portion sizes (E4 - "*diversity, seasonality is very important, the portions and the amount of food you eat*"). Some referred to specific food groups (E5 – *"the predominance of fish over meat"*; E9 – *"less and less carbohydrates in the dishes, using more and more vegetables"*). Regarding chefs' opinion on whether the application of nutrition principles influence customers' acceptance, 4 out of 5 chefs with formed opinion said "no" (E4 - *"the clients do not have that perception"*).

When asked regarding the components of a nutritionally adequate meal, some chefs reported that this is variable depending on the individual (E5 - *"it really varies from person to person and the needs of each one"*), others referred to meal courses (E9 - *"a starter, a main course and a dessert, fruit"*), types of protein (E6 - *"try to find balance between (…) animal and vegetable protein"*) and the importance of adequate quantities (E1 - *"to eat what our body needs, in an adequate way, with adequate amounts, without exaggeration"*). Almost all chefs (90.9%) believed that the meals they offer are nutritionally adequate. However, 90.9% also stated that there was no Nutrition professional present or involved in the preparation of their dishes, though admitting the possibility of change in the future.

When asked if the Portuguese gastronomy facilitates or hinders the production of healthy meals, more than half (54.5%) defended that it facilitates, while one chef thinks that it does not; the remaining affirm that it depends on the location and the target population.

Regarding their perception on whether the Michelin Guide takes into account nutritional adequacy, only three chefs thought that this component might be a possible evaluation criterion, while the others reported not believing that the guide takes this into account, at least not in a direct or quantitative way. When asked about a future synergy between nutrition and haute cuisine, most chefs (90.9%) hoped that it will become one of the next steps in this gastronomic concept.

3.2. Quantitative analysis of the recipes' food and nutritional composition

A total of 29 recipes were made available by the chefs, comprising 9 appetizers, 15 main courses (5 meat and 10 seafood) and 5 desserts, corresponding to both classic/traditional dishes and innovative compositions, with diverse food compositions (Figure 1).

The food groups used as ingredients in the recipes evaluated and the respective quantities per capita are presented in Table 2. Appetizers were most frequently composed of vegetables (78%), with a median quantity of 41 g/capita, shellfish (56%, 25 g/capita), butter (56%, 50 g/capita), spices (67%, 5 g/capita), herbs (56%, 9 g/capita) and added sugar (78% 2.5 g/capita).

Meat main courses were more frequently constituted by red meat (60%, 100 g/capita), and to a lesser extent by white (40%, 151 g/capita) and processed meat (40%, 8 g/capita), and mostly accompanied with vegetables (80%, 181 g/capita), tubers (60%, 104 g/capita) and fruit (60%, 28 g/capita). Vegetable oils other than olive or sunflower (i.e., sesame, coconut, palm and grapeseed oils) were commonly used in meat dishes (60%, 8 g/capita), and spices were added in all recipes from this category (median of 3 g/capita).

Regarding seafood main courses, these included more frequently fish (90%, 175 g/capita) than shellfish (30%, 50 g/capita), and were commonly sided with whole cereals (40%, 75 g/capita) or tubers (30%, 170 g/capita). Virgin olive oil (70%, 11 g/capita), butter (50%, 13 g/capita) and other vegetable oils (50%, 8 g/capita) were the most

