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# The Snow White Effect: How Food Colour Saturation Impacts Food Likeability and Perceived Weight

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**Resumo**

Vivemos rodeados por cores, quer pelos objetos que vemos, quer pelo que a natureza teve função de pintar, como os alimentos. As cores influenciam as perceções e os comportamentos dos consumidores, incluindo as preferências e decisões alimentares, tal como evidenciado em inúmeros estudos descritos na literatura. Todavia, existe uma lacuna na investigação de um dos atributos específicos da cor - a saturação - e o seu impacto nos mecanismos psicológicos subjacentes às preferências alimentares.

Neste estudo experimental investigámos de que forma a saturação da cor de alimentos e objetos, influencia a sua gostabilidade e peso percebido. Explorámos, também, o papel mediador do peso percebido nessa gostabilidade. Os participantes (n = 48) viram imagens de produtos comestíveis (naturais e confecionados) e não comestíveis, com dois níveis de saturação da cor (alto vs. baixo) e indicaram, numa escala, a gostabilidade e peso percebido dos produtos. Posteriormente, foram introduzidas duas simulações de situações reais de consumo e a avaliação da perceção de saudabilidade de produtos comestíveis nos dois graus de saturação.

Os resultados sugerem que a saturação da cor dos alimentos, mas não dos objetos, afeta significativamente a perceção de gostabilidade, sendo que os participantes gostam mais de alimentos altamente saturados, independentemente de serem naturais ou confecionados. Em contrapartida, a saturação da cor não influencia o peso percebido, inviabilizando o seu efeito mediador na gostabilidade. Também, não foi verificado um efeito significativo da saturação da cor na saudabilidade percebida.

Esta investigação, além de primar pelo controlo experimental e focar-se no atributo da cor menos estudado na literatura permite, através dos resultados obtidos, informar iniciativas que promovam, através da manipulação da saturação da cor, um impacto positivo e sustentável na nossa saúde e ambiente.

**Palavras-chave:** Saturação da cor, alimentação, gostabilidade/preferência, peso percebido, saudabilidade percebida.

**Classificação APA:**

**3900** Psicologia do Consumidor

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**2300** Psicologia Experimental Humana

**2323** Perceção Visual

## Abstract

We live surrounded by colours, either by the objects we see, or by what nature has been busy painting, such as food. Colours can influence consumers' perceptions and behaviours, particularly regarding food perception and selection, as evidenced by numerous studies described in the literature. However, there is a gap in the investigation of one specific colour attribute - colour saturation - and its impact on the psychological mechanisms that impact food preferences.

In this experimental study we investigated how colour saturation of foods and objects influences their perceived weight and likeability and explore if there is a mediational effect of the perceived weight on the likeability. Participants (n = 48) were exposed to images of edible (natural and cooked) and inedible products, with two levels of colour saturation (high vs. low), and indicated, on a scale, the likeability and perceived weight of the products. Then, simulations of real consumer situations were introduced, as well as a task to assess the perceived healthiness of some edible products with both levels of colour saturation.

Our results suggest that the colour saturation of food, but not of objects, significantly affects the likeability, playing a critical role in food preference, since participants like more highly saturated foods, whether they are natural or cooked. In contrast, colour saturation does not influence the perceived weight, making its mediating effect on likeability unfeasible. Also, there was no significant effect of colour saturation on the perceived healthiness.

This research, besides ensuring experimental control and focusing on the colour attribute less explored in the literature, allows, through the results obtained, to inform initiatives that promote, by manipulating the colour saturation of foods, a positive and sustainable impact on our health and environment.



**Key-words:** Colour saturation, feed, likeability/preference, perceived weight, perceived healthiness.

**American Psychological Association (PsycINFO Classification Categories and Codes):**

**3900** Consumer Psychology

**3920** Consumer Attitudes & Behaviour

**2300** Human Experimental Psychology

**2323** Visual Perception

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## Introduction

We live, certainly, surrounded by a rich palette of colours of immeasurable combinations (Hård & Sivik, 2001; Linhares, Pinto, & Nascimento, 2008). In our daily lives, we are uninterruptedly bombarded by chromatic stimuli, either by the clothes we wear, the cars that cross the avenue or all the objects we see (Elliot & Maier, 2014) as well as, all that nature has been busy painting, such as food (Clydesdale, 1991). Nowadays, consumers have the opportunity to choose products that are available in the most varied versions of colours; technology reduced the cost of colour manufacturing, allowing consumers to express their personality, feelings and vibes through colours (Labrecque, Patrick, & Milne, 2013).

