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Fooled by savouriness? Investigating the relationship between savoury taste and protein content in familiar foods

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ABSTRACT

Selecting savoury foods after consuming a protein depleted diet has been suggested to reflect protein seeking behaviour. The modern diet contains a large number of processed foods, many of which are highly savoury to taste, but not necessarily high in protein. The present two studies aimed to investigate the relationship between savoury taste and protein content (actual and participant estimated). Participants (S1 n = 20, S2 n = 37) completed 100 mm VAS ratings of sensory and nutritional qualities of 18 familiar foods, categorised as sweet low protein, savoury low protein and savoury high protein. In study 2, the individual foods were blended to a fine consistency to disguise their identity and ensure ratings were based primarily on taste. Multilevel linear regression was used to test associations between savoury taste and actual protein content. Protein content did not predict savoury taste rating, irrespective of category. The results also indicated that participants were generally accurate at estimating the protein content of foods, although there was a tendency towards overestimation. The magnitude of this error was increased in low protein savoury foods. Specifically, there was a shift in the spread of estimation scores which showed a greater level of overestimation in some blended compared to unblended foods, and predominantly in savoury foods which participants could not identify. These results provide evidence that savoury taste and protein content are not well linked in the current food environment, but taste may guide nutrient estimations about certain unidentified foods.

1. Introduction

Taste is suggested to function as a way of identifying nutrients and avoiding poisons in foods [1]. The taste of a food is therefore thought to be associated with its nutritional content, and a sweet taste is believed to signal the presence of sugars, or carbohydrates in foods [2]. Similarly, dietary protein is positively correlated with savouriness in a variety of commonly consumed foods in the Netherlands [3]. In a further study, savoury taste was moderately associated with protein content in a variety of Australian foods [4]. Additionally, Martin, Visalli [5] created a food-taste database, and note that foods with a higher intensity of savoury taste are also higher in animal protein content. However, a recent study has found weak correlations between a savoury taste and protein content ($r < 0.3$) [6], therefore more research is needed to determine the strength of this relationship. The savoury taste thought to represent protein in foods is the umami taste, which is often defined as “meaty” or “brothy” [7]. The compound which underlies this taste is glutamic acid, an amino acid which is abundant in protein containing foods including meat, fish, dairy and some vegetables [8]. This taste is also elicited by Monosodium Glutamate (MSG), the sodium salt of the amino acid L-glutamate, which is a savoury flavor enhancer commonly used in both Western and Eastern processed foods and home cooking [35]. It, and the ribonucleotides such as Inosine 5′monophosphate (IMP) and Guanosine monophosphate (GMP), elicit the taste sensation of “umami”.

It has been suggested that humans may use taste-nutrient associations to guide food choices and counteract dietary imbalances. In a dietary intervention study, participants showed a greater preference for savoury high-protein foods after consuming a lower, compared to a higher protein diet [9]. In a further study, reward-related brain activation when exposed to savoury food cues was found to be increased following protein restriction [10]. It is argued that selecting savoury foods after consuming a protein depleted diet may reflect protein-seeking behaviour, and that this could be important for the control of dietary protein intake. It is unclear whether this behaviour is guided by a preference for a savoury taste, or specifically for dietary protein. One study has found that individuals who habitually consume a higher protein diet are more sensitive to an induced protein deficit than lower habitual protein consumers, which is reflected in their increased liking of a high concentration of MSG in this state [11]. This suggests that the

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Table 1
Nutritional composition of study foods.

Category	Food	Macronutrients (g) per 100 g					Energy per 100 g		Percentage of energy		
		Protein	Carbohydrate	Sugars	Fat	Salt	kCal	kJ	Protein	Carbohydrate	Fat
Savoury High Protein	Roast Beef	24.4	1.0	0	2.4	1.0	123	515	79%	3%	18%
	Dry Roasted Peanuts	28.8	9.4	5.3	48.8	1.1	608	2544	19%	6%	72%
	Breaded Ham	23.2	1.2	0	4.0	2.5	134	561	69%	4%	27%
	Chicken Mayonnaise Sandwich	31.0	36.0	2.9	13.1	1.5	400	1674	31%	36%	29%
	Salmon Fillet	23.5	0.5	0	14.9	0.1	228	954	41%	1%	59%
	Mean	26.2	9.6	1.6	16.6	1.2	299	1251	35%	13%	50%
	SD	3.5	15.2	2.4	18.8	0.9	206	862	7%	30%	82%
Savoury Low Protein	Potato Wedges	2.0	22.4	1.0	5.3	0.7	151	632	5%	59%	32%
	Tangy Cheese Doritos	8.2	57.1	3.4	5.3	1.8	510	2134	6%	45%	9%
	Vegetable Spring Rolls	4.8	26.6	5.1	11.1	0.9	230	962	8%	46%	43%
	Sausage Rolls	10.6	20.2	1.0	28.4	1.1	380	1590	11%	21%	67%
	Garlic and Cheese Slices	9.5	35.9	1.8	17	1.1	340	1423	11%	42%	45%
	Crispy Garlic Mushrooms	4.5	20.2	1.2	7.4	0.9	167	699	11%	48%	40%
	Mozzarella Pizza	11.0	26.0	0.0	14.0	0.1	272	1138	16%	38%	46%
	Mean	7.2	29.8	1.9	12.6	0.9	296	1238	10%	40%	38%
	SD	3.5	13.2	1.7	8.2	0.5	139	582	10%	38%	53%
Sweet Low Protein	Toffee Popcorn	1.8	80.3	55.6	9.3	1.4	420	1757	2%	76%	20%
	Jam Ball Doughnuts	4.9	49.6	40	31.8	0	340	1423	6%	58%	84%
	Chocolate and Honeycomb Cheesecake	3.7	33.7	21.5	20.7	1.0	340	1423	4%	40%	55%
	Angel Cake Slice	3.0	59.6	39.2	18.2	0.8	420	1757	3%	57%	39%
	Dried Apricots	4.0	36.0	36.0	0.6	0.1	178	745	9%	81%	3%
	Milk Chocolate Raisins	4.4	69.0	62.0	15.0	0.4	435	1820	4%	63%	31%
	Mean	3.6	54.7	42.4	15.9	0.6	284	1189	5%	77%	50%
	SD	1.1	18.4	14.5	10.6	0.6	163	682	3%	45%	59%

