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Quantidade de sal presente nas refeições servidas em Cantinas Universitárias. Resultados de uma intervenção para reduzir e controlar o conteúdo de sal adicionado

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Salt Content in Meals Served in University Canteens. Results of an Intervention to Reduce and Control the Added Salt

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iMC Salt Project – Innovation to Monitor and Control Added Salt intake

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Resumo

Introdução: A redução do consumo de sódio pela população é reconhecida como prioridade pela Organização Mundial da Saúde e governos em todo o mundo para reduzir a prevalência de doenças crónicas não transmissíveis. Estudos anteriores demonstraram que o teor de sódio das refeições servidas em cantinas universitárias portuguesas é elevado e bastante variável. No entanto, não existem dados sobre os padrões de consumo, conhecimentos e atitudes sobre sal dos estudantes universitários portugueses, bem como estratégias de intervenção inovadoras para a diminuição do sal de adição nas refeições confecionadas nas cantinas universitárias.

Objetivos: Esta dissertação teve dois objetivos principais: (1) demonstrar a aplicação prática de um equipamento inovador de dosagem de sal de fácil utilização (Salt Control-C), por meio de uma intervenção em cantinas universitárias públicas portuguesas, bem como avaliar o seu impacto na redução do teor de sal adicionado às refeições, e no nível da aceitação dos consumidores e manipuladores de alimentos; (2) descrever os conhecimentos, atitudes e comportamentos relacionados com o consumo de sal num grupo de estudantes universitários consumidores regulares de refeições nas cantinas universitárias, bem como analisar o padrão de ingestão de sódio e de potássio, tendo em conta as fontes alimentares e o contexto de refeição.

Métodos: Este estudo insere-se no projeto iMC SALT, que visa desenvolver e estudar a eficácia de um equipamento inovador para monitorizar e controlar a utilização de sal na preparação de refeições em cantinas. Os dados do primeiro objetivo foram obtidos por meio da avaliação de duas cantinas de uma

universidade pública, coletados entre março e junho de 2021. A primeira etapa (período *baseline*) ocorreu ao longo de três semanas. As avaliações foram realizadas, em ambas as cantinas, em cinco dias aleatórios para determinar a quantidade média de sal adicionado na preparação das refeições (sopa e prato principal: vegetariano, carne e peixe), analisado através de espectrofotometria de emissão atómica, bem como o nível de satisfação dos consumidores. Após a primeira etapa, as cantinas foram randomizadas em cantina controlo e cantina de intervenção.

Na segunda etapa (período de intervenção) foram realizadas reduções graduais de 0,5%/dia ao longo de oito semanas até atingir 30% menos do teor de sal adicionado na cantina de intervenção, utilizando o equipamento Salt Control-C. Foram analisados os teores de sal dos menus servidos em nove dias nas últimas cinco semanas de intervenção: cinco dias correspondentes aos mesmos menus analisados no período *baseline*, e mais quatro dias extra de forma a obter um maior número de dados para avaliar o impacto do equipamento sobre os níveis de sal adicionado nas refeições. A satisfação dos consumidores foi avaliada em ambas as cantinas nos cinco dias de avaliação dos menus equivalentes aos analisados no período *baseline*.

A satisfação dos consumidores consistiu na avaliação de questionários de satisfação, disponibilizados online através de QR *code*, e do desperdício alimentar no prato, avaliado por pesagem. No final da intervenção, a satisfação dos manipuladores de alimentos da cantina de intervenção com a utilização do equipamento de dosagem de sal foi avaliada por meio de um questionário de satisfação.

Para o segundo objetivo, foi recrutado um grupo de 20 estudantes universitários através de convite direto realizado em duas cantinas durante o horário das refeições, em março de 2021. Os conhecimentos, atitudes e comportamentos relacionados com o sal foram obtidos através do questionário *STEPwise* da Organização Mundial da Saúde. Os padrões de ingestão de sódio e potássio e as principais fontes de ingestão de sódio foram obtidos por recordatório alimentar de 24 horas anteriores e excreção urinária de 24 horas, durante um dia de avaliação.

Resultados: Na cantina controlo, no geral, observou-se um aumento da quantidade de sal adicionado às refeições. Na cantina de intervenção foi observada uma redução do teor de sal adicionado de 34,3%/100 g na sopa, 41,1%/100g no prato de peixe e 48.0%/100g no prato de carne. No prato vegetariano verificou-se um aumento de 6,1%/100 g.

Não se observaram diferenças com significado estatístico na satisfação dos consumidores, antes e após a intervenção, tendo sido apenas reportado um aumento de 15,7% (p = 0,044) em relação à satisfação com o sabor do prato principal. Não foram encontradas diferenças significativas no desperdício de alimentos, antes e depois da intervenção. Os manipuladores de alimentos mostraram um elevado nível de aceitação com a utilização do equipamento Salt Control-C.

A maioria dos estudantes universitários avaliados percebem o seu consumo de sal como “baixo” ou a “quantidade certa” (60,0%), 73,3% adicionam habitualmente sal ao cozinhar e 60% admitem consumir frequentemente alimentos processados com alto teor de sal. A excreção urinária média de sódio na amostra de estudantes avaliada foi de 2.976 ± 973 mg/dia, sendo que 93,3% apresentaram

excreção excessiva de sódio. Relativamente à excreção urinária de potássio, 93,3% dos participantes apresentaram uma excreção inadequada. No que diz respeito às fontes de sódio, 52,7% foi proveniente de alimentos processados, sendo que os grupos que mais contribuíram para a ingestão de sódio foram o pão (23,0%, $\bar{x}$ 465 mg/sódio), carnes e peixes processados (21,0%, $\bar{x}$ 417 mg/sódio) e queijos (13,9%, $\bar{x}$ 237 mg/sódio).

Conclusões: O equipamento Salt Control-C parece ser eficaz na redução gradual superior a 30% dos níveis de adição de sal nas refeições de cantinas, sem afetar negativamente a satisfação dos consumidores. Além disso, este estudo apresenta informações relevantes sobre o uso excessivo de sal adicionado na preparação das refeições de cantinas universitárias e a necessidade urgente de desenvolver estratégias práticas e eficazes, como o equipamento Salt Control-C, para controlar a adição de sal e garantir níveis adequados de sódio nas refeições servidas neste tipo de estabelecimentos de alimentação coletiva.

Por outro lado, observou-se uma elevada prevalência de ingestão excessiva de sódio e do rácio Na:K, bem como uma ingestão inadequada de potássio na amostra de estudantes universitários analisada, o que pode indicar um risco para este grupo da população de desenvolver hipertensão e doenças cardiovasculares.

Embora todos os participantes estivessem cientes da relação entre a ingestão excessiva de sódio e os problemas de saúde relacionados, verificou-se que a maioria desconhecia sua ingestão excessiva de sódio.

Apesar das suas limitações, este estudo fornece dados preliminares sobre os conhecimentos, atitudes e comportamentos relacionados com o sal, bem como sobre os padrões de ingestão de sódio e potássio em estudantes universitários. Os dados obtidos contribuem para reforçar o alerta sobre a indústria de alimentos, restaurantes, dietistas/nutricionistas e consumidores sobre a importância de reduzir o uso de sal e melhorar as escolhas alimentares nas refeições para reduzir a ingestão de sódio e aumentar a ingestão de potássio.

No entanto, estudos em amostras representativas da população geral de estudantes universitários e cantinas universitárias são necessárias para confirmar os dados e priorizar as futuras intervenções.

Palavras-Chave: sódio, sal de adição, redução de sal adicionado, estudantes universitários, cantinas, alimentação coletiva, política alimentar, nutrição em saúde pública, hipertensão, doenças cardiovasculares

Abstract

Background: Reducing sodium consumption by the population is recognized as a priority by the World Health Organization and governments worldwide to reduce the prevalence of non-communicable diseases. Previous studies have shown that the sodium content of meals served in Portuguese university canteens is high and highly variable. However, data on consumption patterns, knowledge and attitudes about salt among Portuguese university students are scarce. Besides, innovative intervention strategies to reduce added salt in meals prepared in university canteens weren't found in the literature.

Objectives: This study had two main objectives: (1) to demonstrate the practical application of an innovative, easy-to-use salt dosing equipment (Salt Control-C), through an intervention in Portuguese public university canteens, as well as to evaluate its impact on reducing the amount of salt added to meals, and on the level of acceptance by consumers and food handlers; (2) to describe the knowledge, attitudes and behaviors related to salt consumption in a group of university students who regularly consume meals in university canteens, as well as to analyse the pattern of sodium and potassium intake, taking into account the food sources and the meal context.

Methods: This study is part of the iMC SALT project, which aims to study the effectiveness of innovative equipment to monitor and control the use of salt in the preparation of meals in canteens. Data for the first objective were obtained by evaluating two canteens at a public university, collected between March and June 2021. The canteens were randomized into control canteen and intervention canteen. The first stage (baseline period) took place over three weeks. The

evaluations were carried out on five random days to determine the average amount of salt added in the preparation of meals (soup and main course: vegetarian, meat and fish), analysed through atomic emission spectrophotometry, as well as the level of consumer satisfaction, in both canteens.

In the second stage (intervention period) gradual reductions of 0.5% were carried out over eight weeks until reaching 30% less of the added salt content in the intervention canteen using the Salt Control-C equipment. The salt contents of menus served in nine days over the last five intervention weeks were analysed: five days corresponding to the same menus evaluated in the baseline period, plus four extra days in order to obtain a greater number of data to evaluate the impact of the equipment on salt added in meals. Consumer satisfaction was evaluated in both canteens in the five evaluation days with the equivalent menus to those analysed in the baseline period.

Consumer satisfaction consisted of the assessment through satisfaction questionnaires, available online through QR code, and food waste on the plate, assessed by weighing. At the end of the intervention, the food handlers' satisfaction with the salt dosing equipment was evaluated through a satisfaction questionnaire.

For the second objective, a group of 20 university students was recruited through a direct invitation carried out in canteens during meal times, in March 2021. Knowledge, attitudes and behaviors related to salt were obtained through the Organization's STEPwise World Health Organization questionnaire. Sodium and potassium intake patterns and major sources of sodium intake were

obtained by 24-hour food recall and 24-hour urinary excretion over one assessment day.

Results: In the control canteen, overall there was an increase in the amount of salt added to meals. In the intervention canteen, it was observed a mean reduction in the added salt content of 34.3%/100g in the soup, 41.1%/100g in the fish dish and 48.0%/100g in the meat dish. In the vegetarian dish, there was an increase of 6.1%/100 g.

No statistically significant differences were observed in consumer satisfaction before and after the intervention, with only an increase of 15.7% ($p = 0.044$) being reported regarding satisfaction with the taste of the main dish. No significant differences were found in food waste before and after the intervention. Food handlers showed a high acceptance of the use of Salt Control-C equipment.

Most of the evaluated university students perceive their salt intake as "low" or the "right amount" (60.0%), with 73.3% usually adding salt when cooking and 60% admitting to frequently consuming high-sodium processed foods. The mean urinary excretion of sodium was 2,976 ± 973 mg/day, with 93.3% having excessive sodium urinary excretion. About urinary potassium excretion, 93.3% of participants had inadequate excretion.

Concerning main sodium food sources, 52.7% of intake was from processed foods. The groups that most contributed to sodium intake were bread (23.0%, $\bar{x}$ 465 mg/sodium), meat and fish processed foods (21.0%, $\bar{x}$ 417 mg/sodium) and cheese (13.9%, $\bar{x}$ 237 mg/sodium).

Conclusions: The Salt Control-C equipment seems to be effective in gradually reducing more than 30% of the levels of added salt in canteen meals, without

negatively affecting consumer satisfaction. Also, this study contributes to informing about the excessive discretionary salt usage in the preparation of university canteen meals and the urgent need to develop practical and efficient strategies, such as the Salt Control-C equipment, to control and achieve adequate levels of sodium in meals served in this type of food establishments.

On the other hand, it was observed a high prevalence of excessive sodium and Na:K ratio intake, as well as an inadequate potassium intake among the university students analysed sample, which may indicate a risk for university students developing hypertension and CVDs.

Although all participants were aware of the relationship between excessive sodium intake and related health problems, it was found that the majority were unaware of their high sodium intake.

Despite the limitations, this study sheds light on salt-related knowledge, attitudes and behaviors, and sodium and potassium dietary intake patterns in university students. It reinforces the food industry, restaurants, dietitians/nutritionists and consumers about the importance of reducing discretionary salt usage and improving food choices between meals to reduce sodium and increase potassium intake.

However, estimates in representative samples of the general university student population are needed to confirm these findings and prioritize interventions.

Keywords: sodium, added salt, added salt reduction, university students, canteens, collective catering, food policy, public health nutrition, hypertension, cardiovascular diseases

Índice

INTRODUÇÃO

Introdução

O sódio é um nutriente essencial, e a forma mais comum de consumo é através de cloreto de sódio, comumente conhecido como sal de cozinha ou de mesa. Os termos sal e sódio são frequentemente usados com o mesmo sentido. No entanto, com base em peso, o sal compreende 40% de sódio e 60% de cloreto (1 g de sódio = 2,5 g de sal).

O corpo humano precisa de uma quantidade muito pequena de sódio proveniente da alimentação para manter o equilíbrio de fluidos e a homeostasia celular [(1)]. Durante vários milhões de anos, a fonte de sódio para os nossos ancestrais era apenas o teor de sódio intrínseco naturalmente presente nos alimentos, e a ingestão estimada de sódio era inferior a 0,2 g/dia. Contudo, há cerca de 5000 anos, com a descoberta das suas propriedades conservantes, o sal foi introduzido na alimentação humana e tornou-se gradualmente a mercadoria mais tributada e comercializada no mundo, ao mesmo tempo que as populações foram se tornando cada mais dependentes do seu consumo [(2)]. O problema instala-se quando o consumo de sal se torna excessivo relativamente às necessidades fisiológicas de sódio.

Nos dias de hoje, embora as tecnologias de refrigeração eliminem a necessidade do sal como conservante, o consumo de sal estabeleceu-se nos hábitos e paladar da população global, sendo atualmente média estimada de consumo de sódio em adultos superior a 5 g/dia (12,5 g/dia de sal) na grande maioria dos países [(3, 4)], o que representa um aumento superior a 25 vezes num curto período de tempo da escala evolutiva humana. São inúmeras as repercussões do excesso de sódio na saúde, pois a fisiologia humana não se adaptou para excretar essas grandes quantidades de sódio [1]. As principais consequências refletem-se sobretudo ao nível de um aumento geral da pressão arterial, a qual danifica as artérias, causando danos nos principais órgãos-alvo, sendo esta uma das principais causas de derrames vasculares, ataques cardíacos, doenças cardiovasculares, e outras doenças crónicas não transmissíveis, como doenças renais, osteoporose, cancro de estômago, obesidade e demência [1, 5-9]. A elevada ingestão de sódio é hoje considerada um dos 3 principais fatores de risco alimentar para a perda de anos de vida ajustados por incapacidade, e responsável por cerca de 3 milhões de mortes anualmente a nível mundial [4].