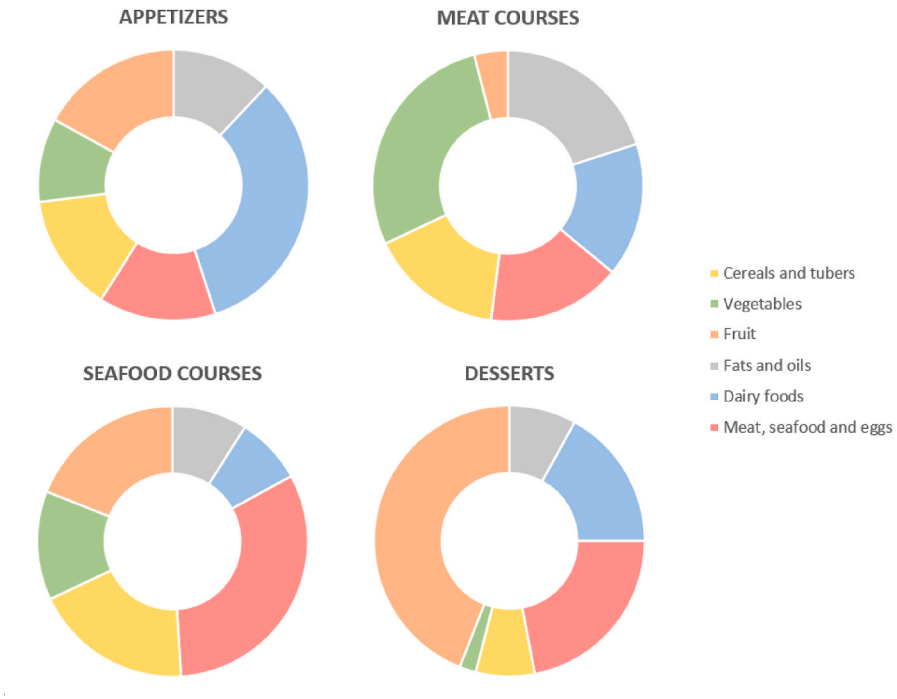

Fig. 1. Percentual contribution of each food group of the Portuguese food wheel to the total weight of each recipe type.

frequently used fats in seafood dishes, while herbs and spices were added to almost all recipes from this category.

All desserts had fruit (median of 137 g/capita), butter (24 g/capita) and sugar (167 g/capita) as ingredients; eggs (80%, 68 g/capita), refined cereals (80%, 17 g/capita), and dairy products (80%, 53 g/capita) were also widely used.

All dishes (i.e., appetizers, main courses and desserts) had added salt in their composition, which was not quantified in 45% of the recipes (described as "salt to taste"). In the recipes in which it was quantified, it varied between 0.3 g/capita in a strawberry dessert and 20 g/capita in confit piglet, being higher in the main courses and lower in desserts. Alcoholic beverages were used in more than one-third (34.5%) of all recipes, the quantities ranging from 5 to 150 g/capita. Algae, seeds, vegetable proteins and nuts were seldom used (the latter mostly in the context of a dessert). The inclusion of pulses was not observed in any of the analyzed dishes.

Table 3 presents the cooking methods used in the recipes evaluated. Boiling was used in all appetizers, although raw and braised foods were also frequently used (each in more than half of appetizers). All meat courses with data on cooking methods included roasting, and almost all (3 out of 4) included boiled foods; frying (50%) and grilling (50%) were also frequent. The most common cooking methods in seafood dishes were boiling (89%), grilling (67%), frying (56%), braising (56%) and sauté (56%). Regarding desserts, all included boiled foods, followed by roasted (80%) and raw (60%). Stews constituted the less frequently used technique.

Table 4 describes the nutritional composition of the recipes assessed. The median energy content was higher in desserts (1594 kcal/serving), followed by seafood dishes (938 kcal/serving), appetizers (889 kcal/serving) and meat courses (549 kcal/serving). Total fat was the highest contributor to total energy value (TEV) in almost all recipe types, especially in appetizers and seafood dishes, in which total fat contributed to nearly half of the energy content. Nevertheless, the median contribution from saturated fatty acids was highest in desserts (21% of TEV). Desserts also presented the highest amounts of carbohydrates (55% of TEV), mostly added sugar (49% of TEV). Protein was highest in meat dishes (27% of TEV) and lowest in desserts (4% of TEV). Median dietary fiber ranged between 3.3 g/100 kcal in appetizers and 6.0 g/100 kcal in meat dishes and desserts. Seafood courses presented the highest amounts of quantified added salt (median of 16.1 g/serving).