Colour is a phenomenon dependent on the arrangements between the light source, the reflective power of a target object, and the visual sensitivity of each individual (Mendoza, Dejmek, & Aguilera, 2006). Colour is characterized by the type of light present in the wavelengths within the visible electromagnetic spectrum that are assimilated by the retina of the eye (Singh, 2006). Following, the brain decomposes the light into a spectrum of six possible colours: red, orange, yellow, green, blue and violet. Thus, when someone visually perceives an object, for example, of colour blue, it is because this object has absorbed all the wavelengths of the spectrum of light, excepting the blue light. The light that has not been absorbed is reflected to the eyes and then interpreted as blue by the brain. However, the visual experience of colour is subjective for each person, so the way someone perceives a particular colour is personal and distinct from the others (Singh, 2006).

Most research discriminates three attributes of colour: hue, value and saturation (Labrecque et al., 2013). The hue or tonality of the colour is the visual perception relative to the wavelengths of the visible electromagnetic spectrum, which allows us to distinguish what we commonly call blue, green, yellow, etc. (Labrecque & Milne, 2011). The value or brightness refers to the degree of clarity or darkness of a colour, where a high value contains a greater amount of white mixed with the hue, as opposed to the low value which presents a greater amount of black combined with a certain hue (Labrecque & Milne, 2011; Labrecque et al., 2013). Colour saturation or chroma refers to the amount of pigment present in a colour. Thus, a colour of low saturation is perceived as faded, less pure, by the greater amount of grey fused in the hue; on the other hand, a highly saturated colour, that is, with less amount of grey in its composition, reveals itself of a great intensity and vividness (Labrecque & Milne, 2011; Labrecque et al., 2013).

The complex phenomenon of colour has been a target of multiple studies across several disciplines (Elliot & Maier, 2014). Not surprisingly, colour has been associated to consumer behaviour, promoting the ability to captivate consumers' attention and influence consumers' perceptions and behaviours (Labrecque & Milne, 2011), including their choices concerning food (Clydesdale, 1993). In the food context there is a variety of colour effects that have been investigated: the food itself, packaging, dishes, table decoration, among many others (Hagtvedt & Brasel, 2017). For example, it is possible to verify that fast food restaurants create logos using red and yellow colours, given that these vivid colours seem to capture consumers' attention, while, at the same time, stimulate appetite and encourage food consumption (Singh, 2006). On the other hand, Singh (2006) also verifies that formal restaurants prefer blue tones because of its relaxing effect on consumers: since blue stimulates calm and comfort, they expect customers to spend more time in their facilities and, therefore, consume more.

In what concerns specifically the impact of food colour on food perception, an enormous body of investigations has focused on the effect of colours on flavour and taste perceptions across multiple foods and beverages (Spence, Levitan, Shankar, & Zampini, 2010). However, although there is a growing body of evidence showing the impact of colour on both food perception and food selection, little is known about the underlying mechanisms, namely, how colour properties, such as colour saturation, can shape food preferences. So, does food colour saturation impacts food likeability? If vivid and intense colours stimulate food likeability, does this effect covers both natural and cooked food products? And can the eventual impact of food colour saturation on food likeability be explained by more saturated foods being perceived as having a bigger size?

This dissertation was inspired by Hagtvedt and Brasel (2017)'s article, which aimed to study the impact of colour saturation of objects in their perceived size. Throughout several experiments, using geometric objects and consumer products with various shapes and hues, the authors demonstrated that the perceived size of objects depends on their colour saturation. Objects with high colour saturation were perceived as being larger, in comparison with the exact same objects but of low colour saturation. The authors also provide compelling evidence that this is because more vivid and intense colours generate more arousal and capture more attention, leading objects of high colour saturation being perceived of a larger size. Our question is: does this effect remain for food products? And can it account for differences in likeability? Since bigger products are considered visually more attractive and are often selected more than smaller products (Burger, Cornier, Ingebrigtsen, & Johnson, 2011; Sharpe, Staelin, & Huber, 2008), can the perceived weight influence the likeability for the products? In this experiment we chose to measure the perceived weight instead of the perceived size because weight is more relevant than size for food items; also, the perceived weight is an approximate measure for the perceived size, since the same product with a larger size tends to weight more (Buckingham & Goodale, 2010, Buckingham & Goodale, 2013).