Em 2013, a Organização Mundial da Saúde (OMS) recomendou que todos os estados membros visassem reduzir a ingestão de sódio da população em 30% até 2025 [10]. Houve um aumento no número de iniciativas de redução do consumo de sódio em todo o mundo desde 2014. No entanto, nenhum país conseguiu ainda atingir a meta de redução de 30% [11]. Neste sentido, os esforços devem ser acelerados, sendo necessário potencializar os esforços de monitorização e avaliação das estratégias para atingir a meta de redução de consumo de sódio.

Estima-se que cerca de 75% a 90% do sódio consumido é proveniente do sal adicionado, tanto nos alimentos processados pela indústria alimentar, como durante a confeção de refeições, em restaurantes ou em casa [3, 12]. A redução do sal adicionado ao nível da restauração e indústria alimentar preocupa as organizações comerciais pelo desafio inerente à aceitação dos consumidores [13], uma vez que a preferência pelo sabor salgado é um fator importante que está relacionado com a elevada ingestão de sódio [14]. O sal adicionado tem também um grande impacto na estrutura dos alimentos, o que afeta tanto a libertação de aromas quanto a perceção de texturas [15]. Portanto, a redução do teor de sódio representa um desafio complexo devido à sua funcionalidade específica em termos de aspetos sensoriais, sabor e palatabilidade (16). Por este motivo, as estratégias utilizadas para diminuir os altos níveis de sódio devem ser feitas sem causar mudanças significativas nas características sensoriais e na perceção do consumidor de forma a não impactar negativamente na aceitação dos consumidores e a consequente viabilidade financeira dos negócios de alimentação (17-19). Diversos estudos têm demonstrado que reduções consistentes e graduais até 30% da adição de sal nos alimentos não tem impactado negativamente a aceitação dos consumidores (20-22).

A restauração coletiva pode ser um excelente meio de intervenção para diminuir a ingestão de sódio (13), e alguns estudos mostraram que uma única refeição ou um único componente como a sopa, fornecido nas cantinas pode contribuir para exceder a ingestão diária adequada (21-27). Num estudo realizado em cantinas universitárias portuguesas, Barbosa et al. observaram que o teor médio de sal fornecido numa única refeição (sopa e prato principal) atingiu cerca de 53% da ingestão diária recomendada (25).

Os manipuladores de alimentos são uma peça importante na redução de sal de adição (13). Numa pesquisa realizada em 100 unidades de catering de uma empresa portuguesa verificou-se que um terço dos cozinheiros não tem o hábito de provar, ou prova apenas ocasionalmente, os alimentos antes da adição de sal, enquanto a grande maioria dos cozinheiros saboreia os alimentos somente após a adição de sal (27). Outros estudos observaram que a adição de sal depende apenas do paladar dos cozinheiros/chefes responsáveis, os quais tendem a ser menos sensíveis devido à exposição regular ao sódio (28) e isso poderá impactar significativamente na quantidade de sal adicionada. No entanto, além de educar, é necessário desenvolver estratégias eficazes para que restaurantes e empresas de restauração coletiva/catering possam reduzir e monitorizar o teor de sal de adição. O desenvolvimento de equipamentos que auxiliem no controlo e redução do sal disponível para a preparação de alimentos poderá ser uma estratégia prática e eficaz, no entanto, não foram encontrados estudos prévios que tenham recorrido a esse tipo de abordagem [26].

Por sua vez, a informação relativa ao consumo de sódio em estudantes universitários portugueses é escassa, tal como dados relativos aos níveis de ingestão, conhecimentos, comportamentos, fontes alimentares e padrões de consumo. Num estudo realizado em 2006 por Polónia *et al.* [29], foi avaliado a ingestão de sódio de quatro populações portuguesas distintas, incluindo os estudantes universitários, as quais apresentaram níveis muito superiores aos recomendados pela OMS. Os resultados indicam que o elevado consumo de sal está globalmente presente em diversos segmentos da população, inclusive em indivíduos jovens em formação universitária onde, segundo os dados reportados no estudo, 71% dos estudantes avaliados ingeriram mais de 3,6 g sódio por dia.

É essencial compreender o conhecimento e os hábitos alimentares dos estudantes universitários para promover estratégias que melhorem os comportamentos alimentares deste grupo populacional [30]. Um estudo transversal multicêntrico, realizado em seis países da Europa e Ásia, destacou a existência de graves lacunas e desinformação sobre o conhecimento relacionado com o sal entre estudantes universitários, tanto nos países desenvolvidos como em desenvolvimento [31]. O conhecimento desses dados é crucial para planear uma estratégia de intervenção eficaz que vise a redução da ingestão de sódio.

Desta forma, os principais objetivos desta dissertação foram:

(1) demonstrar a aplicação prática de um equipamento inovador de dosagem de sal de fácil utilização (Salt Control-C), por meio de uma intervenção em cantinas universitárias públicas portuguesas, bem como avaliar o seu impacto na redução do teor de sal adicionado às refeições e no nível da aceitação dos consumidores e manipuladores de alimentos;

(2) descrever os conhecimentos, atitudes e comportamentos relacionados com o consumo de sal num grupo de estudantes universitários consumidores regulares de refeições nas cantinas universitárias, bem como analisar o padrão de ingestão de sódio e de potássio, tendo em conta as fontes alimentares e o contexto de refeição.

Esta dissertação incluiu a elaboração dos seguintes manuscritos (publicados ou em processo de revisão para publicação):

1. Faria AP, Padrão P, Pinho O, Silva-Santos T, Oliveira L, Esteves S, Pereira JP, Graça P, Moreira P, Gonçalves C. Pilot Study to Reduce Added Salt on a University Canteen through the Use of an Innovative Dosage Equipment. *Foods*. 2022; 11(2):149. https://doi.org/10.3390/foods11020149

2. Faria AP, Gonçalves C., Pinho O, Silva-Santos T, Oliveira L, Esteves S, Pereira JP, Graça P, Moreira P, Padrão P. Knowledge, Attitudes, Behaviors and Patterns of Salt Intake in University Students (em processo de revisão para publicação).

Para além da elaboração dos manuscritos, foram ainda apresentados publicamente resultados desta dissertação nos seguintes eventos:

- 15º Encontro de Investigação Jovem da Universidade do Porto (IJUP), Porto, maio 2022: *Salt Content in Meals Served in University Canteens – Results of an Intervention to Reduce and Control the Added Salt* [Poster]. (apêndice A)

- Encontro de Responsabilidade Social Universitária da Universidade do Porto, Porto, maio 2022: *Intervention to Reduce Excessive Added Salt in Canteen Meals at University of Porto with an innovative Equipment (Salt Control-C)* [Poster]. (apêndice B)

Estudo 1

Pilot Study to Reduce Added Salt on a University Canteen through the Use of an Innovative Dosage Equipment

(Foods. 2022; 11(2):149)

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Article

Pilot Study to Reduce Added Salt on a University Canteen through the Use of an Innovative Dosage Equipment

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Abstract: Background: This study aims to demonstrate the practical application of an innovative easy-to-use equipment to dosage cooking salt, and evaluate the effectiveness in reducing 30% of the added salt in meals and the impact on consumer's satisfaction and food waste. Methods: Two canteens from one public university where randomized in one control arm and one intervention arm. The first step was to evaluate the salt added to food through atomic emission spectrophotometry in both canteens, and the second step was to perform gradual reductions of up to 30% of cooking salt in the intervention canteen using the Salt Control-C (SC-C) equipment. Consumer acceptability was assessed through satisfaction questionnaires and food waste was evaluated by weighing. Results: The intervention canteen achieved to a reduction of more than 30% of added salt in soup (−34.3% per 100 g), fish dish (−41.1% per 100 g) and meat dish (−48.0% per 100 g), except for the vegetarian dish (6.1% per 100 g). There was no decrease in consumer satisfaction, with a significant satisfaction increase of 15.7% ($p = 0.044$) regarding the flavor of the main dish. Also, no significant differences were found in food waste. Conclusions: SC-C seems to be effective in reducing 30% of added salt levels in canteen meals, and may be a good strategy to control and reach adequate levels of added salt in meals served outside-the-home, promoting benefits to the individual's health.

Keywords: sodium; added salt; salt-reduction; consumer acceptance; food waste; canteens

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1. Introduction

Excessive salt consumption is a public health problem recognized worldwide as a risk factor for several health problems, such as hypertension-related cardiovascular diseases (CVD) [1–6] and other health complications such as chronic kidney disease, obesity, osteoporosis and gastric cancer [7]. Based on modelling data, 11 million deaths globally are associated with poor diet, 3 million of which are attributable to high sodium intakes which is also related to the loss of 70 million disability-adjusted life-years every year [8]. In Portugal, as well as in Europe, CVD are the leading cause of mortality [9,10]. In 2017, the inadequate eating habits of the Portuguese population were the fifth risk factor that most contributed to the loss of disability-adjusted life-years and mortality due to CVD, with high intake of sodium-rich foods among the top five dietary risk factors [11].

The World Health Organization (WHO) and policy governments around the world recognized and adopted reducing salt consumption by populations as a priority to reduce the prevalence of non-communicable diseases (NCD) [10,12–18]. In 2013, all WHO member states adhered to the goal of reducing 30% population salt intake until 2025 [19], with an ultimate goal of reaching the recommended daily maximum salt intake of 5 g/day (2 g/day of sodium) [7]. In the national strategy for reducing the salt consumption in portuguese population [18] the reduction of availability of foods with a high salt content and the monitoring of the supply (food and meals for sale) were considered imperative measures for public health.

In European countries, approximately 75–90% of salt intake is provided by the added salt in industrially processed foods and in cooked food, both prepared by restaurants/food concessionaires and at home, and only 10–25% occurs naturally in foods [20–23]. Indeed, the salt value in foods' composition can vary considerably [20]. Gonçalves et al. analyzed the salt content in soups served in several public canteens in Portugal and, in addition to verifying a high average salt level (0.7 g/100 g of soup, i.e., 2.1 g of salt in a 300 g portion), they also found a high standard deviation, which demonstrates the existence of great variability in the levels of added salt [24]. In fact, most food handlers recognize that they use a random amount of salt based on personal flavor [25]. It makes it difficult for consumers to comply with dietary recommendations as the salt content of foods available in the market and restaurants is high and varies greatly.

Salt is a natural flavor enhancer in foods, but high levels of salt are naturally unpleasant and repulsive. However, frequent exposure to high levels may become pleasant, and people may develop a taste preference for foods with higher salt content [26–30]. Evidence suggests that the prefered level of salt in foods could be reduced over time, resulting in increased perceived salt intensity and decreased preference for salty foods [31–34]. One of the most important concerns of companies is the potential negative impact of these changes on consumers satisfaction and, consequently, impacting sales [25,31]. In that order, salt reduction interventions need to be gradually performed to be done without affecting consumer acceptability [35,36].

Since young people consume between a third and a half of meals at school or university canteens, this may be a key place for interventions that change the food environment, namely salt offer [37]. In this sense, the development of a quick and easy-to-use instrument to monitor and help control the salt added to food during the preparation of food in canteens could be part of the solution to reduce the population's salt consumption.

In a systematic review, Mota et al. [38] concluded that intervention studies to reduce the salt content in meals provided by canteens are still insufficient and when reductions are gradual, there seems to be no negative impact on the acceptability of foods by the consumer. In this systematic review no intervention has used equipment to assist in salt dosing, so the present study is original and can bring new practical evidence in this field.

The aim of this study was to demonstrate the practical application of an innovative easy-to-use equipment of salt dosage, Salt Control-C (SC-C), and evaluate the effectiveness in reducing the added salt content of meals and the impact on consumer acceptability through an intervention in public university canteens.

2. Materials and Methods

2.1. Study Design

This study was conducted in two canteens (control canteen and intervention canteen) of a public university in northen Portugal, which serve exactly the same menus for lunch and dinner to students and workers from the university. The complete meal offered consists of vegetable soup, main dish (meat, fish or vegetarian), dessert and bread. The main dish includes the garnish (group of cereals, tubers, and/or pulses), the conduit (group of meat, fish and eggs, and/or pulses group or vegetable equivalent, as tofu or seitan), and the vegetables.

It is characterized as an experimental study divided into two consecutive steps: Step 1—baseline evaluation, and Step 2—intervention; performed between March and June of 2021. In the baseline step the salt added to food (soup and main dishes) was estimated in each canteen. During the intervention step, a gradual reduction of up to 30% of salt added to prepare soup and main dishes was carried out in the intervention canteen using the SC-C equipment, in relation to the average level of added salt obtained in baseline analysis. During the two steps of the study, consumer acceptability was assessed through satisfaction surveys and evaluation of plate food waste after mealtime (Figure 1).

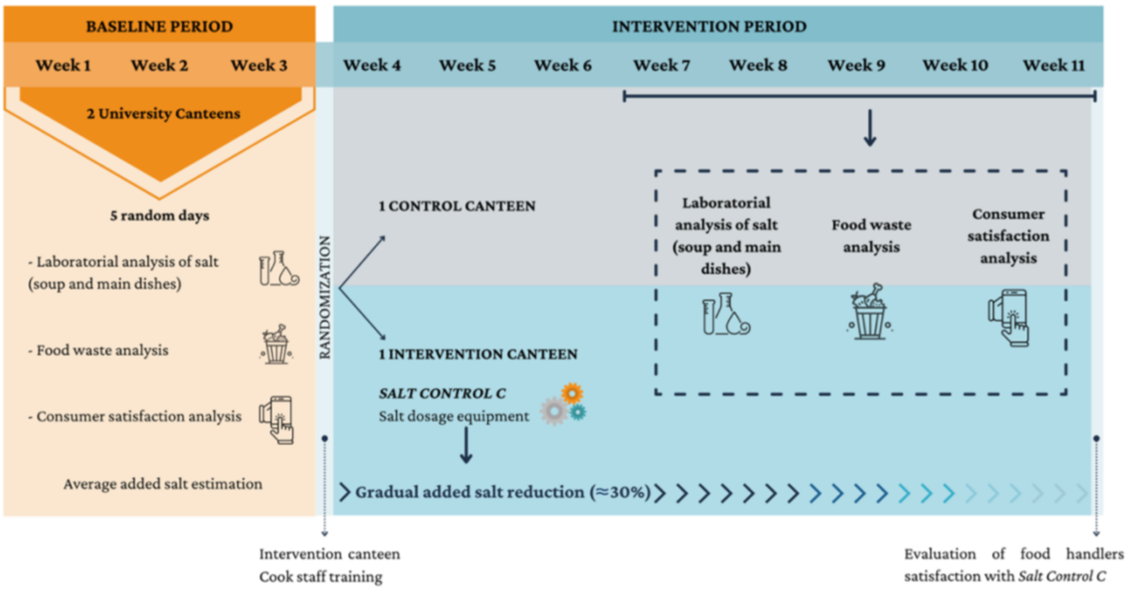

Figure 1. Flowchart with study design.

2.1.1. Step 1—Baseline Assessment

This occurred during the first three weeks, where the assessments were made in five random days on both canteens. The assessments consisted of the analysis of added salt in food (soup and main dishes), evaluation of consumer food waste and consumer satisfaction with meals. The menus information and the technical data of the corresponding recipes were also collected.

The laboratorial salt analysis was performed to estimate the average usual level of salt added to prepare the meals in each canteen. This level of salt was used to program the SC-C equipment with the starting point to perform the gradual dosage reduction of salt dispensed to cook in the intervention canteen.