4. Discussion

This study reports on relevant and innovative data regarding the attitudes and practices of Portuguese haute cuisine chefs in relation to the provision of healthy meals. In general, the interviewed chefs reported positive attitudes and opinions towards nutrition and its importance in their practice, which contrasted with an overall inadequate nutritional profile observed in the recipes provided.

Haute cuisine chefs reported privileging local, seasonal and high-quality food products when planning their gastronomic offer, most of them taking into account consumers' expectations and demands. These principles are very characteristic of contemporary haute cuisine (del Moral 2020). The innovation in the culinary techniques was another highly valued feature, which is in line with what is being developed in the field of haute cuisine at an international level (Beaugé 2012; Caporaso and Formisano 2016; Otero 2018; Schwark et al., 2020). Articulation between chefs and nutritionists during this planning has shown to be practically non-existent, although they seemed to be open-minded regarding possible future collaborations between the two parties, whether permanent or circumstantial. The synergy between the culinary skills of chefs and the inputs from nutrition professionals would allow for the improvement of the nutritional value of the meals offered, without jeopardizing their unique gastronomic identity.

Although the majority of chefs assigned a high level of importance to healthy eating, it was possible to observe that the knowledge and perception of the chefs regarding nutrition concepts were, in general, closely linked to what is seen as common sense, but not very objective. Concepts such as "variety" and "balance" were commonly addressed, however without specifying the principles of a varied and/or balanced diet. Even so, it was possible to perceive that they take into account aspects related to nutrition and health when preparing their recipes, although in accordance with their own interpretations of those principles, which may not be the most accurate. These findings are in line with previous studies, which reported that restaurants' chefs showed positive attitudes towards healthy eating and food practices, but limited

Table 2
Food groups present in the recipes evaluated (n = 29) and respective quantities per capita.