In this work, we aimed to study the impact of colour saturation on the perceived weight of natural and cooked food products and explore if there is a mediational effect of the food perceived weight on food likeability. We anticipate that colour saturation creates an illusion in the weight perception (supposedly due to attention and arousal processes), as so foods with high colour saturation will be perceived as heavier and that this higher weight will, in turn, incite a higher food likeability, since people tend to prefer bigger products.

**Colour and Consumption**

Today's society is a consumer society. For this reason, with the intense globalization and competition of the market, companies are increasingly looking for innovative and alternative ways to influence the consumerist crowd. Thus, organizations strategies must increasingly rely on Sensory Marketing (SM) tools to ensure a solid market position, the creation of value, and the consumer’s connection, recognition and loyalty with their products. The SM preaches that more than one of the five human senses - vision, hearing, touch, taste and olfaction - must be stimulated to interact and support the buying process, appealing to the emotional characteristics of the products and contributing to the creation of value (Hultén, 2011; Funk & Ndubisi, 2006). In this way, facilitating a multisensory product experience affects consumer behaviours and their perception of goods and services (Hultén, 2011).

Vision is of enormous importance for the discovery of changes in the environment, being the most commonly used sense for the perception of products (Hultén, 2011). This is why colours are a cheap and effective SM tool, because they have innumerable emotional connections that can help with: the differentiation of products, increase sales, create positive emotions in the relationship between consumers and products, favour the longer permanence of consumers in stores, increase intentions to consume again, which consequently strengthen consumer exclusivity and lead to a competitive advantage of the brand (Húlten, 2011; Kauppinen-Raisanen & Luomala, 2010; Leigh, Peters, & Shelton, 2006; Sliburyte & Skeryte, 2014). Thus, the colours present on websites, advertisements, food packages, food products, store environments, employee uniforms, company logos, among others, correspond to relatively recent marketing strategies implemented to affect our consumer decisions (Sliburyte & Skeryte, 2014).

A purchase decision process involves several cognitive, sensory and emotional processes that encompass five steps: recognition of the problem/necessity; search for information to cope with the need; evaluation of alternatives; purchase and post-purchase behaviour (Funk & Ndubisi, 2006). Colours perception and consumer decisions are always dependent on consumers' demographic factors (age, gender, culture, education, among others), their lifestyle (how they live and how they spend their time and money), and the area in which colours are applied (culture, entertainment, health, food industry, education, technology, finance) (Sliburyte & Skeryte, 2014). Studying these factors and knowing colours preferences allows the identification of the characteristics and pressing needs of consumers, helping organizations to adopt strategies that best meet these needs (Funk & Ndubisi, 2006).

Thus, colours have the main function of attracting consumers (Kauppinen-Raisanen & Luomala, 2010) and increasing product recognition. In advertising, colours allow ads to be displayed more accurately and attractively, capturing more attention and triggering positive attitudes in viewers. In addition, they contribute to increased ad recognition because coloured parts are more easily and more often remembered, which in turn leads to increased sales (Funk & Ndubisi, 2006). In the food context, several studies have allowed the collection of great knowledge, relevant to the Marketing area: Cheskin (1957, cited by Piqueras-Fiszman et al., 2012) observed that adding 15% more yellow to the outside of a can of 7Up led consumers to become more aware of the lemony flavour of that drink. Strawberry mousses when displayed in white trays (compared to black trays) are perceived significantly more intense, sweeter and tastier, by the greater contrast with the background (Piqueras-Fiszman et al., 2012). Additionally, the red colours of kitchen utensils produce effects in the taste perception of foods and beverages and in their consumption (Elliot & Maier, 2014): coffee is perceived as warmer if served in a red glass, because red is considered to be a warm colour, and therefore might increase the level of perceived temperature associated with that drink (Guéguen & Jacob, 2012); popcorn is perceived sweeter if served in a red bowl (Harrar, Piqueras-Fiszman, & Spence, 2011) and people eat less snacks if these are displayed in a red tray (Genschow, Reutner, & Wänke, 2012).