After the baseline period, the 2 canteens were randomly assigned, 1 was allocated to the intervention group and the other allocated to the control group.

2.1.2. Step 2—Intervention

This step took place during eight consecutive weeks, where the SC-C was used in the intervention canteen to perform the salt dosage. The equipment was pre-programmed to implement a daily salt reduction until 30% less at the end of the intervention than the average of added salt content assessed in the baseline period. In the canteen allocated to the control group, the SC-C equipment was not implemented, and no training was given to the food handlers.

From week 7 until week 11, in both canteens, sodium levels were analyzed in five days in which the menus (soup and main dishes) coincided with the baseline period assessments, along with the measurement of food waste and consumer satisfaction questionnaires in the same days. Also during these weeks, extra meals were collected on another four random days (with the respective recipes technical data) to obtain a larger sampling of meals in order to assess the impact of the equipment on the added salt content of meals with more accuracy.

The distribution of assessments over the last five weeks of intervention was as follows: week 7–8: three laboratorial salt analyses, two consumer satisfaction analyses and two food waste analyses; week 9–10: three laboratorial salt analyses, two consumer satisfaction analyses and two food waste analyses; week 11: three laboratorial salt analyses, one consumer satisfaction analysis and one food waste analysis.

2.2. *Salt Content of Meals*

Food samples from the soup and the three complete main dishes (vegetarian, meat and fish) were weighed and collected at each visit at the canteens. Only the edible parts were considered after deboning fish and meat. The samples were weighed in the kitchen and placed in properly coded plastic bags to be directly transported to the laboratory. They were mantained at refrigeration temperature (4 °C), for a maximum period of 24 h, until sample homogenization processment. The homogenization of the soup samples was made with a hand blender (Electric Co 450 W®), and the main dishes were mixed up with an electric food chopper (Moulinex 700W®) into a homogenous mass. The homogenized mass obtained was distributed on PTEE 60 mL containers and stored in a freezer (−18 °C) until it was used.

2.2.1. Sodium Analysis

The evaluation of the sodium content of the collected meals was carried out by atomic emission spectrophotometry (AES) (flame photometry), the intern reference method to analyze sodium in food matrices [39], in the laboratory of the Faculty of Nutrition and Food Sciences of the University of Porto (FCNAUP).

After each food sample homogenization, 2 g was sampled and 2 mL of nitric acid was added. The mixture was shaken during 90 min to allow the food matrix to complete hydrolysis. Then, 20 mL of water was added, and the mixture was again homogenized using an electric homogenizer (Ultra Turrax blender T25, Sotel, Staufen, Germany). Volume was completed up to 40 mL and shaken for 30 min, followed by centrifugation (4000 rpm, 15 min; Labofuge 6000† Haerus model, Burladingen, Germany). Finally, 1 mL of aqueous supernatant was diluted up to 40 mL of deionized water before reading in the flame photometer (Model PFP7, JenWay, Staffordshire, UK).

2.2.2. Added Salt Levels

The total sodium values obtained in the analyses were converted into total salt (1 g of sodium corresponds to 2.5 g of cooking salt), and to obtain the values specifically of added salt in soup and main dishes the technical data of the recipes were consulted in order to calculate the value of the intrinsic salt of each ingredient according to data of the portuguese Food Composition Table or the food labels [40]. From the total salt value obtained by the analyses, the intrinsic salt value calculated was subtracted, obtaining the values of added salt for each soup and main dish. The added salt content was analyzed per 100 g of food and per portion.

2.3. *Equipment to Dosage Cooking Salt: SC-C*

The SC-C equipment (provisional patent INPI, No. 20211000015906) consists of a dosing device that provides doses of salt according to the age (children or adult) and the number of consumers. The prototype used in this study was made with a material compatible with food, and needs to be connected to the electrical current to operate.

For soup, it dispenses salt according to the liters to be produced, and for main dishes it dispenses salt according to the number of servings to be cooked (Figure 2).

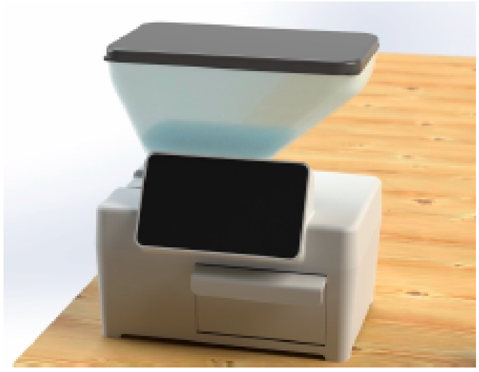

Figure 2. Salt Control-C equipment.

The equipment is available only for testing by researchers in controlled dietary studies, and not for commercial distribution. This prototype system was programmed to dispense a daily level of salt during the eight-week intervention period, with a 0.5% daily reduction in relation to the average baseline quantity of added salt in soup and main dishes obtained in the Step 1.

Before starting the intervention step, food handlers in the intervention canteen received training about the use of the equipment. They were instructed to dosage the salt according to the liters of soup and the total number of main dishes to be cooked, and were responsible for personally managing the distribution of the dispensed salt to prepare the different recipes for the three main dishes (vegetarian, meat and fish). Also, they were informed that did not need to use the entire amount of salt dispensed when they considered it not necessary. During all the intervention period the daily maximum salt used for seasoning meals in the intervention canteen was exclusivelly the dispensed amount by the equipment.

2.4. *Satisfaction*

2.4.1. Consumers Satisfaction Questionnaires

In each evaluation day (5 days in the baseline period and 5 days in the intervention period), consumers were invited to answer a satisfaction questionnaire provided online in both canteens, by scanning QR Codes available on posters strategically placed after returning the food tray before the canteen exit.

In the questionnaire, the consent request for consumer participation was presented initially. It requested the sociodemographic information (sex and age) and the identification of the type of main dish consumed (meat, fish or vegetarian). Regarding meal satisfaction evaluation, seven questions about the degree of satisfaction were presented in a 1 to 5 score scale (from "totally dissatisfied" (1) to "totally satisfied" (5)). The first question was about the global satisfaction with meal, and the other six questions were specifically about the appreciation with the soup and with the main dish regarding global satisfaction, flavor and salt level satisfaction.

2.4.2. Consumers Food Waste

Food waste monitoring on consumers' plates was also evaluated as a parameter of meal acceptability [41]. The measurement of food waste was carried out in each canteen kitchen pantry in the evaluation days (5 days in the baseline period and 5 days in the intervention period), through selective aggregate weighing [42]. This method allowed us to obtain an average waste value after removing all non-edible parts (such as bones, skin and fishbones).

In each evaluation day, the weight of a soup model plate and the mean weight of the three main dish model plates were assessed (rejecting the weight of the non-edible parts of the food). Edible food waste in the consumers plates were separated and weighed by soup or main dish (three main dishes aggregated), in order to calculate the percentage of food waste for soup and main dish.

2.4.3. Food Handlers Satisfaction Questionnaires

At the end of the intervention period, the cooks responsible for handling the SC-C answered a 5-level score scale satisfaction questionnaire (from "totally dissatisfied" (1) to "totally satisfied" (5)) regarding the experience of producing meals with the equipment for dosing the addition salt. The questionnaire presented eight satisfaction questions, particularly related to the control of the salt addition, the flavor of meals produced, the state of the equipment conservation, ease of use, promotion of eating habits, safety and hygiene conditions, and global satisfaction.

2.5. *Data Analysis*

Statistical analysis was performed using the statistical software IBM SPSS STATISTICS, version 26 (SPSS Inc., IBM, Chicago, IL, USA). Mean and standard deviations (SD) were used to characterize the study variables, namely food salt levels, food waste and consumer satisfaction.

The mean or median from the five assessments (added salt and consumers satisfaction) carried out in the baseline period was computed and the same procedure was followed in the three assessments carried out in the week 11. The last week was chosen in order to compare the most extreme values of added salt reduction and correspondent consumer satisfaction. For the food waste, the comparison was performed with the median values of intervention week 10 and 11 assessments ($n = 2$), given that only one assessment was performed in the last week. The t-test for independent samples and the Mann–Whitney test were used to compare the values obtained between the assessments of the baseline period and the last week of intervention for each variable, as appropriate.

Spearman and Pearson correlation coefficient was used to measure the degree of association between added salt levels in food with the food waste and the satisfaction levels of consumers. The null hypotesis was rejected when the critical significance level was less than 0.05.

2.6. *Ethics Committee*

The study was approved by the Ethics Committee of the Faculty of Nutrition and Food Sciences of the University of Porto.

3. Results

Table 1 shows the analysis for the added salt, food waste and consumer satisfaction in each canteen during the baseline and intervention steps of the study. In the control canteen it was found an increase in the avegare levels of added salt per portion of soup and the three main dishes, with a 135% significant increase in the soup portion at the end of the intervention ($p = 0.025$). In the intervention canteen, although the differences obtained were not statistically significant, it was found that there was a reduction in the levels of added salt in the soup (−34.4% per 100 g, and −48.6% per serving), in the meat dish (−48.0% per 100 g, and −51.8% per serving), and in the fish dish (−41.1% per 100 g, and −60.9% per serving). Regarding the vegetarian dish, there was a slight increase in added salt (6.1% per 100 g, and 1.2% per serving).

In terms of food waste, although there was an increase in the waste of soup and main dishes in both canteens (49.0% of total food in the control canteen, and 62.4% of total food in the intervention canteen), the differences found between the baseline period and the last two intervention weeks were not significant.

With regard to consumer satisfaction, in the control canteen there was a decrease in the percentage of satisfaction of all parameters evaluated, but the differences between the baseline period and the last week of intervention were not significant. In the intervention canteen there was an increase in the percentage of satisfaction of almost all the parameters evaluated, and for the satisfaction with the flavor of the main dish there was a significant increase of 15.7% ($p = 0.044$).

It was found two significant associations, one between added salt levels on soup per portion and global satisfaction with the meal ($\rho = 0.133$, $p = 0.007$), and other between total food waste and the added salt levels in soup per 100 g ($\rho = -0.626$, $p = 0.003$).

The two chefs responsible for handling the SC-C equipment rated between "satisfied" (3) and "totally satisfied" (5) all parameters evaluated in the satisfaction questionnaire, namelly, the questions about overall satisfaction and ease of using the device, one chef rated it as "totally satisfied" (5), and the other rated it as "very satisfied" (4), and regarding the flavor of the meals, both chefs rated it as "very satisfied" (4).

Table 1. Added salt, food waste and consumer satisfaction evaluations per canteen over the course of the study.

			Baseline Week 1–3	Week 7–8	Week 9–10	Week 11	Δ% Baseline vs. Week 11	*p*-Value
Control Canteen								
Added Salt Mean ± SD		Samples (n)	5	3	3	3		
	Soup	g/100 g	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.0	0.7 ± 0.2	66.8	0.050 [a]
		g/portion	1.0 ± 0.4	1.0 ± 0.3	1.3 ± 0.2	2.3 ± 0.4	135.0	0.025 [a]
	Vegetarian	g/100 g	0.7 ± 0.2	0.3 ± 0.2	0.7 ± 0.2	0.7 ± 0.2	−9.9	0.633 [b]
		g/portion	2.4 ± 0.7	1.5 ± 0.9	3.0 ± 0.7	3.1 ± 1.0	32.0	0.683 [b]
	Meat	g/100 g	0.7 ± 0.2	0.5 ± 0.2	0.8 ± 0.4	0.6 ± 0.2	−1.9	1.000 [a]
		g/portion	2.3 ± 0.8	2.1 ± 1.0	3.0 ± 1.1	2.6 ± 1.3	12.7	0.880 [a]
	Fish	g/100 g	0.5 ± 0.3	0.5 ± 0.3	0.4 ± 0.2	0.7 ± 0.4	59.4	0.315 [b]
		g/portion	1.3 ± 0.7	1.8 ± 1.1	1.7 ± 0.6	2.9 ± 1.7	117.9	0.297 [a]
Food waste Mean ± SD	Consumers (n)		71	84	66	28		
	Soup	%	7.3 ± 5.0	5.8 ± 8.2	11.7 ± 1.1	8.1	30.2 *	0.585 *,a
	Main dish	%	7.5 ± 5.9	10.5 ± 2.5	12.0 ± 1.1	12.5	69.1 *	0.245 *,a
	Total	%	7.5 ± 4.5	8.6 ± 4.8	11.9 ± 0.1	10.5	49.0 *	0.245 *,a
Consumers satisfaction (score 1–5) Mean ± SD	Global	answers (n)	36	32	40	7	−1.0	0.892 [b]
		evaluation	4.5 ± 0.8	4.1 ± 0.8	4.2 ± 0.9	4.4 ± 0.5		
	Soup—global	answers (n)	31	30	39	7	−6.6	0.452 [b]
		evaluation	4.1 ± 0.8	3.9 ± 0.9	3.7 ± 1.2	3.9 ± 1.1		
	Soup—flavor	answers (n)	31	28	37	7	−13.6	0.148 [b]
		evaluation	4.1 ± 0.9	3.8 ± 1.1	3.6 ± 1.3	3.6 ± 1.0		
	Soup—salt	answers (n)	31	28	37	7	−7.5	0.394 [b]
		evaluation	4.3 ± 0.9	3.6 ± 1.2	3.9 ± 1.3	4.0 ± 0.8		
	Main dish—global	answers (n)	31	31	38	7	−9.8	0.271 [b]
		evaluation	4.3 ± 0.9	3.7 ± 1.0	4.0 ± 0.8	3.9 ± 1.1		
	Main dish—flavor	answers (n)	31	29	36	7	−10.4	0.230 [b]
		evaluation	4.3 ± 0.9	3.7 ± 1.1	4.0 ± 0.8	3.9 ± 0.9		
	Main dish—salt	answers (n)	31	29	36	7	−13.0	0.336 [b]
		evaluation	4.5 ± 0.8	3.6 ± 1.1	4.0 ± 1.0	3.9 ± 1.5		