Food groups	Appetizers (n = 9)		Main courses				Desserts (n = 5)	
			Meat (n = 5)		Seafood (n = 10)			
	n (%)	Quantity (g) Median (min-max)	n (%)	Quantity (g) Median (min-max)	n (%)	Quantity (g) Median (min-max)	n (%)	Quantity (g) Median (min-max)
Fruit	1 (11)	69	3 (60)	28 (18–100)	1 (10)	120	5 (100)	137 (56–339)
Vegetables	7 (78)	41 (3–252)	4 (80)	181 (22–321)	9 (90)	80 (6–334)	2 (40)	6 (5–6)
Meat, seafood and eggs	8 (89)	59 (3–304)	5 (100)	108 (56–300)	10 (100)	200 (80–306)	4 (80)	68 (14–108)
Red meat	1 (11)	35	3 (60)	100 (56–300)	0 (0)	–	0 (0)	–
White meat	0 (0)	–	2 (40)	151 (90–211)	1 (10)	30	0 (0)	–
Processed meat	1 (11)	20	2 (40)	8 (4–13)	1 (10)	13	0 (0)	–
Fish	3 (33)	61 (20–141)	0 (0)	–	9 (90)	175 (60–250)	0 (0)	–
Shellfish	5 (56)	25 (3–269)	0 (0)	–	3 (30)	50 (12–88)	0 (0)	–
Eggs	3 (33)	13 (5–36)	1 (20)	16	2 (20)	23 (9–36)	4 (80)	68 (14–108)
Cereals and tubers	6 (67)	56 (25–350)	3 (60)	104 (42–174)	7 (70)	120 (9–220)	5 (100)	23 (3–100)
Whole cereals	1 (11)	50	0 (0)	–	4 (40)	75 (30–188)	2 (40)	15 (5–25)
Refined cereals	2 (22)	53 (25–80)	1 (20)	25	2 (20)	80 (20–140)	4 (80)	17 (3–100)
Tubers	3 (33)	58 (5–350)	3 (60)	104 (4–174)	3 (30)	170 (9–200)	0 (0)	–
Pulses	0 (0)	–	0 (0)	–	0 (0)	–	0 (0)	–
Dairy products	3 (33)	75 (3–175)	1 (20)	50	3 (30)	50 (30–63)	4 (80)	53 (15–83)
Oils and fats	7 (78)	50 (2–120)	3 (60)	130 (13–201)	8 (80)	57 (11–250)	5 (100)	27 (9–120)
Virgin olive oil	2 (22)	36 (2–70)	0 (0)	–	7 (70)	11 (4–13)	0 (0)	–
Extra virgin olive oil	0 (0)	–	1 (20)	100	1 (10)	50	0 (0)	–
Lard	1 (11)	20	1 (20)	100	0 (0)	–	0 (0)	–
Butter	5 (56)	50 (5–100)	2 (40)	18 (5–30)	5 (50)	13 (8–75)	5 (100)	24 (4–120)
Sunflower oil	1 (11)	25	2 (40)	54 (8–100)	2 (20)	113 (100–125)	2 (40)	4 (3–5)
Other vegetable oils[a]	2 (22)	25 (25–25)	3 (60)	8 (1–100)	5 (50)	8 (3–125)	2 (40)	4 (3–5)
Algae	2 (22)	13 (10–16)	0 (0)	–	3 (30)	8 (1–10)	0 (0)	–
Nuts	2 (22)	15 (5–25)	0 (0)	–	1 (10)	35	3 (60)	24 (4–40)
Seeds	1 (11)	2	0 (0)	–	0 (0)	–	1 (20)	4
Vegetable proteins	1 (11)	75	0 (0)	–	0 (0)	–	0 (0)	–
Spices	6 (67)	5 (0.3–38)	5 (100)	3 (2–20)	8 (80)	3 (1–105)	3 (60)	3 (1–12)
Herbs	5 (56)	9 (2–36)	2 (40)	1 (0.5–2)	9 (90)	4 (0.1–26)	3 (60)	2 (0.2–2)
Added sugar	7 (78)	2.5 (0.1–15)	0 (0)	–	0 (0)	–	5 (100)	167 (5–250)
Added salt[b]	9 (100)	1.5 (1–3)	5 (100)	2 (2–20)	10 (100)	2 (2–5)	5 (100)	1 (0.3–6)
Alcoholic beverages[c]	3 (33)	5 (5–5)	1 (20)	60	4 (40)	85 (18–150)	2 (40)	(94-94)

[a] Other vegetable oils included sesame oil, coconut oil, palm oil and grapeseed oil.
[b] Added salt was not quantified in 3 appetizers, 2 meat dishes, 7 fish dishes and 1 dessert (described as "salt to taste"), and thus these were considered as missing values for calculating added salt quantities. As such, the values presented in the variable "quantity" are relative to n = 6 appetizers, n = 3 meat dishes, n = 3 fish dishes and n = 4 desserts.
[c] The quantities presented refer to grams of beverages added, and not to grams of alcohol.

Table 3
Frequency of cooking methods of the recipes evaluated (n = 27[a]).

Cooking methods	Appetizers (n = 9)	Main courses		Desserts (n = 5)
		Meat (n = 4[a])	Seafood (n = 9[a])	
	n (%)			
Raw	5 (56)	0 (0)	4 (44)	3 (60)
Boiled	9 (100)	3 (75)	8 (89)	5 (100)
Roasted	0 (0)	4 (100)	4 (44)	4 (80)
Fried	2 (22)	2 (50)	5 (56)	1 (20)
Grilled	2 (22)	2 (50)	6 (67)	0 (0)
Braised	5 (56)	1 (25)	5 (56)	0 (0)
Sautéed	3 (33)	1 (25)	5 (56)	1 (20)
Stewed	0 (0)	0 (0)	1 (11)	0 (0)
Gratinated	1 (11)	0 (0)	2 (22)	0 (0)