Thus, knowledge of consumer preferences regarding colour saturation for natural and cooked food products may have major impacts on the food industry and boost the adoption of new marketing strategies in food communication, in order to create a positive impact on today's emergent and critical issues, such as the well-being of the planet and the consumers themselves.

**Colour Perception**

Neuropsychological investigations show that a significant amount of visual processing is devoted to the analysis of colour information, where colour plays an important role for object recognition (Tanaka, Weiskopf, & Williams, 2001).

Colour is the response of the eye's retina and brain mechanisms to the light (OSA, 1953, cited by Choudhury, 2014). This light is the radiated energy of the electromagnetic spectrum to which human vision is sensitive, corresponding to a very narrow range of wavelengths (Westland & Cheung, 2006). Thus, the visible light that enters the eye is absorbed by specialized cells from the retina, the cones, that have an essential role in human colour perception (Westland & Cheung, 2006). Humans are trichromatic beings, which translates in having three types of cones or pigment receptors, which independently detect three colours: red, green and blue. So, this three types of cones are most universally known as R-G-B cones; however, because this nomenclature is not very accurate (since the sensitivity peaks of these cones do not really correspond to the red, green and blue colours), they have been referred to as three channels that differentiate three wavelengths of light: long, medium and short (L-M-S) (Choudhury, 2014). All colours are generated by different degrees of stimulation of the various types of cones. As an example, the red light stimulates the cones that detect the long wavelengths much more than the other cones. As the wavelengths of light decreases, the other two cones are stimulated, causing a gradual change in the hue (Choudhury, 2014). Then, the cones send electromechanical signals to specific cells in the lateral geniculate nucleus (Livingstone & Hubel, 1987), which encodes and transmits these outputs to cortical visual areas, essential for the processing and perception of colour information (Zeki et al., 1991).

It is important to note that colour perception is not solely dependent on its attributes, environmental factors such as the amount and type of ambient light, the distance and viewing angles, the general environment surround, can all influence colour perception (Elliot, 2015; Fairchild, 2015). Moreover, the perception of colour depends also on the psychophysiological aspects of the observer (Choudhury, 2014).

The meanings and associations that colours carry can be interpreted in the light of societal learning, but also of our biologically based tendencies. Regarding the societal learning, throughout our gregarious life we create numerous associations between colours and concepts, between colours and specific episodes of our experiences, between colours and physical contexts, among many others (for example, a grey sky is usually associated with a high probability of rain). The repetition of these pairings throughout our life span, makes the mere perception of a certain colour to strongly activate the associated pair, interfering with our cognitions, affections and behaviours (Elliot & Maier, 2012). However, the meanings attributed to colours represent also our biological inclinations, as colour vision evolved to promote species' survival and adaptation (Changizi, Zhang, & Shimojo, 2006; Elliot & Maier, 2012; Hutchings, 1997; Mollon, 1989). In this way, "social learning might, sometimes, represent a cognitive reinforcement and shape of evolutionarily predispositions" (Elliot & Maier, 2012, p.69). So, detecting ripe fruits from their external appearance, avoiding poisonous animals and detecting prey, assessing the receptivity and health quality of potential sexual partners through the colour of their skin, or identifying the distance and presence of water through the colours of soil vegetation were some of the important functions of colour visualization (Changizi, Zhang, & Shimojo, 2006; Hutchings, 1997; Mollon, 1989).