Table 1. *Cont.*

			Baseline Week 1–3	Week 7–8	Week 9–10	Week 11	Δ% Baseline vs. Week 11	*p*-Value
Intervention Canteen								
		Samples (n)	5	3	3	3		
Added Salt Mean ± SD	Soup	g/100 g	0.7 ± 0.2	0.5 ± 0.1	0.5 ± 0.2	0.5 ± 0.1	−34.3	0.131 [a]
		g/portion	2.4 ± 0.7	1.2 ± 0.4	1.3 ± 0.6	1.2 ± 0.3	−48.6	0.053 [a]
	Vegetarian	g/100 g	0.7 ± 0.3	0.6 ± 0.1	0.7 ± 0.2	0.7 ± 0.2	6.1	0.855 [b]
		g/portion	2.8 ± 1.4	2.3 ± 0.4	3.0 ± 1.0	2.9 ± 0.6	1.2	0.906 [b]
	Meat	g/100 g	1.0 ± 0.7	0.7 ± 0.2	0.7 ± 0.2	0.5 ± 0.2	−48.0	0.230 [a]
		g/portion	3.8 ± 2.4	2.8 ± 1.2	2.0 ± 0.5	1.8 ± 0.4	−51.8	0.230 [a]
	Fish	g/100 g	0.8 ± 0.4	0.9 ± 0.5	0.8 ± 0.1	0.5 ± 0.3	−41.1	0.284 [b]
		g/portion	3.4 ± 2.2	3.0 ± 1.6	2.5 ± 0.8	1.3 ± 0.8	−60.9	0.297 [a]
Food waste Mean ± SD	Consumers (n)		36	438	312	123		
	Soup	%	1.4 ± 2.5	3.9 ± 2.2	0.4 ± 0.4	3.9	167.6 *	0.252 *,a
	Main dish	%	3.0 ± 2.1	2.1 ± 0.2	1.8 ± 1.7	3.9	17.5 *	0.699 *,a
	Total	%	2.2 ± 1.8	2.8 ± 0.8	2.7 ± 0.9	3.9	62.4 *	0.699 *,a
Consumers satisfaction (score 1–5) Mean ± SD	Global	answers (n)	28	96	141	46	2.9	0.607 [b]
		evaluation	4.0 ± 0.9	3.7 ± 0.9	3.8 ± 0.9	4.2 ± 1.0		
	Soup—global	answers (n)	28	94	132	44	3.0	0.660 [b]
		evaluation	3.9 ± 1.1	3.2 ± 1.1	3.4 ± 1.1	4.0 ± 1.1		
	Soup—flavor	answers (n)	27	88	123	44	6.8	0.354 [b]
		evaluation	3.7 ± 1.2	3.0 ± 1.0	3.4 ± 1.0	4.0 ± 1.0		
	Soup—salt	answers (n)	27	88	124	44	12.2	0.098 [b]
		evaluation	3.6 ± 1.1	3.0 ± 1.3	3.5 ± 1.1	4.1 ± 1.1		
	Main dish—global	answers (n)	27	95	140	46	−3.3	0.611 [b]
		evaluation	3.8 ± 0.9	3.3 ± 0.9	3.5 ± 1.0	3.7 ± 1.1		
	Main dish—flavor	answers (n)	26	90	136	45	15.7	0.044 [b]
		evaluation	3.4 ± 1.2	3.3 ± 1.0	3.5 ± 1.1	4.0 ± 1.0		
	Main dish—salt	answers (n)	26	90	136	45	7.4	0.299 [b]
		evaluation	3.6 ± 1.1	3.4 ± 1.0	3.6 ± 1.1	3.9 ± 1.0		

[a] *p*-value calculated by Mann–Whitney test between baseline period and intervention week 11 evaluations; [b] *p*-value calculated by *t*-test for independent samples, between baseline period and intervention week 11 evaluations; * Comparisson between the baseline period evaluations ($n = 5$) and week 10 and 11 evaluations ($n = 2$).

The Figure 3 presents the average values of added salt per 100 g in soup and main dishes in both canteens over the course of the study, and the differences between control and intervention canteen in the baseline period and in the last week of intervention. In the baseline period the intervention canteen showed higher average values of added salt per 100 g compared to the control canteen, but only with a significant difference in the soups (0.3 ± 0.1 g/100 g, $p = 0.026$).

The opposite was found in the last week (week 11) of the intervention period. The levels of added salt in the intervention canteen were lower than the control canteen, with the exception of the vegetarian dish where the levels of added salt remained very close in the two canteens, however without significant differences.

It was also observed that the amount of salt added to the dishes, compared to the total salt values obtained in the laboratorial analyses, corresponded to an average of 94% of the salt in the soup as well as in the vegetarian dish, 88% in the fish dish and 84% in the meat dish. The results of the total salt values per dish obtained through the chemical analysis are available in Appendix A.

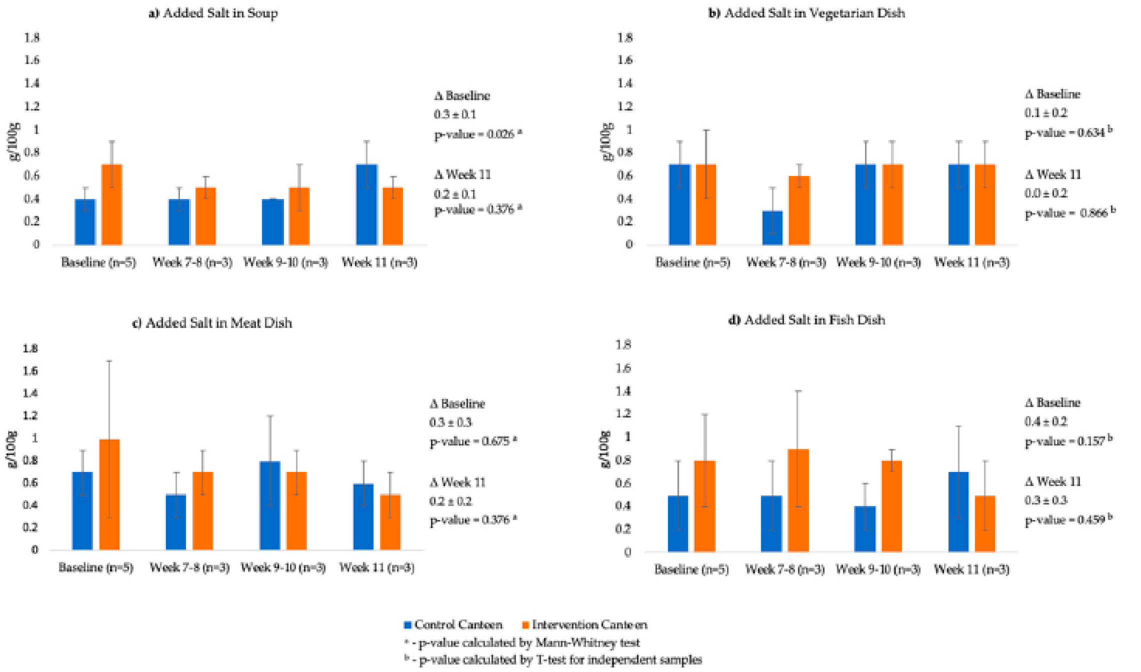

Figure 3. Values of added salt (g/100 g) over the course of the study in the control canteen and intervention canteen. Comparissons between canteens in the baseline period and in week 11. [a]—*p*-value calculated by Mann–Whitney test; [b]—*p*-value calculated by *t*-test for independent samples.

4. Discussion

This pilot study shows that this innovative equipment that dose the amount of salt available to prepare and cook meals in canteens is effective in the reduction of around 30% of added salt. Although no statistically significant differences were obtained, that may be due to the small sample size, and we verified an added salt reduction superior to 30% in the last intervention week for soup, fish and meat dishes. However, the salt levels in the vegetarian dish remained close to the baseline mean. The cooks demonstrated a preference for managing the salt to make greater reductions in fish and meat dishes, keeping the salt levels in the vegetarian dish similar to baseline levels. It could be due to the fact that these dishes are constituted only by vegetable ingredients, which themselves contain lower levels of intrinsic salt, and tend to have the unpleasant natural bitterness that salt could mask and increase saltiness and sweetness flavors [43,44]. This event may also be caused by the cooks' lack of practice and confidence in the preparation of vegetarian meals [45,46], but more studies are needed to explore this assumption regarding the possible difficulty of reducing salt in vegetarian dishes.

Regarding the evaluation of consumer acceptability throughout the intervention, there was no decrease in meal satisfaction. On the contrary, there was a significant increase of 15.7% in satisfaction level regarding the flavor of the main dish. Other studies conducted in Portugal and other countries, with groups of different ages, have reported reductions between 20% to 30% salt content in food without affecting consumer acceptability [36,47,48].

No significant differences were found in the food waste in consumers' plates between baseline and the last two intervention evaluations. A value of 10% has been pointed in the literature as a benchmark for acceptable food waste levels, and the limit of 5% is being considered optimal service performance [49,50]. The control canteen showed mean percentages of total waste throughout the study ranging from 7.5% to 11.9%. Similar food waste percentages were obtained in a study carried out by Aires C. et al. in a Portuguese university canteen [51]. On the other hand, the results of the baseline evaluation in the intervention canteen showed much lower levels of food waste, matching the optimal levels (under 5%) throughout the complete study. Although no significant differences were found on consumers satisfaction and food waste, and the levels observed in the intervention canteen can be considered very satisfactory, soup waste increased on average 167.6% between the mean baseline evaluations and the last two intervention evaluations. Also, a significant negative moderate correlation was observed between the soup salt content and total food waste, suggesting that consumers may prefer soup with higher salt levels. Once again, we observed a possible tendency towards a preference for higher salt levels in dishes made up exclusively of vegetables as soup. A possible strategy to stimulate lower levels of salt in soup and other exclusive vegetable dishes may be the improvement of recipes and food education sessions for food handlers to sensitize and encourage the use of ingredients with a high impact on flavor such as fresh herbs, garlic, onion, and spices to help masking low salt levels, and offering beneficial properties for human health at the same time [44,52].

Another important result was the contribution of this equipment to the standardization of the added salt to meals. Indeed, high standard deviation (SD) values of added salt were observed, especially in the intervention canteen in the five baseline assessments. During the entire intervention period of salt dosage with SC-C, as expected, a smaller SD was observed in the salt added to the dishes (SD off added salt per portion: 0.4 g in soup; 0.7 g in vegetarian; 0.8 g in meat; 1.2 g in fish). Also, between the baseline period and the last intervention week in the control canteen, there was a significant difference, of more than twice, on the average levels of added salt in soup. The values were very heterogeneous, showing no pattern of added salt between different collection days and between canteens. This is probably because the salt added to food may vary according to the cooks' intrapersonal and interpersonal taste and food preparation practices. Similar results of the high variability between meals salt content were observed by Barbosa et al. in a study conducted in seven Portuguese university canteens [53].

A practical standardization strategy of adding salt in food preparation, that respects the daily salt recommendations, is of great importance to stabilize and control the salt content throughout the days and across canteens. A research with Portuguese food handlers showed that many were aware of the maximum salt intake recommendations and the health problems associated with excessive salt consumption. They reported being willing to reduce the salt content of foods produced. However, the greatest difficulty in reducing salt pointed out was the consumers' opinion and the knowledge of food handlers of how to proceed [25]. In this pilot study, particular attention was paid to food handlers, providing them training and initial mentoring in the use of the equipment. Although the cooks' sample was very small, in the satisfaction questionnaire answered, they showed good satisfaction levels with SC-C equipment to carry out the dosage of cooking salt.

Since WHO recommends a maximum daily salt intake of less then 5 g [7], the salt levels provided by canteens can be considered excessive. The average total salt content per complete meal (soup and main dish) of both canteens, prepared without the intervention of the SC-C equipment, was 5.9 ± 1.9 g/portion, which corresponds to 118% of the maximum recommended daily salt intake. Even in the last intervention week, a complete meal offered in the intervention canteen provided, on average, a total salt value of 3.9 ± 1.1 g/portion, which corresponds to 77% of the recommended daily salt intake. In both canteens, the average salt levels in the soup and main dishes obtained in the set of days of the baseline period are similar, or even higher, than others reported in the literature [24,47,53,54]. In the study carried out in Portuguese university canteens, Gonçalves et al. observed that the average salt content of one meal (soup and main dish) reached about 53% of the recommended daily intake [53]. Another two research articles conducted in Portugal obtained range values of added salt per 100 g on soup in nursing homes, kindergartens and elementary schools similar to those we obtained [24,47].

Salt reductions must be performed without negatively impacting consumers' salt and hedonic perceptions because, for individuals who are used to tasting high levels of salt, its sudden decrease may cause food rejection [31,32,44,55]. It is especially relevant for food companies as these types of interventions may impact sales. Thus, small gradual reductions of added salt might be a valuable strategy to reduce salt intake, and this study reinforces 30% as a feasible benchmark for reduction interventions.

The dosage with SC-C equipment is a practical intervention comprising simple training to food handlers that may positively impact patterning and reductions in added salt levels. It can be easily implemented in different settings and similar institutions, and the results of this study may help support the reproduction of this type of intervention. Many workplaces, schools or social institutions provide daily meals and thus have the potential to provide options and induce healthy food consumption for their consumers [56]. Geaney et al. have shown that structured catering initiatives in the public sector can reduce dietary salt intakes [57]. Reynoso et al. performed an intervention study of a 20% added salt gradual reduction on a working food concessionaire in Peru, without affecting consumers' food acceptability, and demonstrated a significant positive impact on reducing customers' blood pressure.

In terms of public health, it would be desirable that consumers exposed to meals outside the home could benefit from meals that provide adequate salt levels and make informed choices. Longer studies are needed to assess the long-term effects and evaluate the implementation of greater added salt reductions.

Due to the pilot experimental design, this study has several limitations that include the possibility of making inaccurate predictions or assumptions on the basis of pilot data, as well as problems related to the small sample and small assessments that could be reflected in uncertainties in the results. In addition, the small number of consumers in canteens occured because many of the classes were taking place online due to the COVID-19 pandemic restrictions. In future larger studies, the number of assessments should be increased consistently throughout the study for all the outcomes.

The consumers were unaware of the salt reduction strategy, so we consider it could not bias results. The innovative proposal, the experimental nature with a control and intervention group selected randomly, and the reference laboratorial methodology used to accurately detect salt levels in foods represent the main strengths of this pilot study.

5. Conclusions

The use of the SC-C equipment to perform the dosage of cooking salt, programmed for a gradual reduction of 30% over the eight weeks of intervention, seems to be effective in reducing the levels of salt in the soup (−34.3% per 100 g), meat dish (−48.0% per 100 g) and fish dish (−41.1% per 100 g). However, in the vegetarian dish there was no decrease in the salt content. There was a significant increase of 17.5% in satisfaction level with the taste of main dish, and no significant impact in terms of food waste on consumers' plates was observed.

This work presents data that show a wide variation in the values of added salt within and between canteens. It has also been found that consumers of university canteens can easily exceed the WHO maximum daily salt intake recommendations.

This equipment is intended to help food handlers to control and approximate the added amount of cooking salt to values that respects the WHO recommendations through a practical procedure. Similar interventions should be replicated in similar and other contexts as they may positively impact the efforts to reach adequate levels of added salt in meals served outside the home and thus promote benefits to individuals' health.

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Data Availability Statement: The authors will make the data available by correspondent request.

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Appendix A

Table A1. Total salt content of the soup and main dishes per canteen over the course of the study (total sodium by chemical analisis).