The sum of percentages may exceed 100% because the same recipe can include multiple cooking methods.
[a] The cooking methods were not described in one meat course and one seafood course.

awareness and knowledge on this subject (Bull and Wise 2000; Middleton 2000; Johnson et al., 2002; Hu et al., 2005; Condrasky et al., 2007; Obbagy et al., 2011). This can be seen as an opportunity for improvement, through nutrition education strategies that enhance awareness, knowledge and skills of these professionals reading nutrition principles that they can apply in their creations. In this context, it is worth exploring the emerging disciplines of culinary medicine and culinary nutrition, which integrate the art of preparing, cooking and presenting food with the science fields of medicine and nutrition (de Tomas et al., 2021; Worldchefs 2024a). The inclusion of such curricular units in the training of future professionals, as well as in the continuous education of current chefs, should be prioritised for its importance in promoting the healthiness of the food offer. Worldwide, more and more culinary schools and professional organizations are including diet- and nutrition-related curricula in their courses (Institute of Culinary Education 2024; Worldchefs 2024b), showing a possible promising future in this area. Using their increasing visibility in the media (Villani et al., 2015), well-informed gourmet chefs also have the potential to be transmitters of good eating practices through the recipes they share with the public, showing that it is possible to have high-quality gastronomic

Table 4
Nutritional composition of the recipes evaluated (n = 29).

Nutritional parameters	Appetizers (n = 9)	Main courses		Desserts (n = 5)
		Meat (n = 5)	Seafood (n = 10)	
Energy (kcal/serving)	889 (221–1673)	549 (172–2414)	938 (321–2680)	1594 (378–2169)
Protein (% TEV)	11.9 (4.5–65.3)	26.5 (13.8–50.3)	17.4 (6.6–55.6)	4.5 (3.5–6.9)
Total fat (% TEV)	49.4 (2.4–85.7)	45.2 (17.8–63.8)	48.8 (13.0–90.4)	38.1 (33.3–52.3)
SFA (% TEV)	14.4 (0.4–50.7)	17.5 (6.3–31.1)	14.6 (2.8–39.7)	21.2 (13.6–31.5)
Carbohydrates (% TEV)	23.8 (9.0–86.9)	21.4 (16.4–34.9)	25.4 (0.6–63.0)	55.0 (37.5–60.2)
Simple sugars (% TEV)	5.9 (0.7–70.6)	6.2 (3.7–27.9)	2.4 (0.1–27.2)	48.9 (29.6–52.9)
Dietary fiber (g/1000 kcal)	3.3 (1.2–12.0)	6.4 (3.2–15.0)	4.7 (1.2–19.0)	6.4 (1.5–11.0)
Salt (g/serving) [a]	3.5 (0.1–18.5)	3.7 (2.7–4.7)	12.9 (1.8–23.9)	1.4 (0.3–3.3)

SFA, saturated fatty acids; TEV, Total Energy Value. Values are expressed as median (min-max).

[a] It was not possible to calculate the salt content in 17 recipes (5 appetizers, 3 meat courses, 8 seafood courses and 1 dessert), either because the addition of salt was not quantified (e.g., "salt to taste") or because the preparation methods did not allow an accurate estimate (e.g., use of broths or marinades in intermediate steps, which are subsequently wasted or not used in full). As such, the values presented for this variable correspond to n = 4 appetizers; n = 2 meat courses; n = 2 seafood courses and n = 4 desserts.

experiences, both in organoleptic and nutritional terms.

According to the perception of the interviewed chefs, haute cuisine customers do not seem to hinder the application of healthy eating principles in their dishes. These results contradict previous literature, in which customers were identified by chefs as barriers to the inclusion of healthier food options in their menus, with taste being reported as the most important factor for acceptance (Middleton 2000, Obbagy et al., 2011; Condrasky et al., 2015). However, these studies did not focus specifically on haute cuisine restaurants, that serve very distinct consumer segments, which may explain this difference. Our sample also generally viewed Portuguese gastronomy as a promoter rather than an impediment of healthy eating practices, which can be explained by the strong influence of the Mediterranean diet on Portuguese cuisine (Turismo de Portugal 2013). Therefore, these two factors should not constitute barriers to improving the food practices associated to this type of gastronomic concept.