In this way, colour vision enables better target detection, visual field segregation and organization, and the identification and description of specific objects and their subsequent communication with other observers (Mollon, 1989; Witzel & Gegenfurtner, 2018). Individuals with colour blindness, unlike those who can see colours, have particular difficulty detecting targets on dappled surfaces with heterogeneous lightness - surfaces with different reflectance levels and different incident lighting angles. These conditions are very frequent in nature, for example, the recognition of ripe fruits on a dappled foliage, whereas colour vision proved to be an evolutionary advantage (Mollon, 1989). The segregation of the visual field, on the other hand, is a process of perceptual organization of the various elements that make up a given visual image - colours, shape, texture, context - allowing to isolate a certain object from the environment in which it is inserted, so that the object can be analysed as a whole, separate from its background. Segregation is an important mechanism for object recognition (Mollon, 1989). Some object recognition theories claim that cognitive representations that assist in the initial recognition of objects, use information based solely on the shape of objects, providing access to the function, meaning and name of that object (Biederman & Gerhardstein, 1993; Marr & Nishihara, 1978). Other theories assert that object recognition encompasses not only information about the object's shape but also about its surface attributes, such as colour (Bramão, Reis, Faísca, & Petersson, 2011; Tanaka et al., 2001). Colour-diagnostic refers to the usual colour of an object, that we memorize by our contact with it, allowing that colour to be indicative or diagnostic of that object. For example, a strawberry is clearly associated with the red memory colour. On the other hand, cars are examples of colours neutral objects as they are not cognitively associated with a specific colour. So, colour information cues facilitate the identification and recognition of segregated objects, especially those with an associated memory colour (Bramão et al., 2011). Thus, both social and biological aspects come together to contribute to the way humans construct colour (Elliot & Maier, 2012).

**Impact of Colour on Food-Related Context**

The multiple sensory properties of food, together with our expectations and other contextual factors, are crucial for food perception (Piqueras-Fiszman et al., 2012). These visual cues are omnipresent in our environment, making colour an important indicator for the assessment and selection of food products, even before their intake. Colour affect almost every aspect of food: aesthetics, security, gustatory, olfactory and textural properties, acceptability and consumption, important for the daily dietary decision-making process (Clydesdale, 1993; Dubose, Cardello, & Maller, 1980; Koch & Koch, 2003; Spence et al., 2010).

Regarding aesthetics, colour is really an important factor to the appearance of food (Spence et al., 2010), especially for fruits and vegetables due to their colourfulness (Paakki, Aaltojärvi, Sandell, & Hopia, 2018). So, our response to the appearance of food is associated with our preference judgments, such as if we like the product, if we find it interesting, attractive and pleasing to see, and therefore if we want to consume it or, in the other hand, reject it (Shimamura, 2012). In addition, the sensory experience of aesthetics is more pleasant as easier to recognize and perceive the product is (Paakki et al., 2018).

Concerning food security, from a very young age, individuals cognitively associate colours with food acceptability (Clydesdale, 1993). Specifically, atypical colours (e.g., green colour on cheese, discolouration of meat and fruit) signal possible dangers of consumption or possibility of strange taste (Clydesdale, 1993).

Therefore, humans perceive foods by assessing, trough vision, five types of expectations: the perceived safety of food, as so whether it is safe to consume that product; the visual identification, that is, whether the product is cognitively recognized or entirely new, and consequent evaluation of the expected flavours and textures; the usefulness of food in meeting the biological needs felt at that moment; the pleasantness of the experience of consuming that product, if one will like or not that product; and, finally, the visually assessed satisfaction, that is how satisfied and satiated one will be after consuming that food (Hutchings, 2012). So, from an evolutionary perspective, survival was dependent on the association of food colours with processes of food safety such as maturation, but also of food enjoyment, such as flavour (e.g., banana, apple, etc.) and taste perception (sweet, sour, bitter, salty, etc.) (Clydesdale, 1991; Spence et al., 2010).

Regarding the investigations in the food colour literature, these have been done essentially with liquid stimuli, since it is easier to manipulate the level of colour in solutions (Koch & Koch, 2003). It is known that the expected colour for a food, according to our memory, significantly influences the colour preference for that product (Lee, Lee, Lee, & Song, 2013) as well as the perception of its flavour. Thus, people expect red juices to have flavours related to red fruits, such as raspberries, and green drinks to taste like lime or mint (Dubose et al., 1980; Spence et al., 2010). When drinks have atypical colours, for example, an orange juice of green colour, people's ability to properly identify the orange flavour reduces significantly, with the responses tending to a flavour congruent with the green colour of the drink, such as lime. So, consumers tend to prefer products that have colours that are congruent with their conceptual memory (Wei, Ou, Luo, & Hutchings, 2012), and that is why foods with inadequate colours are perceived with less intense flavours and with lower quality (Christensen, 1985). Wheatley (1973) invited some guests to a dinner party consisting on a meal of steak, chips and peas. The lighting of the dining room was scarce, in order to conceal the true colour of the participants' meal. In the middle of the dinner, the illumination returned to normal, and revealed that the colour of the food had been artificially modified: a blue steak, green chips and red peas was indeed the meal served. Once the guests realized what they had been eating, several felt suddenly ill, despite the food tasting exactly what it was supposed to. So, it is really important for accepting, liking, and consume food that its colour is considered right, by the memory we have of it (Wei et al., 2012). For each person, there is an acceptable range of colours that each food can have. Foods outside this range of colours produce strong avoidance and rejection responses (Francis, 1995).