		Mean ± SD	Baseline Week 1–3 (n = 5)	Week 7–8 (n = 3)	Week 9–10 (n = 3)	Week 11 (n = 3)
Control Canteen	Soup	g/100 g	0.4 ± 0.1	0.4 ± 0.1	0.5 ± 0.0	0.7 ± 0.2
		g/portion	1.1 ± 0.4	1.1 ± 0.3	1.4 ± 0.2	2.4 ± 0.5
	Vegetarian	g/100 g	0.8 ± 0.2	0.4 ± 0.2	0.7 ± 0.2	0.8 ± 0.2
		g/portion	2.5 ± 0.7	1.6 ± 0.9	3.1 ± 0.7	3.6 ± 0.7
	Meat	g/100 g	0.8 ± 0.3	0.6 ± 0.2	0.9 ± 0.4	0.9 ± 0.1
		g/portion	2.7 ± 1.0	2.6 ± 1.2	3.4 ± 1.2	3.5 ± 1.0
	Fish	g/100 g	0.5 ± 0.3	0.6 ± 0.3	0.5 ± 0.2	0.9 ± 0.3
		g/portion	1.5 ± 0.8	2.1 ± 1.2	1.9 ± 0.6	3.4 ± 1.1
Intervention Canteen	Soup	g/100 g	0.8 ± 0.2	0.5 ± 0.1	0.5 ± 0.2	0.5 ± 0.1
		g/portion	2.5 ± 0.7	1.3 ± 0.4	1.4 ± 0.6	1.3 ± 0.3
	Vegetarian	g/100 g	0.7 ± 0.3	0.6 ± 0.1	0.7 ± 0.2	0.8 ± 0.3
		g/portion	2.9 ± 1.4	2.4 ± 0.3	3.1 ± 1.1	3.2 ± 0.8
	Meat	g/100 g	1.1 ± 0.7	0.8 ± 0.3	0.8 ± 0.1	0.7 ± 0.2
		g/portion	4.3 ± 2.4	3.3 ± 1.6	2.3 ± 0.6	2.8 ± 1.1
	Fish	g/100 g	0.9 ± 0.4	1.0 ± 0.6	0.8 ± 0.1	0.6 ± 0.1
		g/portion	3.6 ± 2.1	3.3 ± 1.7	2.7 ± 0.8	1.6 ± 0.5

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Estudo 2

Knowledge, Attitudes, Behaviors and Patterns of Salt Intake in University Students

(Em processo de revisão para publicação)

Knowledge, Attitudes, Behaviors and Patterns of Salt Intake in University Students

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ABSTRACT

Background: Reducing sodium consumption by populations has been recognized as a priority by the World Health Organization and governments worldwide to reduce the prevalence of non-communicable diseases. Previous studies demonstrated that the sodium content of university canteen meals is high and varies greatly, but data about students' patterns of consumption, as well as their knowledge and attitudes is scarce. This study aims to describe the patterns of sodium and potassium consumption and salt literacy among university students who frequently consume university canteen meals.

Methods: A focus group of 20 volunteers, students from a Portuguese public university was recruited. Salt related knowledge, attitudes and behaviors were obtained through the WHO STEPwise questionnaire. Sodium and potassium intakes patterns and food sources were obtained by 24-h food recall and 24 h urinary excretion over one-day evaluation.

Results: The majority of the participants perceive that their salt consumption as the right amount or lower (60%), always add salt while cooking (73.3%) and admit consuming high salt processed foods often (60%). Mean sodium urinary excretion was 2976 ± 973 mg/day. All the participants reported to have consumed fruits and/or vegetables, but only 20% met the recommended daily intake of 400g. A total of 93.3% of participants presented an inadequate daily potassium intake, and a sodium and Na:K ratio intake above the recommendations. Sodium from processed foods was the most important contributor to total intake (52.7%). The processed food groups that most contributed to sodium intake were bread (23.0%, $\bar{x}$ 465 mg of sodium), processed meat and fish (21%, $\bar{x}$ 417 mg of sodium) and cheese (13.9%, $\bar{x}$ 237 mg of sodium).

Conclusions: This study found a high prevalence of excess sodium and insufficient potassium intake among university students, although most of students perceive their intake of salt as the right amount. Processed foods were the greatest contributor for sodium intake in this group. Public health strategies to increase awareness and to control added salt during food processing is crucial.

Key words: salt-literacy, sodium, potassium, 24-h urinary excretion, university students

INTRODUCTION

There is a well-established evidence that high sodium intake negatively affects endothelial and cardiovascular function, being a major risk factor for high blood pressure and cardiovascular diseases (CVD) (1-3), as well as other non-communicable diseases (NCD) (4).

The recent data from modelling estimates by the Global Burden of Disease suggests a worldwide daily average sodium intake in the adult population of 5600 mg (5), nearly three times the maximum limit recommended by the World Health Organization (WHO) of 2000 mg/day (5000 mg/day of salt). Other studies have estimated lower sodium intakes of 4000 mg/d (3, 6), which still substantially exceed WHO recommendations.

In Portugal, the estimated average sodium intake per capita among the adult population is 4300 mg/day, ranking as one of the highest among European countries (7). However, the evidence suggests that it also affects younger groups, as research on children and adolescents shows that sodium consumption far exceeds daily recommendations (8, 9). This is a matter of great concern, given that arterial hypertension has a high prevalence in Portugal, exceeding 40% in the adult population (10), and CVDs are the leading cause of death and disability (11).

WHO recommends a population reduction in salt intake as one of the most feasible, affordable and cost-effective strategies that should be prioritized to tackle the global burden of NCDs (12, 13). In the global action plan for the prevention and control of NCD, WHO member states agreed to work towards a 25% reduction in premature mortality from CVD, a 25% reduction in raised blood pressure and a 30% reduction in average population salt intake as a goal by 2025 relative to 2010 levels (14). It is estimated that meeting the WHO recommendation could prevent approximately 1.65 million deaths from CVDs each year and substantially reduce health care costs for governments and individuals (3).

Consumers' better diet knowledge, attitudes and behaviors are associated with better health status (15). Considering that greater comprehension about salt intake enhances interventions' effect on changing behavior towards healthier choices (16, 17), understanding salt literacy level and perception of their own exposure levels in different population groups may contribute to an accurate strategic development and implementation of salt reduction programs, either at a population level or high-risk group targets.

Dietary sodium consumption patterns are dependent of a populations' cultural context and dietary habits (18, 19). The three primary sources of sodium in diet are common discretionary salt (added to food during cooking or at the table), processed foods (such as cookies and crackers, bread, processed meats, cheese and snack foods), and intrinsic sodium naturally present in a variety of foods (such as meat, milk and shellfish). There are only a few studies that document populations major food sources contributing to sodium intake. Saiuj, B. et al. conducted a recent systematic review of the sodium dietary sources around the world and found that bread, cereal and grain products and meat and dairy products contribute the greatest proportion of total daily sodium intake in most populations, including Portugal. They also found a wide variation in the pattern of discretionary salt consumption across the world, depending on the country's economic development, ranging from 20% to more than 50% (19). Other studies show that in industrialized countries, about 75% of sodium intake comes from sodium added by industry in processed foods, while 10-12% of intake is attributed to naturally occurring sodium in foods and the remaining 13-15% from added cooking salt. In particular, the proportion of dietary sodium consumed from discretionary cooking salt (from foods made at home or outside the home) versus sodium consumed from processed foods is an important consideration, as the effectiveness of interventions developed for the more common consumption pattern is often higher (19).

In addition, potassium is an essential nutrient inversely associated with blood pressure (20, 21). It is important to consider the relation between potassium and sodium when assessing the adequacy of sodium intake since both are key nutrients needed for maintaining total body fluid volume, acid and electrolyte balance and normal cell function. Thereby, potassium increases urinary sodium excretion attenuating excess sodium's adverse effects (22, 23).

Evidence shows that the sodium to potassium (Na:K) molar ratio is a more important risk factor in CVDs and mortality than isolated dietary sodium or potassium daily intake (24, 25). WHO recommends a minimum daily intake of 3510 g/day of potassium in adults (26). If the consumption of both nutrients attains the WHO guideline levels, the ratio of Na:K should be one to one, which is associated with health benefits (27). However, most populations worldwide consume a ratio of Na:K of two or more (18). Thus, in addition to reduce sodium consumption, the potassium intake level must be increased to maintain the ratio at one (26). Potassium is commonly found in various unrefined foods, especially fresh fruits, vegetables and legumes (26). Therefore, a diet low in fresh fruits, legumes and vegetables and high in processed foods is commonly energy dense, low in potassium and high in sodium (28).

Besides estimating the daily nutritional sodium and potassium intake, studying the pattern of intake distribution throughout the day may also be of great interest. Meal and snacking patterns can affect the development of several chronic diseases (29, 30). Evidence suggests that consuming a single meal high in sodium and low in potassium may negatively affect vascular function (31-34). In a study from Dickinson et al., using data from the Australian Health Survey, showed that the levels of sodium, potassium and the ratio NA:K differ widely according to eating occasion (35). However, few studies still reported the food sources and sodium and potassium consumption distribution throughout main meals (breakfast, lunch and dinner) and snacks between meals.

Entry to university often represents a crucial transient period for students. Since many have move away from home for the first time, they have to deal with increased responsibilities concerning housing, financial management and food choices (36, 37). The lack of time, desire and food knowledge, a stressful lifestyle, the peer socialization, and the easy access to ready meals and fast food constitute important aspects that influence the eating behaviors of these young adults (38, 39). In a review study by Bernardo et al. (40), it was observed that the food consumption of university students worldwide was characterized as unhealthy, regardless of undergraduate course and gender, particularly those who had moved away from the family home and became responsible for their own food. Evidence exists that university students have a dietary pattern high in fat, salt and sugar and a low consumption of fruit and vegetables, with higher consumption of ready meals and takeaway meals and fewer home-cooked meals, when first enrolling at university (38, 40, 41). Specific information about sodium consumption patterns among Portuguese university students is scarce. A study by

Polónia et al. (42), who analysed sodium intake in a sample of Portuguese university students, found an average 4.52 g/day of sodium intake. A similar sodium intake was also observed among individuals who predominantly ate at home or in canteens/restaurants.

University canteens are a potential place where university students choose to eat most meals outside the home, and are also a privileged place to promote healthy eating habits, as they are included in an educational environment and determine the types of food and beverages served. However, it seems that there is no pattern of added salt and sodium content in canteen meals. A previous study within iMC Salt Project conducted in two Portuguese university canteens showed that the average total sodium content of a single complete meal (composed by soup and main dish) was 2400 ± 800 mg/serving, which corresponds to 118% of the maximum daily recommended sodium intake, and around 84-94 % of the sodium was provided by added salt during cooking (43). In another study carried out in Portuguese university canteens, Barbosa et al. observed that the average salt content of a complete meal reached about 53% of the recommended daily intake (44).

In addition to developing effective intervention strategies to reduce and control the adding salt in canteen meals, having a broader understanding of university student's dietary patterns of sodium and potassium consumption, as well as their salt-related literacy, can be of great interest in order to develop effective intervention strategies regarding excessive salt consumption risk in this population group.

The aims of this study were (1) to evaluate self-reported knowledge, attitudes and behaviors related to salt, (2) to examine the sodium, potassium and ratio

Na:K intake, by daily consumption and according to different meal times, and (3) to identify the contribution of major food sources of sodium consumption from a sample of university students who are frequent consumers of university canteens.

METHODS

This study is included in iMC SALT project, launched in 2019, which aims to study the effectiveness of two innovative equipments, SALT CONTROL H (45) (trial registration number NCT03974477; INPI, No. 20191000033265) and SALT CONTROL-C (provisional patent INPI, No. 20211000015906) to monitor and control salt usage when cooking at home or at canteens, respectively. Detailed description of the methods of the iMC SALT study has been published previously (16, 43, 46).

Study Design and Participants

This study was conducted in march 2021. A focus group of students from a Portuguese public university were recruited as volunteers through a direct invitation held in the canteens during mealtimes. The only inclusion criterion was having at least 5 weekly canteen meals (lunch or dinner). University canteens are open 7 days a week and serve lunch and dinner. The initial sample included 20 participants, but 5 participants were excluded due to invalid urine collection (final sample n = 15; female 26.7%; mean age 23 years).

<u>Sociodemographic, blood pressure and anthropometric variables</u>

Sociodemographic characteristics were assessed through a questionnaire based on the WHO STEPS sociodemographic questionnaire by a face-to-face interview (32). It included sex (female, male), age (years), marital status (single, married, marital union, divorced, widower), education (no schooling; primary education – 4, 6 or 9 years; secondary education – 12 years; technical post-secondary education (not higher education); higher education (bachelor's, master's or doctoral), smoking habits (smoker, non-smoker) and alcohol consumption (number of drinks consumed in the previous week).

Blood pressure and heart rate were measured through a portable sphygmomanometer (Edan M3A, Edan Instruments, Shenzhen, China), with the participants seated and after 5 minutes of rest. The measurements were taken on both arms to determine possible arm-related measurement differences. A new measurement was taken on the arm with the highest value, and the average value was calculated. If the blood pressure difference between the two assessments in the same arm was greater than 10 mmHg, a third assessment was performed, and the mean was calculated from the last two assessment values.

Regarding anthropometric variables, height (SECA 213 portable stadiometer, Hamburg, Germany) and waist circumference (SECA 201 ergonomic circumference measuring tape) were measured according to international standard procedures [43]. The weight, body mass index (BMI), and percentage of body fat (%) was assessed using Tanita MC 180 MA body composition analyzer (Tanita, Illinois, USA), and all measurements were performed with participants wearing light clothing and no shoes.

<u>Salt-Related Knowledge, Attitudes and Behavior</u>

Participants knowledge, attitudes and behavior related to salt were assessed through a questionnaire based on WHO STEPwise approach to surveillance of chronic disease risk factors (47). The questionnaire consisted of 16 questions. Three questions assessed the behavior related to added salt through a 5-point likert scale ("always", "often", "sometimes", "rarely", "never"): add salt during meal preparation, discretionary use of table salt, and consumption of processed foods with high salt content.

Four questions evaluated the knowledge and attitudes, including knowledge of the relationship between salt and health problems ("yes", "no"), perception of own salt consumption ("far too much", "too much", "just the right amount", "too little", "far too little"), importance of reducing salt intake ("very important", "somewhat important", "not at all important"), and the agreement about the promotion of a controlled salt diet to respect the global recommendations ("yes", "no").

Seven questions evaluated the behaviors to control salt intake with binary responses ("yes", "no"): avoid the consumption of processed foods, observe salt labels on food, buy low-salt alternatives, eat meals without adding salt at the table, cook meals without adding salt, use herbs and spices other than salt when cooking, and avoid eating out. The last two questions assessed if the participant ever had an education session on a lower salt diet, and if they ever shared the knowledge with others about a lower-salt diet ("yes", "no").

24-h Urinary Sodium and Potassium Excretion

One 24-h urinary sodium and potassium excretion was used as a proxy of salt and potassium intake, respectively. The urine collection was performed at any day of the week (except on Friday and Saturday due to laboratory availability). A coded sterilized container was supplied and participants were carefully instructed through oral and written guidelines (provided on a leaflet), to collect their urine over a 24-h period before the appointment. They also received instructions to maintain their usual dietary and physical activity patterns. On the day of urine collection, the first morning urine was discarded and afterwards all the urine was collected during the entire day and night, including the first urine when getting up on the following morning. Urine samples were analyzed for volume, sodium and potassium (by indirect potentiometry), and creatinine (by photometry). The validity of the 24-h urine collection was evaluated through the relationship between urinary creatinine (mg/day) and body weight (kg) (creatinine coefficient = creatinine (mg/day)/weight (kg)) (48). Coefficients between 10.8 to 25.2 in women and 14.4 to 33.6 in men were considered sufficient to ensure that the samples corresponded to a 24-h period as recommended. This led to the exclusion of the samples from five participants, and a total of 15 were considered for data analysis.

The conversion of the units in which sodium and potassium were expressed from mmol to mg was performed by multiplying sodium and potassium by their atomic weight, 23 and 39 respectively (mmol = mg/atomic weight). The Na:K molar ratio was obtained by dividing sodium (mmol) by potassium (mmol).