The majority of participants did not believe that the nutritional adequacy of dishes is directly and quantitatively evaluated by Michelin inspectors. In fact, nothing points to this being one of the criteria for the Michelin distinction, as the five publicly acknowledged assessment criteria are the quality of the products, the mastery of flavour and cooking techniques, the personality of the chef in his cuisine, the value for money and the consistency between visits (Michelin Guide 2023d). The inclusion of a criterion related to the nutritional adequacy or healthiness of the offer would constitute an incentive for chefs to investigate more about this topic, that way promoting collaborative practice with Nutrition specialists.

The assessment of the food and nutritional composition of the dishes showed both positive and concerning results. A high use of fats and oils was observed, reaching 20% of weight in meat courses, explaining the high total fat contributions widely found. Total fat was the highest contributor in all dish types except desserts, representing almost half of the TEV (i.e., the total daily energy intake). These levels are way above the dietary intake goals set by the World Health Organization (WHO), which preconize a total fat proportion in diet between 15 and 30% of TEV (World Health Organization 2003). Also, an important part of this fat was saturated, SFA levels being much higher than the recommended upper limit of 10% of TEV (World Health Organization 2003) in all types of dishes. The frequent use of highly-saturated fats such as lard, butter or coconut oil in appetizers and main courses, as well as butter in desserts, explain these results and highlight the need for improvements in the quantity and quality of the fats added for cooking, since the replacement of saturated for unsaturated fats have been linked to decreased cardiovascular risk (Sacks et al., 2017). The high fat amounts also explain the high energy contents found: considering a reference adult consuming 2000 kcal/day, many of the assessed recipes represented more than half of the total daily energy intake, which means that a person who consumes a full meal has a high probability of exceeding their energy needs for the whole day. This was especially worrisome in the desserts, whose excessive energy value reflected not only a high amount of fat, but also of sugar, which constituted nearly half of the energetic content of these dishes. Excess energy and sugar intakes have been consistently linked to the development of overweight/obesity and type 2 diabetes (Lang et al., 2021).

On a more positive note, it was observed the frequent use of vegetables and fruit, although in moderate to low quantities, as well as a moderate use of whole grains and tubers, demonstrating that chefs are familiarized with using and preparing these foods. Still, it would be important to increase the representation of these nutrient-dense food groups in the offered dishes to improve their overall nutritional value. In the recipes assessed, median dietary fiber contents were found to be low when compared to the adequate intake of 14 g/1000 kcal advocated by the U.S. Department of Agriculture (2015) and the WHO's intake goal of at least 25 g/day (World Health Organization 2003). In the dishes evaluated, the inclusion of pulses was not observed, which can be explained by the fact that these food products are generally identified as cheap staples and not usually associated to luxury meals. Nevertheless, these foods are not only rich in dietary fiber, but also a good source of protein, micronutrients and phytochemicals, and their consumption has been associated to several health benefits (Hall et al., 2017). Furthermore, they are an important part of the Mediterranean gastronomy and would be easily integrated in the local cuisine-centered concepts reported by the interviewed chefs. Their low-cost, sustainability and versatility are additional advantageous features that chefs can potentiate, that way promoting the consumption of these nutritive and often overlooked foods. These professionals' unique skills and innovative techniques should be seen as an opportunity to reinvent this food group.

