



Gastroenteric hormone responses to hedonic eating in healthy humans

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Summary Hedonic eating differentiates from homeostatic eating on two main aspects: the first one is that eating occurs when there is no need for calorie ingestion and the second one is that the food is consumed exclusively for its gustatory and rewarding properties. Gastroenteric hormones such as ghrelin, colecystokinin-33 (CCK) and peptide YY_{3–36} (PYY_{3–36}) are known to play a pivotal role in the homeostatic control of food intake. To the contrary, their role in hedonic eating has been never investigated. Here we report peripheral responses of CCK, PYY_{3–36} and ghrelin to the consumption of food for pleasure in well-nourished satiated healthy subjects.

Plasma levels of CCK, PYY_{3–36} and ghrelin were measured in 7 satiated healthy subjects before and after *ad libitum* consumption of both a highly pleasurable food (hedonic eating) and an isoenergetic non-pleasurable food (non-hedonic eating).

The consumption of food for pleasure was associated to a significantly increased production of the hunger hormone ghrelin and a significantly decreased secretion of the satiety hormone CCK. No significant changes in plasma PYY_{3–36} levels occurred in the two eating conditions.

These preliminary data demonstrate that in hedonic eating the peripheral hunger signal represented by ghrelin secretion is enhanced while the satiety signal of CCK production is decreased. This could be responsible for the persistence of peripheral cues allowing a continued eating as well as for the activation of endogenous reward mechanisms, which can drive food consumption in spite of no energy need, only for reward.

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1. Introduction

In present times, because of the large availability of food in the environment, human beings are prompted to eat not only

to maintain energy homeostasis but also just for pleasure. In the first case, named homeostatic eating, food ingestion is driven by acute negative energy imbalance and is independent from the palatability of the food. In the second case, named hedonic eating, the consumption of food occurs even if there is no need for caloric ingestion, and the food is

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consumed because of its gustatory rewarding properties, independently from calorie content (Lowe and Butryn, 2007). It is intuitive that hedonic eating may promote powerfully food intake in an environment where highly pleasurable foods are omnipresent and contribute to the diffusion of overweight and obesity. Therefore, understanding the physiological modulation of hedonic eating might help to contrast obesity and/or other eating disorders.

A huge amount of research clarified the physiological modulation of homeostatic eating. Briefly, in the condition of acute energy depletion, central and peripheral hunger modulators are released in order to promote food intake. The ingestion of food, in turn, stimulates the release of central and peripheral satiety signals and inhibits the secretion of hunger mediators with the aim to adapt food consumption to the organism's caloric needs so that energy balance is restored in the short-term and body weight remains stable in the long-term (Druce et al., 2004; Schwartz et al., 2007). Gastroenteric hormones, such as ghrelin, colecystokinin-33 (CCK) and peptide YY₃₋₃₆ (PYY₃₋₃₆) are known to play a pivotal role in this process. Indeed, the secretion of the gastric hunger hormone ghrelin increases during fasting and drops after food ingestion contributing to promote and stop eating, respectively (Cummings et al., 2005). Conversely, the production of the satiety-stimulating peptides CCK and PYY₃₋₃₆ rises after a satiating meal prompting the termination of food intake (Murphy and Bloom, 2006).

In order to maintain the drive to eat even when the subject is satiated, such as in hedonic eating, different responses of

appetite modulators to the ingestion of food for pleasure can be supposed. In a previous study (Monteleone et al., 2012), we demonstrated that the consumption of food for pleasure was associated with increased peripheral levels of both ghrelin and the endocannabinoid 2-arachidonoyl glycerol (2-AG), and we speculated that these changes could prompt the drive to eat in a condition where there is no need for calorie ingestion. To the best of our knowledge, the role of CCK and PYY₃₋₃₆ in hedonic eating has been never investigated. Therefore, here we report the peripheral responses of CCK, PYY₃₋₃₆ and, again, ghrelin to the consumption of food for pleasure, in well-nourished satiated healthy subjects who took part in our previous study (Monteleone et al., 2012).

2. Subjects and methods

Plasma levels of CCK, PYY₃₋₃₆ and, again, ghrelin were measured in seven out of the eight subjects, who participated in the previous study (Monteleone et al., 2012). The 7 healthy subjects were 3 men and 4 women, with a body mass index (BMI) < 25 kg/m² (mean ± SD = 22.07 ± 2.5 kg/m²) and no antecedent of obesity. They were aged 21–33 years (mean ± SD = 25.2 ± 4.1 years) and had normal eating behaviours without food restriction or dieting or bingeing, as ascertained by a clinical interview. All were drug-free, had normal physical examinations, normal values of routine blood and urine tests, and a normal electrocardiogram. All subjects signed a written consent after being fully informed of the

Table 1 Calorie and nutrient contents (g), list and total weight (g) of palatable and non-palatable foods eaten by each participant.

Subject	Kcal	Lipids	Carbohydrates	Proteins	Food	Total weight (g)
Palatable food						
S-1	373.0	13.0	56.0	8.0	Babà with Nutella (typical Neapolitan sponge cake soaked in a rum syrup and covered with Nutella)	130
S-2	316.2	18.6	33.6	3.6	Nutella	60
S-3	460.0	14.4	67.0	15.6	Cestino con le fragoline (typical Neapolitan pastefrolle cake covered with custard cream and strawberries)	164
S-4	373.0	13.0	56.0	8.0	Babà with Nutella (typical Neapolitan sponge cake soaked in a rum syrup and covered with Nutella)	130
S-5	538.2	34.6	50.3	6.4	Dark chocolate	100
S-6	425.3	6.1	71.5	21.1	Delizia al limone (typical Neapolitan sponge cake with custard lemon cream)	132
S-7	489.0	24.6	62.1	4.8	Fiesta Ferrero (sponge snack filled with cream and covered with chocolate)	120
Mean ± SD	424.9 ± 76.7	17.7 ± 9.3	56.6 ± 12.4	9.6 ± 6.3		119.4 ± 32.3
Non-palatable food						
S-1	403.0	11.0	68.0	8.0	Bread + butter	100 + 13
S-2	319.2	20.0	31.0	3.8	Bread + butter	45 + 25
S-3	449.9	16.2	68.0	8.0	Bread + butter	100 + 20
S-4	567.1	32.4	61.3	7.5	Bread + butter	90 + 40
S-5	403.0	11.0	68.0	8.0	Bread + butter	100 + 13
S-6	389.4	4.6	74.0	13.0	Bread + milk	100 + 140
S-7	493.8	24.3	61.2	7.5	Bread + butter	90 + 30
Mean ± SD	432.2 ± 80.2	17.0 ± 9.3	61.6 ± 14.2	7.9 ± 2.6		129.4 ± 52.4

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