24-h Dietary Recall

Dietary intake referring to the day of urine collection was assessed using a 24-hour dietary recall questionnaire administrated by trained interviewers using a photographic book and household measures to quantify portion sizes (49). Data was collected regarding the amount of different foods consumed, identifying those consumed on university canteens, home and outside home. The conversion of food intake into energy and nutrients was performed using an adapted Portuguese version of the nutritional analysis software Food Processor Plus (ESHA Research, Inc., Salem, OR, USA), and discretionary salt added to food was not quantified.

Prevalence of inadequate sodium, potassium and ratio Na:K intake

The prevalence of inadequate intakes of potassium and sodium among the sample of university students were estimated comparing the values from 24h-urinary excretion with WHO recommendations for daily minimum potassium intake (3510 mg/day), for maximum sodium intake (2000 mg/day), and for adequate Na:K ratio (1:1).

Sodium and Potassium ingestion by eating occasions

Eating occasions were classified as breakfast, lunch and dinner, and other snacks eaten in-between-meal time (morning, evening and night snacks), as reported by participants. It was evaluated the contribution of sodium and potassium per eating occasion, according to the ingestion reported in the 24-h dietary recalls in relation to the total intakes estimated by 24-h urinary excretion. In order to standardize the sodium and potassium intakes for analysis, sodium and potassium densities were also calculated (mg/kcal).

Contribution of sodium intake by dietary sources

Naturally occurring sodium and sodium added to foods during processing (non-discretionary sodium) were estimated from the 24-h dietary recall data, and the sodium added during culinary preparations (from discretionary salt) was estimated by the difference between 24-h urinary sodium excretion values and non-discretionary sodium intakes.

To analyze the contribution of the different types of processed foods to sodium consumption, in relation to the sodium assessed by the 24-h urine excretion, processed food and beverage items consumed were distributed into 17 groups, adapted from the WHO Sodium Benchmarks food group categories (50), from where it was excluded the foods and food groups characterized as unprocessed or minimally processed according to the NOVA classification (51, 52): (1) Chocolate and sugar confectionary, energy bars, sweet toppings and desserts; (2) Cakes, sweet biscuits and pastries; (3) Savoury snacks; (4) Beverages; (5) Edible ices; (6) Breakfast cereals; (7) Yogurt, sour milk, cream, other similar foods; (8) Cheese; (9) Ready-made and convenience foods and composite dishes; (10) Butter and other fats and oils; (11) Bread, and bread products; (12) Fresh or dried pasta, noodles; (13) Processed meat/fish; (14) Processed fruit, vegetables and legumes; (15) Plant-based food/meat analogues; (16) Sauces, dips and dressings; (17) Culinary ingredients (sugar and sweeteners, vinegars, other complements).

Data Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Version 27). Comparisons of the sodium and potassium excretion between consumers who did not consume any meals in the canteens and who consumed at least one meal in the canteens were performed using the independent t-test and One Way ANOVA test, as appropriate. The Mann-Whitney U test and Kruskal-Wallis test were performed to compare the sodium and potassium excretion among participants who ate 1, 2 or no meals in the canteen. A significance level of $p < 0.05$ was considered statistically significant.

Descriptive statistics are presented as percentage, mean ± SD, median (P50%) and percentiles (P25% and P75%), and minimum and maximum values.

Ethics Committee

The study was approved by the Ethics Committee of the Faculty of Nutrition and Food Sciences of the University of Porto.

RESULTS

The mean age of participants (n=15) was 24.9 years, and most participants were male (73.3%). All the participants were single. The majority had higher education (86.7%) and were nonsmokers (73.3%). Alcoholic drinks' mean consumption during the previous week was 3.2 drinks/week. Participants' average BMI was 24.3 kg/m^2, waist circumference was 83.3 cm, and body fat was 20%. Regarding arterial parameters, the mean systolic and diastolic blood pressure were 121.1 mmHg and 71.8 mmHg, respectively, and the heart frequency rate was 71.4 bpm (Table 1).

Table 1. Sociodemographic, lifestyle, blood pressure and anthropometric characteristics of a sample of university students (n=15)

Participants Characteristics	**(%)**					
Women	26.7					
Education						
Higher education	86.7					
Secondary education (12 years)	13.3					
Marital Status - single	100					
Smoking habits - smoker	26.7					
	Mean ± SD	**P25**	**P50**	**P75**	**Minimum**	**Maximum**
Age (years)	24.9 ± 6.4	22.0	23.0	25.0	18.0	44.0
Blood pressure						
SBP (mmHg)	121.1 ± 15.6	107.2	125.0	132.2	96.0	151.0
DBP (mmHg)	71.8 ± 3.9	69.5	71.5	74.0	64.0	78.0
Heart rate (bpm)	71.4 ± 8.9	65.0	70.0	75.8	59.0	89.0
Body mass index (kg/m^2)	24.3 ± 3.4	21.9	24.0	26.3	19.0	32.7
Body Fat (%)	20 ± 7.5	11.8	20.1	25.4	10.2	34.4
Waist circumference (cm)	83.3 ± 8.3	76.0	81.5	85.0	72.0	103.0
Alcohol intake (drinks/week)	3.2 ± 4.8	0.0	1.0	4.0	0.0	16.0

The Table 2 shows the knowledge, attitudes and behavior about dietary salt of the university students participating in this study. Only one participant ever had an education session on a lower salt diet. All the participants agreed that too much salt could cause health problems and responded positively about the importance of promoting a controlled salt diet to respect the recommendations. More than half (60%) of the participants perceive their salt consumption as the right amount or lower, and 26.6% do not know or consider it unimportant to low their dietary salt. All the participants refer that they rarely add or do not add salt at the table, but 73.3% add salt while cooking, and 60% admit consuming high salt processed foods often. In order to reduce salt intake, only 20% search for low-salt food alternatives to buy, and 33.3% avoid eating out, cook their meals without adding salt and use spices to replace salt flavour.

On the evaluation day, 73.3% of the participants consumed at least one meal at the university canteens (26.7% did not consume any meal at the canteen, 26.7%

ate only one meal at canteen, and 46.7% consumed both lunch and dinner at the canteen). There were found no statistically significant differences between sodium and potassium intake in participants who consumed 2, 1 or none of the main meals in the canteens.

Table 2. Knowledge, Attitudes and Behaviors towards dietary salt in a sample of university students (n=15)

	n	%
Behavior related to added salt		
Add salt while cooking (often or always)	11	73.3%
Add salt to prepared food, or while eating (rarely or never)	15	100.0%
Consume processed foods high in salt (often or always)	9	60.0%
Knowledge and attitudes		
Perceived salt consumption (very low, low, or the right amount)	9	60.0%
Importance of lowering salt in the diet (Not at all important, or don't know)	4	26.6%
Agreed that too much salt could cause health problems (yes) (%)	15	100.0%
Agreed that controlled salt diet should be promoted to respect the recommendations (yes) (%)	15	100.0%
Behaviors to reduce salt		
Avoid consuming processed foods (yes) (%)	3	20.0%
Look at the salt labels on food (yes) (%)	5	33.0%
Eat meals without adding salt at the table (yes) (%)	15	100.0%
Buy low-salt alternatives (yes) (%)	3	20.0%
Cook meals without adding salt (yes) (%)	5	33.3%
Use spices other than salt when cooking (yes) (%)	5	33.3%
Avoid eating out (yes) (%)	5	33.3%
Ever had an education session on a lower salt diet (yes)	1	6.7%
Ever shared the knowledge with others about a lower-salt diet	2	13.3%

The Table 3 presents the descriptive data assessed through 24-h dietary recall and 24-h urinary excretion regarding nutritional intake (energy, sodium, potassium, Na:K ratio and discretionary added salt), as well as the inadequate sodium, potassium and Na:K ratio intake. Mean sodium intake estimated from diet recall and urinary excretion was 1992 ± 867 mg/day, and 2976 ± 973 mg/day, respectively.

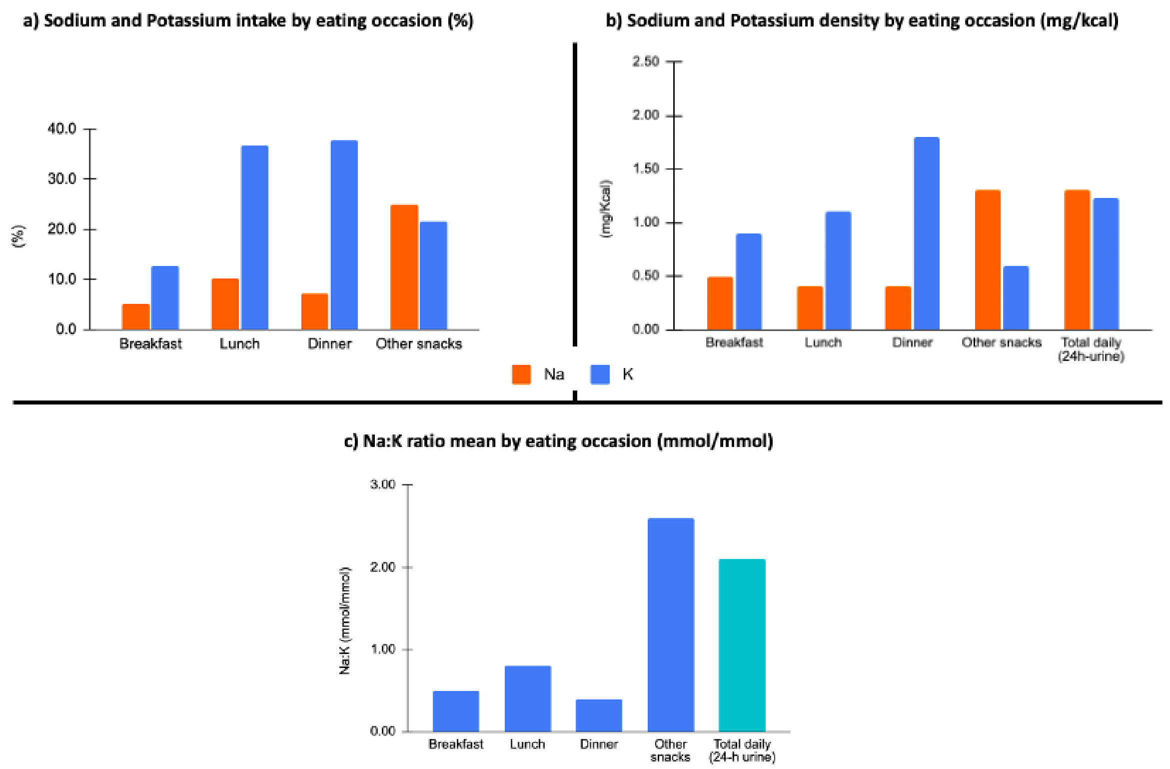
All the participants consumed fruits and/or vegetables, but only 20% met the recommended daily intake of at least 400 g (53, 54).

Table 3. Characterization of dietary intake through 24-h dietary recall and 24-h urine sodium and potassium excretion, in a sample of university students (n=15)

Outcomes	Mean ± SD	P25	P50	P75	Min	Max
Dietary intake - 24h dietary recall						
Weight consumption (g/day)	2762 ± 731	2256	2653	3089	1557	4370
Energy consumption (kcal/day)	2144 ± 554	1711	2144	2600	1235	3035
Fruits and vegetables (g/day)	330 ± 170	237	294	388	93	743
Non-discretionary sodium (mg/day)	1992 ± 867	1520	1803	2264	511	4265
Non-discretionary sodium (mg/1000kcal)	928 ± 323	730	887	1101	378	1685
Potassium (mg/day)	2679 ± 1149	1837	2493	3277	1235	5248
Potassium (mg/1000kcal)	1277 ± 502	966	1309	1453	585	2589
Urinary excretion - 24h urine collection						
Sodium (mg/day)	2976 ± 973	2346	2990	3300	1886	5267
Sodium (mg/1000kcal)	1434 ± 438	1146	1298	1750	798	2212
Potassium (mg/day)	2464 ± 695	1950	2262	3120	1482	3744
Potassium (mg/1000kcal)	1185 ± 300	1102	1233	1314	672	1831
Na:K ratio (mmol:mmol)	2.1 ± 0.6	1.7	2.1	2.5	1.0	3.1
Naturally occurring sodium (mg/day)	411 ± 204	303	331	593	104	741
Sodium from processed foods (mg/day)	1580 ± 929	1123	1286	1929	206	3956
Sodium from added salt (mg/day)	968 ± 628.	558	742	1258	289	2449
Compliance with recommendations (n) %						
Urinary Na (< 2000 mg)	(1) 6.7 %					
Urinary K (> 3510 mg)	(1) 6.7 %					
Urinary Na:K ratio (≤ 1:1)	(1) 6.7 %					

The average sodium intake from added salt, calculated from the difference between the values of urine excretion and diet recall, was 968 ± 628 mg/day (2420 ± 1570 mg/day of discretionary salt), which represents a 32.2 ± 17.2 % contribution to total sodium intake. Besides, potassium intake estimated using diet recall data was 2679 ± 1149 mg/day, and through urinary excretion data was 2465 ± 438 mg/day. The analysis also showed a mean Na:K ratio of 1.4 ± 0.7 from diet recall and 2.1 ± 0.6 from urinary excretion data.

Based on the 24-h urinary excretion analysis, 93.3% of participants presented a daily potassium intake below the recommendation, and the same prevalence of participants presented sodium daily intakes and Na:K ratios above recommendations.



Na - Sodium; K - Potassium. a) values are based in the 24-h dietary recall data, do not contemplate discretionary salt added to foods; b) and c) values by eating occasion (breakfast, lunch, dinner and snacks) are based in 24-h dietary recall data (do not contemplate discretionary salt added to foods), and total daily levels are based in 24-h urinary excretion data.

Figure 1. Median intakes by eating occasion of sodium and potassium (contribution (%) and densities (mg/kcal)), and Na:K ratio in a sample of university students (n=15)

The median Na:K ratio, and sodium and potassium intake contribution (%) and densities (mg/kcal) according to meal occasions are shown in figure 1. Snacks between main meals were the eating occasions that contributed the greatest amount of sodium intake (24.9%), sodium density ($\bar{x}$ 1.3 mg/kcal), and the highest Na:K ratio of ($\bar{x}$ 2.6). Dinner had the greatest intake contribution of potassium (37.7%), and potassium density ($\bar{x}$ 1.8 mg/kcal). Detailed results of sodium, potassium and Na:K ratio consumption by eating occasion are presented in Appendix A.

Sodium from processed foods was the most important contributor to total sodium intake (52.7%), followed by sodium from discretionary added salt

(32.3%), and naturally occurring sodium present in unprocessed foods contributed for 15% of the overall intake (figure 2, a).

The top 3 food groups that most contributed to sodium intake from processed foods were bread and bread products (23.0%, $\bar{x}$ 465 mg/sodium), processed meat and fish (21%, $\bar{x}$ 417 mg/sodium) and cheese (13.9%, $\bar{x}$ 237 mg/sodium) (Figure 2, b). Detailed results from sodium intake from processed foods according to eating occasions are presented in Appendix B (figure B1).