Salt was used in all the dishes assessed. However, in more than half of the recipes it was not possible to calculate the total salt content. This happened because either the added salt was not quantified in the technical sheets (being described as "salt to taste") or the preparation techniques did not allow for an accurate estimate (e.g., use of broths or marinades in intermediate steps, which are subsequently wasted or not used in full). This is in line with previous evidence showing that chefs were commonly reluctant to provide information on the amounts of salt added to their recipes (Johns 2011). In our sample, this was especially true in the main courses, which are the recipes where the amount of salt should be presumably higher. This lack of control over the addition of salt means that the amounts added to each recipe are often highly dependent on the chef's own perception of saltiness, which can be highly variable, as well as on the food matrix itself, rather than being based on nutritional recommendations. Considering the recipes with quantified salt, median levels per capita frequently exceeded the maximum intake recommended by the WHO of 5 g/day, some more than twice (World Health Organization 2012). It was also worrying to perceive that, even in sweet recipes such as desserts, salt median values corresponded to relevant proportions of this daily limit, which would not be expected. These findings are concordant with results from a qualitative study conducted in a convenience sample of chefs from UK and USA, who viewed salt as an essential ingredient of any recipe and reported adding salt to all dishes (Murray et al., 2015). Excessive consumption of sodium is widely documented as a major risk factor for hypertension and cardiovascular disease (Filippini et al., 2022). As such, decreasing the

addition of salt and sodium-rich ingredients by haute cuisine chefs would bring benefits to the health of their customers. However, chefs' negative attitudes regarding reduction in salt contents have been reported, mainly due to a potential decrease in food's sensory acceptability (Johns 2011, Murray et al., 2015), although several studies have shown successful salt reduction strategies without affecting sensory quality and consumer's saltiness perception (Hoppu et al., 2017). It has been shown that gradual reductions above 30% in the amounts of salt added to soups and main dishes had no significant effect on consumer's satisfaction (Gonçalves et al., 2014; Faria et al., 2022; Dantas et al., 2023). In the context of haute cuisine, the experimental creation of new combinations of herbs, condiments and other aromatic ingredients may be useful approaches to compensate for the decrease in the amount of added salt (Ghawi et al., 2014; Dougkas et al., 2019), while promoting novelty in flavours.

Regarding the cooking methods, frying was among the least frequently used, whereas boiling and grilling were much more common. However, this does not seem to be reflected in the nutritional profile of the recipes, indicating that the type of ingredients included, and their quantities might play a more significant role in the nutritional adequacy of these dishes. As such, the cooking techniques and ingredients should be reviewed as a whole, considering the sensory and nutritional perspectives together. This reinforces the importance of joining Nutrition and culinary expertise through partnership building.

This study has some strengths and limitations. The low number of interviewed chefs (n = 11) may not represent the setting, which is an important limitation of the present investigation, which was mainly caused by the low availability of chefs to participate, mostly due to lack of time. However, since the population to be studied is rather small (33 Michelin-awarded chefs in Portugal), and considering the in-depth nature of the information extracted from the qualitative interviews, we consider that this study provides a relevant overview on a subject still largely unexplored. Understandably, most of the participating chefs showed reluctancy in providing recipes for multiple gastronomic proposals within their tasting menus, which also resulted in a reduced number of dishes to evaluate. Another possible limitation is the existence of social desirability bias, once the responses may have been influenced by what they considered to be socially accepted, namely regarding attitudes and opinions around the importance of nutrition, leading to more positive outcomes. It is also possible that the chefs selected the dishes they understood to be healthier, so we cannot rule out that the reality of the food and nutritional composition of the recipes may be worse than what is presented. Nevertheless, the novelty of this work should be highlighted as, to our knowledge, this is the first study exploring the nutritional adequacy of haute cuisine meals, as well as the importance given to this theme by the respective chefs. The mixed-methods design, which used both qualitative and quantitative strategies, allowed for the generation of in-depth information regarding chefs' attitudes, opinions and knowledge, and the integration of these data with the descriptive analysis of the nutritional content of some of the dishes offered, as well as comparison with current guidelines. Thus, this study offers us a unique vision of this gastronomic concept from a Nutrition and Public Health point of view.