Over the years, various effects of colour in various dimensions of our behaviour have been described, namely, in food perception and food selection. However, the explanations of these colours effects duly substantiated with the possible underlying psychological mechanisms are extremely limited. Although we are aware of the practical effects of colours on foods, is still lacking the theoretical work that relates those effects with psychology, in other words, acquiring and understanding under what conditions this colour effects happen. In addition, the theoretical work does not account whether these effects are due to only one specific colour attribute or a combination of colour attributes, whereas the variation in any or all of these attributes can produce a big influence on the affect, cognition and behaviour of individuals (Elliot, 2015).

**Issues with Investigations with Colours**

The problems associated with colour investigations are mainly due to the lack of specifications of the colour measurements used, and the lack of experimental control which allows the simultaneous variation of more than one colour attribute (for example, in studies that sought to assess the impact of hue but did not control the colour measures of saturation and value). This makes dubious the results and effects obtained, and result in the impossibility of making replications and reliable comparisons between investigations (Elliot & Maier, 2014; Valdez & Mehrabian, 1994). Therefore, there is an urgent need for more controlled investigations of chromatic nature and its impact on consumer behaviours (Kareklas, Brunel, & Coulter, 2014; Labrecque et al., 2013; Lee, Deng, Unnava, & Fujita, 2014).

Moreover, the total focus of studies on the hue dimension - especially the red hue given its prominence in nature (Elliot & Maier, 2014) - suggest that the hue is the most important attribute to influence the likeability for a certain colour, however, some studies have pointed colour saturation as being the attribute that most influences likeability, arousal and colour pleasantness (Helson & Lansford, 1970; Smets, 1982; Valdez & Mehrabian, 1994).

Also, the focus of most studies on the hue attribute opens a disproportionate gap in the knowledge and investigation of other dimensions, especially colour saturation (Labrecque et al., 2013). In a review by Labrecque and colleagues (2013) of colour studies and their implications for marketing, only three of the 19 papers focused on colour saturation: Gorn, Chattopadhyay, Yi, and Dahl (1997) showed that paper ads with higher colour saturation cause greater feelings of excitement in consumers, which in turn increased the likeability and positive attitude towards the ad; Gorn, Chattopadhyay, Sengupta, and Tripathi (2004) showed that a lower colour saturation of a Web page increased the feelings of relaxation, making the loading time to be perceived as passing more quickly, as compared to a higher colour saturation condition that induced more excitement on the consumers; Finally, Labrecque and Milne (2011) refer that colour saturation used on brands' logos also have the power to influence brand personality perceptions and brand likeability, where colour saturation has a positive impact in a set of human features that are associated with the brand, such as excitement - like daring, imaginative, spirited, up-to-date - and ruggedness – like tough, strong, rugged, outdoorsy (Aaker, 1997).

Considering that colour saturation has been associated with likeability, and likeability refers to the act of liking more, being used here as a synonym of preference (Camgöz, Yener, & Güvenç, 2001), studying the effect of colour saturation of food might be relevant to inform the mechanisms underlying food preference.

**Impact of Colour Saturation on the Food Context**

People tend to like more saturated colours with respect to low saturated colours (Cohn 1894, cited by Eysenck, 1941; Guilford, 1934; Guilford & Smith, 1959), and this preference is verified in the food context, especially for red and green products (Lee et al., 2013). Some studies provide evidence to that preference. However, given the shortage of studies in the field of colour saturation in food, the impact of food colour saturation in food preference calls for further investigation.