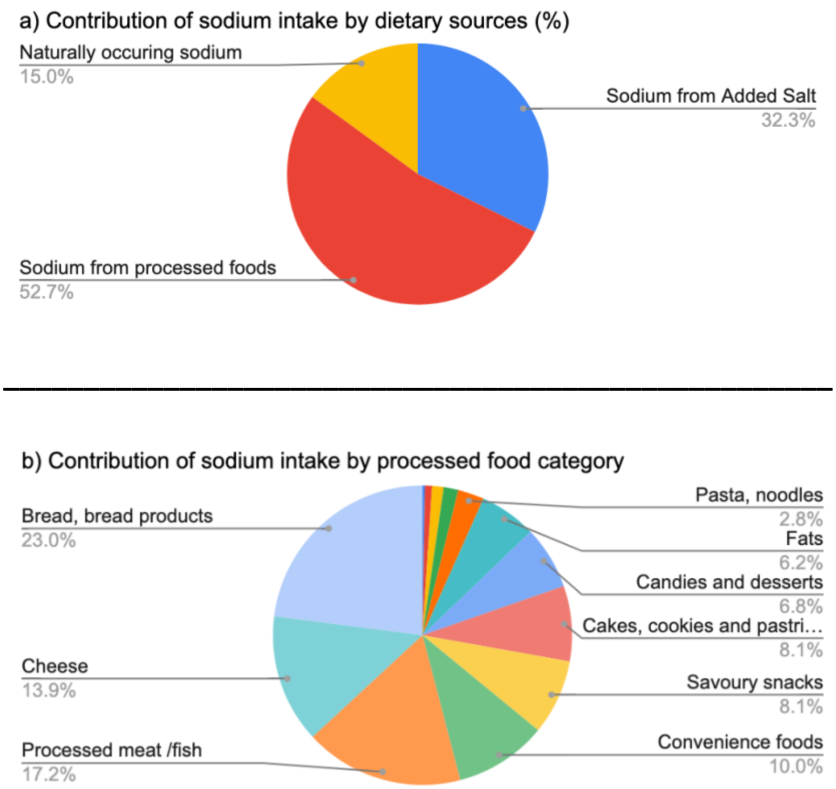


Figure 2. Contribution of sodium intake by dietary sources and by processed food group category (%) in a sample of university students (n=15)

DISCUSSION

To the best of our knowledge, this is the first study with Portuguese university students that assesses sodium and potassium intakes using 24-h urinary excretion and describes the intake patterns, knowledge, attitudes and behaviors towards salt.

This study showed that most participants reported adding salt during cooking often or always. More than half of the participants perceived their salt intake as "just the right amount" or even lower, and more than one quarter did not consider it important to lower their dietary salt. However, we observed a prevalence of excess sodium intake higher than 90%. These findings are consistent with previous studies among university students, where more than half reported consuming just the right amount of salt (55-57). However, the same studies estimated that more than two-thirds of the participants exceeded the WHO recommendations (55-57). These data suggest that perceived intake does not necessarily reflect actual intake.

It may be a concern that most students in this study rarely or never check the salt content on food labels. Marakis et al. (57) found the same behaviour pattern in university students from different countries. They observed low importance given by most participants to check the salt content on food labels and a lack of knowledge that processed foods are the most important dietary sources of salt. Besides, they observed the frequent perception that salt recommendations are confusing and/or contradictory.

We observed a mean of 2972 mg of sodium excretion per day, which is 48.6% higher than the recommendations. This value is lower than the average estimated by Polónia et al. of 4100 mg of sodium intake per capita in the Portuguese population (7). This reason may be related to the participants' high education level and also the level of knowledge about the importance of a low salt diet, since all the participants were aware about the relation between excess salt intake and health problems and agreed that a controlled salt diet should be promoted to respect the recommendations. Though we found a high prevalence of excess salt intake, a lower proportion of the participants believed that their intake was high. As a result, only 33.3% took actions to lower their intake as avoiding consuming processed foods, looking at food salt labels, buying low-salt alternatives, cooking meals without adding salt and using spices other than salt, and avoiding eating out.

Added salt during cooking contributed to approximately one third of total sodium intake, slightly higher than that mentioned in previous studies in Portugal that showed a discretionary salt contribution between 21% and 29.2% to total intake (7) (16, 58). The leading main source of sodium intake in this sample of university students was sodium from processed foods, accounting for more than half of the total sodium intake. Almost two thirds of participants admitted to consume processed foods "often" or "always", and only 20% stated to avoid consuming processed foods to control/reduce salt consumption. Studies conducted in European and North American countries show that sodium intake is dominated by sodium added by industry in processed/ultra-processed foods (28). These data reinforce the need to regulate the amount of sodium in processed foods and the importance of working together with the food industry to gradually reduce the sodium added during industrial processing (50).

Regarding the intake of processed foods, the food group that contributed to the greatest proportion of sodium intake was the group of bread and bread products, and 86.7% of the participants ate bread on the evaluation day. This is consistent with other reports that described that bread contributes substantially to sodium intake in developed countries (16, 19, 28, 35, 59). The amount of salt in bread, used as a reference for the nutritional composition in this study, was the maximum amount legislated since 2009 in Portugal (Decreto de lei n.º 75/2009, August 2009) (60) of 1.4g of salt per 100g of bread. Despite the legislation, it seems that bread continues to play a prominent role as a contributor to daily sodium intake. Processed meat/fish and cheese food groups were also great contributors to the total sodium intake. This data reinforces the need to keep the efforts at the political and economic level, to establish legislative measures, as the introduction of tax measures for high sodium products, and the stimulation of voluntary sodium reduction by industry and restaurants.

The other major finding is that, besides sodium from discretionary salt usually added in cooked meals at lunch and dinner, snack meals contributed to a considerably high proportion of sodium to the total daily intake, as well as sodium density and Na:K ratio. This is consistent with previous studies in which younger students are reported to consume more sodium from snack foods compared with meals (61, 62). Also, in snack meals, the main processed food group contributors to sodium intake were bread, processed meat/fish and cheese. The results regarding the contribution of processed foods to sodium intake may indicate that students consume the typical sandwiches with cheese and ham (or similar charcuterie products) as a frequent habit in their diets, perhaps due to its practicality and low cost. Data from the National Health and Nutrition Examination Survey showed that the adults who reported eating a sandwich on the survey day had significantly higher sodium intake than those who did not eat a sandwich (58). Dietary and meal pattern research can be helpful to understand better how foods are consumed in real life to assist populations in achieving dietary targets (35). Therefore, more studies are needed to investigate and understand university students' dietary habits and sodium intake patterns.

In addition to high sodium intake, a low potassium intake was also observed. The levels of urinary potassium excretion were well below the lower limit recommended by the WHO, and only one person had an adequate intake. Our results are also lower than the average potassium intake in Portugal, estimated by the National Food, Nutrition and Physical Activity Survey (2015–2016) (58), of 3055 mg per day. This reflects the low consumption of dietary sources of potassium such as fruit, vegetables and pulses. Only 13.3% of the sample consumed more than 400 g/day of fruits and vegetables, and only one third consumed pulses in the evaluation day.

Urinary Na:K ratio represents a more robust marker of sodium and blood pressure relation and a better predictor of hypertension and blood pressure outcomes than the isolated urinary excretion of both nutrients. Consumption of sodium and potassium at 1.0 ratio is considered beneficial for health (24, 25). The mean consumption of Na:K ratio was 2.1 (± 0.6), double of the WHO recommendations [53]. This finding can indicate that university students may be at higher risk of developing hypertension and CVDs.

There were no statistically significant differences in sodium intake between participants who consumed the meals in the canteens or out of the canteens. However, it is worth noting that the average daily sodium intake in participants who consumed at least 1 main meal in the canteen was 2806 mg/day, while in participants who did not consume any meals in the canteens was 3444.2 mg/day, that is, 18.5% higher intake. Regarding the participants who consumed both

meals in the canteens (mean 2871.7 mg/day of sodium intake), consumption was approximately 16.6% lower compared to participants who
did not consume any meal in the canteens. On the other hand, the average sodium intake from discretionary salt in participants who consumed at least 1 meal in the canteen was 989.5 mg/day, while those who did not consume any meal in the canteens had a slightly lower average intake of 908.0 mg/day which represents a lower 8.2% of added salt intake. Also, it was observed that participants who consumed both meals in the canteens had a 21.6% greater intake of discretionary salt than those who did not consume any meal in the canteen. These data suggest that university students may consume a higher amount of total sodium when they do not consume meals in the canteens, which may be due to greater consumption of processed and convenience foods. However, when they consume meals in the canteens, despite consuming less processed foods at these meals, they may be exposed to a higher contribution of the discretionary salt added to the cooking process. Despite the small sample of participants in this study, these data align with other studies that demonstrated an excessive amount of sodium served in canteen meals, the vast majority provided by added salt. For this reason, university canteen consumers may be exposed to high sodium content caused by excessive addition of cooking salt (43, 44).

It is challenging for individuals to be aware of and control salt intake from added salt, especially for those who consume meals outside the home, such as in canteens, besides the high dietary sodium intake from processed foods. Foods that contributed most to sodium intake may not be recognisable to the consumer as high-sodium foods, such as bread, cheese, processed meat/fish, cakes, biscuits and pastries. Moreover, these foods do not typically offer low-salt or reduced-salt alternatives.

Only one participant ever had an educational session on a low salt diet, and the majority reported not implementing attitudes to control or low dietary salt. The "National Program for the Promotion of Healthy Eating" in Portugal (11), aligned with internationally recommended interventions (63), strongly advocates for the implementation of strategies to reduce dietary sodium intake in educational environments, such as schools and universities. It defends providing information on healthy eating and strengthening consumer protections, namely by reducing the sodium content of canteen meals. For this reason, it is important to invest in educational strategies, such as teaching and encouraging individuals to read labels to identify lower-sodium products and substitute cooking salt with spices and herbs, as well as inform for increased consumption of potassium-rich foods. Besides, developing tools to help control added salt levels in food preparation, both at home and at food concessionaires, is of great importance (43, 45, 46).

This study has its strengths and limitations that need to be acknowledged. The 24-h urine collection can be considered the major strength of our study, which is considered the gold standard method to assess sodium and Na:K ratio intake, since approximately 90–95% of ingested sodium is excreted in the urine (22). Besides, rigorous validation through urinary creatinine excretion minimizes bias due to under or over-collection. However, more than one evaluation day should ideally have been obtained from each participant in order to decrease daily variability. Therefore, the misclassification of sodium and potassium excretion levels in a one-day-only collection can reflect a higher random error. Also, the dietary intake data described are based on one 24-h recall, which may not necessarily represent the participants' usual dietary intake or eating pattern, and may result in dietary misreporting. However, the short recall period (previous 24-h), and the use of memory aids (photographic food book with portion sizes) may have contributed to minimizing it. Also, interviewers were trained to assist the participants and instructed not to be judgmental to minimize the dietary intake social desirability bias.

Other limitations of the present study must be noted. It was based on a non-representative sample of university students, which limits the extrapolation of the obtained data to this groups' overall population. And it is also important to emphasize that the data collection was carried out during the COVID-19 pandemic, consequently students eating patterns may not have accurately reflected common eating habits due to confinements.

Despite the limitations, this study sheds light on salt-related knowledge, attitudes and behaviors, and sodium and potassium dietary intake patterns in university students. It can contribute to informing the food industry, dietitians/nutritionists and consumers about the importance of improving food choices between meals to reduce sodium and increase potassium intake. However, estimates in representative samples of the general university student population are needed to confirm these findings and prioritize interventions.

CONCLUSIONS

We found a high prevalence of excess sodium intake and inadequate potassium intake. The ratio of the two nutrients is twice the WHO recommendations for health benefits, which may indicate a risk for university students developing hypertension and CVDs.

Although all the participants were conscient of the relation between excess salt intake and related health problems, as well as the importance of promoting a controlled salt diet to respect the recommendations, it was found that many participants were unaware of their high salt intake.

Besides the high intake of discretionary salt that represented nearly one third of total sodium intake, it was found that sodium from processed foods was the greater contributor to daily sodium, and the main processed food sources were bread, cheese and processed meat/fish. Another important finding was the high consumption of sodium intake in snacks between meal times, where the same food groups were the main sodium contributors.

The university represents an excellent opportunity for nutritional education and our findings suggest the need to intensify the debate on this topic in the school context. Also, the university needs to provide a supportive food environment that promotes low-sodium and high-potassium food options, such as fruit, vegetables and pulses.

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APPENDIX A

Table A1. Characterization of sodium, potassium (mg and mg/kcal) and Na:K ratio (mmol/mmol) intake by eating occasion, in a sample of university students (n=15)

Median [P25; P75]	Breakfast	Lunch	Dinner	Other snacks
Nutritional Intake				
Energy (kcal)	2601 [71; 417]	680 [458; 960]	558 [511; 680]	506 [257; 591]
Non-discretionary sodium (mg)	105 [9; 357]	327.8 [214; 700]	206.7 [159 647]	798 [326; 1116]
Non discretionary sodium (mg/kcal)	0.5 [0.1; 1.0]	0.4 [0.3; 0.9]	0.4 [0.3; 1.0]	1.3 [0.7; 2.2]
Potassium (mg)	285 [82; 511]	841.6 [622.8; 1372.1]	1026.5 [607; 1187]	473 [195; 647]
Potassium density (mg/kcal)	0.9 [0.4; 1.6]	1.1 [1.0; 1.8]	1.8 [1.0; 2.2]	0.6 [0.5; 1.2]
Total daily contribution				
Non-discretionary sodium (%)	5.1 [0.5; 11.9]	10.2 [7.2; 25.1]	7.1 [4.7; 24.3]	24.9 [10.2; 47.2]
Potassium (%)	12.6 [3.6; 17.1]	36.7 [26.3; 56.1]	37.7 [22.2; 55.9]	21.5 [7.9; 24.6]

APPENDIX B

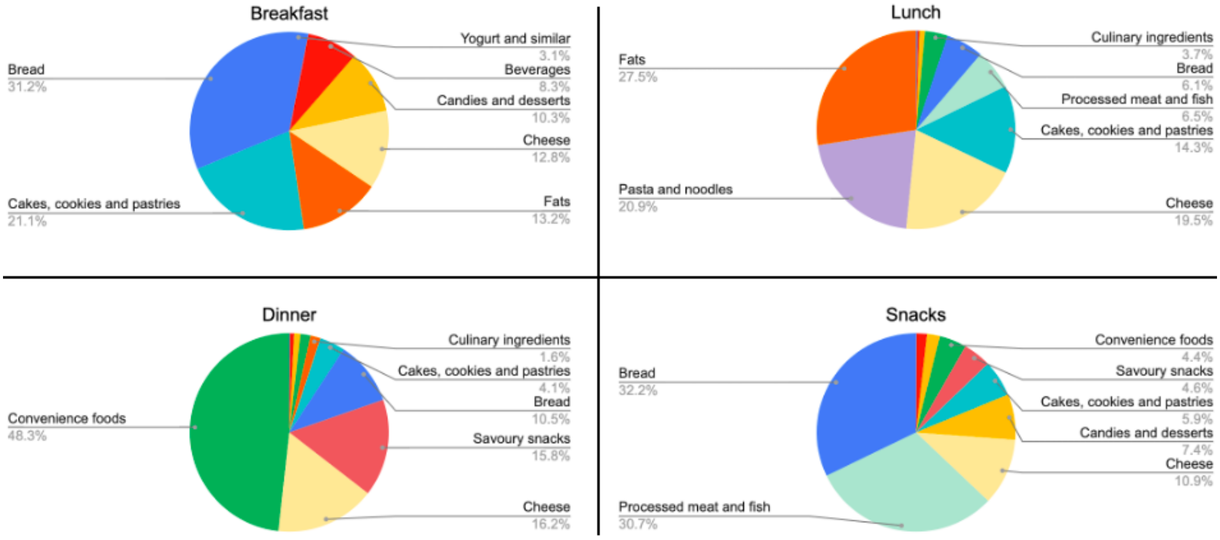

Figure B1. Contribution of different food groups to sodium intake from processed foods by eating occasions, in a sample of university students (n=15)

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DISCUSSÃO GERAL E CONCLUSÕES

Discussão geral e conclusões

Os dados deste trabalho mostram que as refeições servidas em cantinas universitárias apresentam valores excessivos de sódio, maioritariamente proveniente do sal de adição. Ao mesmo tempo, observou-se que não existe uma padronização nos teores do sal de adição. Neste sentido, os consumidores destes estabelecimentos poderão facilmente ultrapassar as recomendações de ingestão diária máxima de sal preconizada pela OMS.