Future studies may include restaurants with other Michelin Guide distinctions, such as the "Bib Gourmand" or the recent "Green Star" (that way introducing the themes of value for money and food sustainability), as well as restaurants referenced by the Michelin Guide but without any distinction or listed in other relevant gastronomic guides. A multicentered, international study including haute cuisine chefs from several countries would allow for an intercultural comparison of attitudes and gastronomic realities. To assess nutrition literacy levels in haute cuisine chefs using a validated instrument, and to measure associations with the nutritional value of the meals offered in their restaurants, would also be an important step in future work.

5. Conclusions

Despite chefs showing positive attitudes towards the importance of nutrition, the nutritional composition of their recipes was far from ideal, with exceeding levels of energy, total fat, saturated fat, sugar and salt, as well as insufficient contents of dietary fiber. This may be related to the inconsistent levels of knowledge demonstrated by the chefs, particularly in regard to healthy eating related concepts and nutrition principles. There seems to be room for improvement of the nutritional adequacy of the meals offered, particularly through the enhancement of the recipes and culinary techniques, such as the improvement of the quantity and quality of oils and fats used, reduction of sugar- and salt-rich ingredients coupled with the increasing in aromatic elements, and the inclusion of larger amounts of nutrient-dense high-fiber foods, such as vegetables, fruit, pulses and whole grains. Nutrition education targeted at these professionals will allow combining their positive attitudes with the appropriate knowledge, to enable long-term sustained good food practices. In this context, reinforcing training programs in this area of knowledge to include curricular contents on diet and nutrition into the culinary schools' and professional organizations' frameworks, will be essential to capacitate both current and future chefs in encompassing healthy and eco-friendly practices with the experiential aspects (i.e., sensory properties, creativity, pleasure, aesthetics) characteristic of the haute cuisine gastronomic concept.

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Authorship

PP and AM designed the study. MP was responsible for the study implementation and data collection. MP, SS and PP performed the analysis and interpretation of the results. SS drafted the manuscript. All authors critically revised and gave final approval of the manuscript submitted for publication.

Ethical standards

This study was conducted in accordance with the Declaration of Helsinki, and all procedures were approved by the Ethics Committee of the Faculty of Nutrition and Food Sciences of the University of Porto. Written informed consent was obtained from all participants.

Implications for gastronomy

Haute cuisine has been given much public attention, having a significant role for gastronomy through the valorisation of culinary tradition and heritage, while promoting innovation and creativity, thus contributing to the evolution of this field. Michelin-awarded restaurants are currently a great attraction not only to local consumers who appreciate the gastronomic experience of fine-dining, but also to foreign visitors who wish to savour local dishes with culinary excellence.

Our study found that Michelin-awarded chefs have positive perceptions about following food and nutrition guidelines, whereas the composition of their recipes (both in terms of foods and nutrients) showed room for improvement. Increasing the inclusion of vegetables,

fruit, pulses, nuts, whole grains, herbs and spices, as well as olive oil in detriment of other fats, would contribute to increase nutritional adequacy, while promoting the use of ingredients that are not only typical of the Mediterranean dietary pattern but also pivotal components of the Portuguese gastronomic identity.

Haute cuisine chefs' willingness to be involved with Nutrition specialists in the creation of their dishes should be seen as an opportunity to take advantage of their unique skills to promote the use of traditional ingredients without jeopardizing taste, namely through innovative cooking techniques. This synergy could result in more healthy meals which maintain high-end quality, while not only preserving but also promoting local food culture.

CRediT authorship contribution statement

M. Pereira: Writing – review & editing, Investigation, Formal analysis. **S. Sousa:** Writing – review & editing, Writing – original draft, Formal analysis. **A. Melo:** Writing – review & editing, Conceptualization. **P. Padrão:** Writing – review & editing, Formal analysis.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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Data availability

Data will be made available on request.

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