sensing of MSG may be involved in the detection of protein in the diet, particularly when participants habitually consumed higher amounts of protein. Additionally, as humans appear to be able to adapt dietary intake in longer term studies, it has been suggested that they are capable of recognising the macronutrient content of a food [3,11], although it is unclear whether this is based on explicit or implicit knowledge of the protein content of foods.

If selecting savoury foods is associated with appetite for protein, what then underlies this relationship? Rats and hamsters deprived of protein display a preference for a taste which has previously been associated with the nutrient [12,13]. It is argued that humans also have the capacity to form these associations [14], and that learned associations between dietary cues and post-ingestive consequences [15] guide protein appetite. The availability of foods with tastes which are incongruent with their nutritional content could therefore degrade this dietary learning. This is supported by previous research (van Dongen et al. [3]) which found that taste-nutrient relationships may be disrupted by competing tastes within the same food. Psychophysical research has demonstrated that savoury taste can enhance the perception of sweet and salty tastes, and suppress bitterness and sourness [16,17]. A characteristic of many foods in our current dietary environment is the presence of competing tastes. For example, there are “ultra-processed” food products which contain both added salt and sugar [18].

The modern diet contains a large number of processed foods, and it is estimated that in the United Kingdom highly processed foods contribute up to 59% of energy consumed [19]. Here, a highly processed food is defined as a food which has been subjected to industrial processes such as roasting, coating, use of industrial ingredients, salting and heat treatments. Monosodium glutamate, and other savoury flavourings are often used in highly processed foods [20,21]. Many of these foods are highly savoury to taste, but not necessarily high in protein. It has been suggested that humans have a tight physiological control of dietary protein intake, and may overconsume calories to meet absolute protein requirements [22]. This could be of concern, as low protein savoury foods may disrupt protein-seeking behaviour and could contribute to overconsumption of energy and obesity [23]. Although it is important to note that this hypothesis has not been universally supported, and on some low protein diets humans do not overconsume calories [24]. However, granted that there is a drive to maintain adequate protein intake and that savouriness is used as a cue for protein, the presence of low protein savoury foods in the diet will increase overall energy intake.

Accordingly, the aim of the present studies was to investigate the relationship between savoury taste and protein content across a range of savoury and sweet foods. We were also interested in how much protein these foods are perceived to contain, and whether this is overestimated specifically in low protein savoury foods.

2. Study 1

2.1. Method

2.1.1. Participants

All participants were recruited through the University of Bristol, School of Experimental Psychology Experimental Hours Scheme, and received one experimental hour's credit in remuneration for their participation. They were sixteen female and four male participants aged 18–22 years ($M = 19.4$, $SD = 1.3$) with a BMI of 18.4–25.1 kg/m^2 ($M = 21.4$, $SD = 1.7$). In study 2, thirty-four female and three male participants aged 18–27 years ($M = 20.9$, $SD = 2.3$) with a BMI of 17.2–27.7 kg/m^2 ($M = 20.9$, $SD = 2.3$) took part in the study. This study was conducted according to the ethical guidelines laid down in the Declaration of Helsinki. Written informed consent was obtained from all participants.

2.2. Measures

Participants completed Visual Analogue Scale (VAS) ratings of the sensory and hedonic properties of each food. These comprised a computerised sliding scale ranging between 0 “not at all” and 100 “extremely”. VAS ratings were completed for pleasantness, familiarity, sweetness, savouriness and saltiness, using for example the question “How PLEASANT is the taste of food “*x*””. The protein, carbohydrate and fat content of each food were also estimated (as a percentage of total energy), using VASs, but only protein estimations are included in analyses. Responses at each end of these latter VASs were anchored