Os resultados desta dissertação também mostraram, através dos dados da excreção de urina de 24-h, uma elevada prevalência de ingestão excessiva de sódio numa amostra de estudantes universitários portugueses, consumidores habituais das mesmas cantinas, excedendo as recomendações da OMS. Além do elevado contributo do sal de adição nas refeições para a ingestão total de sódio, verificou-se também que neste grupo de estudantes mais de metade da ingestão de sódio foi proveniente de alimentos processados, sobretudo em refeições intercalares como os lanches, na sua maioria proveniente de pão, carne/pescado processados e queijos. Observou-se ainda que a grande maioria dos indivíduos apresentaram um baixo consumo de produtos hortícolas, fruta e leguminosas, bem como uma ingestão inadequada de potássio. A média do rácio Na:K observada entre os participantes representa o dobro das recomendações da OMS (33), o que pode indicar um maior risco existente entre os estudantes universitários de desenvolverem hipertensão arterial e doenças crónicas não transmissíveis.

Apesar deste estudo apresentar algumas limitações, os resultados obtidos podem refletir, em certa medida, os conhecimentos sobre sal e hábitos de consumo de sódio e potássio na população de jovens adultos portugueses com acesso a educação superior, e apontam para a importância de manter uma vigilância sobre esta população para monitorizar o seu comportamento e padrões de consumo. A universidade é um ambiente educacional propício para implementar estratégias de educação, promoção de hábitos saudáveis e modulação da oferta alimentar [(30, 34, 35)]. Num estudo realizado em Portugal, Guiné *et al.* [(34)], verificaram que os estudantes reportaram a universidade como uma das suas principais fontes de informação para obtenção de informações sobre alimentação saudável. Por outro lado, através dos dados obtidos neste estudo, tal como em dados de outras pesquisas [(31, 36-38)], constata-se que existem semelhanças claras nas descobertas de que há uma necessidade de melhorar o conhecimento, atitudes e comportamentos sobre a ingestão de sódio em jovens estudantes, e isso deverá ser realizado através de estratégias de educação alimentar em paralelo com intervenções para melhorar o ambiente alimentar de forma a facilitar escolhas mais saudáveis, tais como garantir a oferta de uma ampla variedade de opções de alimentos saudáveis com baixo teor de sódio nas cantinas, cafeterias e máquinas de venda automática no campus universitário [(10)].

Em conclusão, para diminuir a ingestão de sódio em grupos específicos da população, como os estudantes universitários, é importante o desenvolvimento de uma estratégia projetada de forma abrangente levando em consideração as principais fontes de consumo de sódio. A dosagem do sal de adição com o equipamento Salt Control-C poderá ser uma estratégia inovadora eficaz, de simples treinamento e manuseio para os manipuladores de alimentos, que poderá auxiliar na padronização e redução gradual dos níveis de sal adicionado, de acordo com os níveis de aceitação dos consumidores, aproximando o teor de sódio das refeições consumidas fora de casa às recomendações da OMS.

Este estudo traz também um contributo científico para as empresas de restauração, manipuladores de alimentos, gestores de restauração e comunidade em geral, ao evidenciar que uma redução até 30% do teor de sódio das refeições (sopa e pratos principais) não apresentou alterações significativas na aceitação geral, perceção de salinidade e desperdício de comida, tal como verificado em outros estudos [(21, 22, 26, 39)].

É fundamental também direcionar o trabalho da indústria alimentar no sentido de estimular o desenvolvimento de medidas e soluções para melhorar a qualidade da oferta alimentar, nomeadamente na diminuição dos teores de sódio e melhoria da relação sódio potássio dos alimentos, de forma a proteger a saúde das populações de uma forma mais abrangente e efetiva [(40)].

Recomenda-se ainda a realização de estudos semelhantes em larga escala para poder generalizar os resultados para a população de jovens estudantes universitários .

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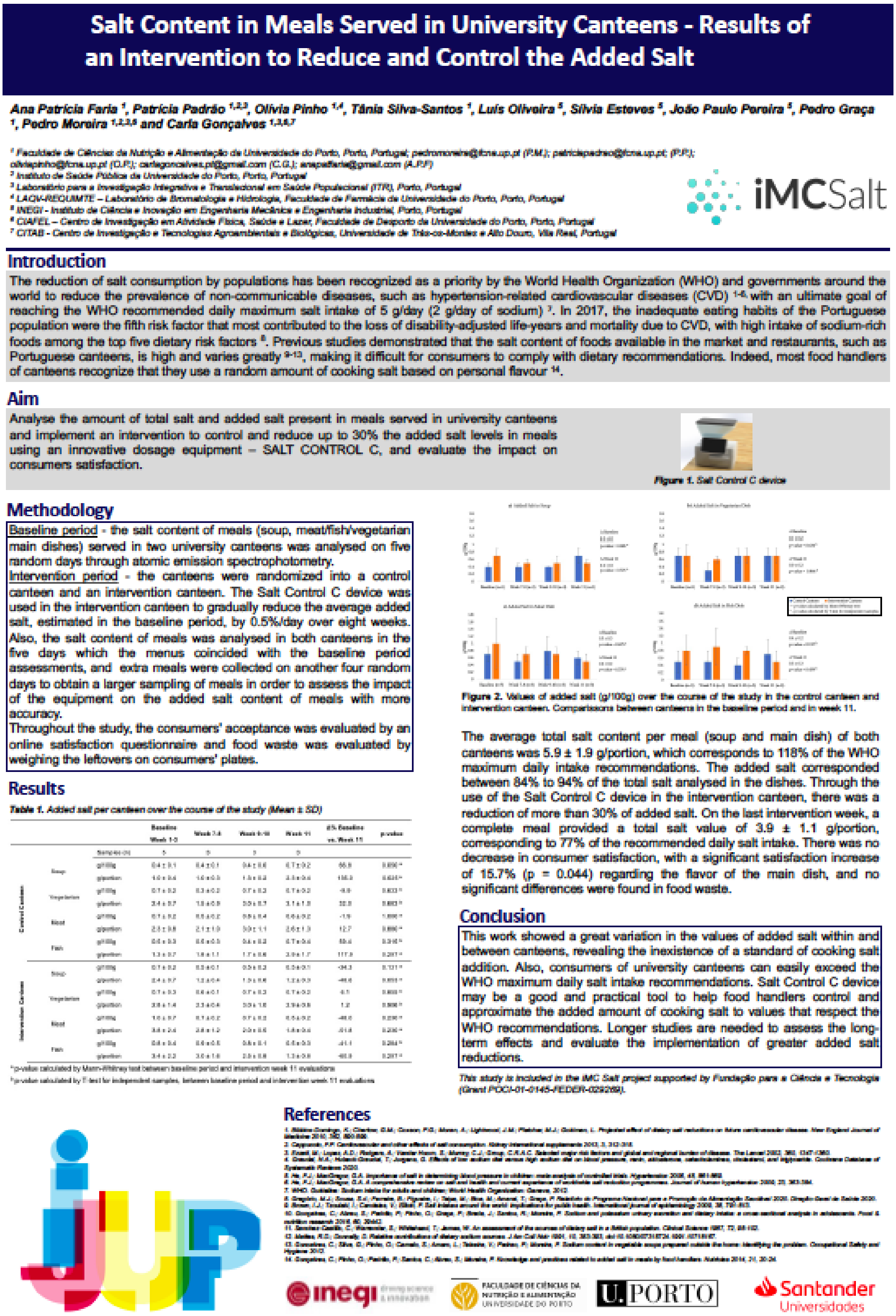
APÊNDICES

Índice de Apêndices

Apêndice A - Apresentação de Poster: Encontro de Investigação Jovem da Universidade do Porto

Salt Content in Meals Served in University Canteens – Results of an Intervention to Reduce and Control the Added Salt [Poster]. Apresentado no 15º Encontro de Investigação Jovem da Universidade do Porto (IJUP), Porto, maio 2022. https://www.up.pt/ijup/ijup-2022/



Salt Content in Meals Served in University Canteens - Results of an Intervention to Reduce and Control the Added Salt

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Introduction

The reduction of salt consumption by populations has been recognized as a priority by the World Health Organization (WHO) and governments around the world to reduce the prevalence of non-communicable diseases, such as hypertension-related cardiovascular diseases (CVD) [1-6] with an ultimate goal of reaching the WHO recommended daily maximum salt intake of 5 g/day (2 g/day of sodium) [7]. In 2017, the inadequate eating habits of the Portuguese population were the fifth risk factor that most contributed to the loss of disability-adjusted life-years and mortality due to CVD, with high intake of sodium-rich foods among the top five dietary risk factors [8]. Previous studies demonstrated that the salt content of foods available in the market and restaurants, such as Portuguese canteens, is high and varies greatly [9-13], making it difficult for consumers to comply with dietary recommendations. Indeed, most food handlers of canteens recognize that they use a random amount of cooking salt based on personal flavour [14].

Aim

Analyse the amount of total salt and added salt present in meals served in university canteens and implement an intervention to control and reduce up to 30% the added salt levels in meals using an innovative dosage equipment – SALT CONTROL C, and evaluate the impact on consumers satisfaction.

Figure 1. Salt Control C device

Methodology

Baseline period - the salt content of meals (soup, meat/fish/vegetarian main dishes) served in two university canteens was analysed on five random days through atomic emission spectrophotometry.
Intervention period - the canteens were randomized into a control canteen and an intervention canteen. The Salt Control C device was used in the intervention canteen to gradually reduce the average added salt, estimated in the baseline period, by 0.5%/day over eight weeks. Also, the salt content of meals was analysed in both canteens in the five days which the menus coincided with the baseline period assessments, and extra meals were collected on another four random days to obtain a larger sampling of meals in order to assess the impact of the equipment on the added salt content of meals with more accuracy.
Throughout the study, the consumers' acceptance was evaluated by an online satisfaction questionnaire and food waste was evaluated by weighing the leftovers on consumers' plates.

Results

Table 1. Added salt per canteen over the course of the study (Mean ± SD)

			Baseline Week 1-3	Week 7-8	Week 9-10	Week 11	Δ% Baseline vs. Week 11	p-value
Control Canteen		Samples (n)	5	5	5	5		
	Soup	g/100g	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.0	0.7 ± 0.2	66.8	0.690 a
		g/portion	1.0 ± 0.4	1.0 ± 0.3	1.5 ± 0.2	2.5 ± 0.4	155.3	0.025 a
	Vegetarian	g/100g	0.7 ± 0.2	0.3 ± 0.2	0.7 ± 0.2	0.7 ± 0.2	-9.9	0.603 b
		g/portion	2.4 ± 0.7	1.0 ± 0.8	3.0 ± 0.7	3.1 ± 1.8	32.8	0.683 b
	Meat	g/100g	0.7 ± 0.2	0.5 ± 0.2	0.8 ± 0.4	0.6 ± 0.2	-1.9	1.000 a
		g/portion	2.3 ± 0.8	2.1 ± 1.0	3.0 ± 1.1	2.6 ± 1.3	12.7	0.690 a
	Fish	g/100g	0.6 ± 0.3	0.6 ± 0.5	0.4 ± 0.2	0.7 ± 0.4	55.4	0.310 b
		g/portion	1.3 ± 0.7	1.8 ± 1.1	1.7 ± 0.8	2.9 ± 1.7	117.9	0.201 a
Intervention Canteen	Soup	g/100g	0.7 ± 0.2	0.3 ± 0.1	0.5 ± 0.2	0.3 ± 0.1	-34.3	0.131 a
		g/portion	2.4 ± 0.7	1.2 ± 0.4	1.9 ± 0.8	1.2 ± 0.3	-46.6	0.033 a
	Vegetarian	g/100g	0.7 ± 0.3	0.6 ± 0.1	0.7 ± 0.3	0.7 ± 0.2	-6.1	0.603 b
		g/portion	3.8 ± 1.4	2.3 ± 0.4	3.0 ± 1.8	3.9 ± 0.8	1.2	0.906 b
	Meat	g/100g	1.0 ± 0.7	0.7 ± 0.2	0.7 ± 0.3	0.5 ± 0.2	-48.0	0.236 a
		g/portion	3.4 ± 2.4	2.8 ± 1.2	2.0 ± 0.6	1.6 ± 0.4	-51.8	0.230 a
	Fish	g/100g	0.8 ± 0.4	0.6 ± 0.5	0.6 ± 0.1	0.5 ± 0.3	-41.1	0.264 b
		g/portion	3.4 ± 2.2	3.0 ± 1.6	2.0 ± 0.8	1.3 ± 0.8	-60.8	0.207 a

a p-value calculated by Mann-Whitney test between baseline period and intervention week 11 evaluations
b p-value calculated by T-test for independent samples, between baseline period and intervention week 11 evaluations

Figure 2. Values of added salt (g/100g) over the course of the study in the control canteen and intervention canteen. Comparisons between canteens in the baseline period and in week 11.

The average total salt content per meal (soup and main dish) of both canteens was 5.9 ± 1.9 g/portion, which corresponds to 118% of the WHO maximum daily intake recommendations. The added salt corresponded between 84% to 94% of the total salt analysed in the dishes. Through the use of the Salt Control C device in the intervention canteen, there was a reduction of more than 30% of added salt. On the last intervention week, a complete meal provided a total salt value of 3.9 ± 1.1 g/portion, corresponding to 77% of the recommended daily salt intake. There was no decrease in consumer satisfaction, with a significant satisfaction increase of 15.7% (p = 0.044) regarding the flavor of the main dish, and no significant differences were found in food waste.

Conclusion

This work showed a great variation in the values of added salt within and between canteens, revealing the inexistence of a standard of cooking salt addition. Also, consumers of university canteens can easily exceed the WHO maximum daily salt intake recommendations. Salt Control C device may be a good and practical tool to help food handlers control and approximate the added amount of cooking salt to values that respect the WHO recommendations. Longer studies are needed to assess the long-term effects and evaluate the implementation of greater added salt reductions.

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References

Apêndice B - Apresentação de Poster: Encontro de Responsabilidade social Universitária da Universidade do Porto

Intervention to Reduce Excessive Added Salt in Canteen Meals at University of Porto with an innovative Equipment (Salt Control-C) [Poster]. Apresentado no Encontro de Responsabilidade Social Universitária da Universidade do Porto, Porto, maio 2022.