In a subjective test of colour preference, highly saturated red foods (apple and strawberries) were preferred (Lee et al., 2013). This result has an underlying association with the fruit ripening process (and the correlated change in taste and colour), which involves the transition from the sour taste, usually green in colour, to the sweet state with red colour (Maga, 1974). Thus, people prefer red fruits with high colour saturation because of the perception that they are more likely to be mature and therefore tastier (Lee et al., 2013). A preference for green foods (cucumber and lettuce) of high saturation was also discernible, due to the greater perception of their freshness and non-contamination (Lee et al., 2013). So, these preferences for high saturated colours are associated with both inherited traits and empirical learning, which leads humans to choose accordingly to processes of maturation, safeness and freshness (Lee et al., 2013).

In another study, by Paakki and colleagues (2018), participants preferred the high colour saturated food portions, because vivid and intense colours in foods are perceived as more attractive, pleasant and appetizing. Also, Saluja and Stevenson (2018) found a positive correlation between colour saturation and the perceived flavour concentration, where more saturated colours leads to the intensification of the perceived flavour by the greater amount of pigment. Thus, colour has the ability to affect our expectations and perceptions of the sensory characteristics of foods and their acceptability (Dubose et al., 1980).

In the same direction, Dubose and colleagues (1980) studied the impact of colour saturation of beverages on flavour and taste intensity. The results showed that when solutions, such as orange juice, are of high colour saturation, they tend to arise more intense responses to taste and flavour, comparing to beverages with low colour saturation. For example, when juices show a very saturated red colour, sweetness perception increases significantly (Johnson & Clydesdale, 1982), antagonistically to green drinks that increase acidity perception (Maga, 1974), associated with the process of fruit maturation (Koch & Koch, 2003; Maga, 1974). So, consumers tend to perceived foods with more vivid colours has having more intensely flavours (Spence, 2015) and more quality due to the higher pigment content (Francis, 1995).

Moreover, colours can influence the attention level of the consumer, as well as increase their emotional arousal (Farley & Grant, 1976; Pan, 2010). It has been established by several studies that stimuli with highly saturated colours are more salient and intense, provoking a greater arousal and capturing more the visual attention of the consumer (Michael & Gálvez-García, 2011; Mizzi & Michael, 2014). This is relevant as there is empirical evidence supporting the existence of a relationship between visual attention and food intake (Hummel, Zerweck, Ehret, Winter, & Stroebele-Benschop, 2017), with attention affecting the formation of food preferences (Mitterer-daltoé, Queiroz, Fiszman, & Varela, 2014; Velazquez & Pasch, 2014). By virtue of having more pigmentation, high saturated colours stand out more than lower saturated colours (Labrecque & Milne, 2011; Labrecque et al., 2013). This means that a product is more detectable and highlighted for our attention if it is of high colour saturation, due to the higher colour contrast of the product itself with its background (Egusa, 1983). Thus, visual saliency in a stimulating environment, is able to influence our choices more than our own preferences (Milosavljevic, Navalpakkam, Koch, & Rangel, 2012). Since highly saturated colours capture more attention and generate more arousal, because they are more visible in the environment, leading to a longer duration of gaze fixation, there is a greater likelihood that that food will increase the appetite and therefore be chosen by the consumer (Wang, Cakmak, & Peng, 2018). Finally, stimuli that elicit more attention and arousal are also more likely to be stored in memory (Pan, 2010)**.**

Although saturated colours of food have advantage to preference and consumption, the high saturated colours in foods should, however, be perceived as natural in order to be liked (Paakki et al., 2018), otherwise consumers show some concerns about the safety and healthiness of foods with artificial colours, due to the possible inclusion of food additives (Tepper, 1993). The extent to which these concerns influence likeability judgments for the foods is not yet well-known (Tepper, 1993) but, accordingly to Hutchings (2003, cited by Jantathai, Danner, Joechl, & Dürrschmid, 2013) consumers reveal negative attitudes towards colour additives, preferring healthy and natural foods free from artificial colourings. So, there is the possibility that highly saturated foods are not liked if people perceive the level of colour saturation as too artificial and not congruent with their conceptual memory, leading to the perception of food colour additives that might be harmful to their health. In this context, Mead and Richerson (2018) investigated the impact of colour saturation of food packaging on the perception of healthiness of the products themselves. The results show that consumers perceive a lower healthiness of the foods of the packages with highly saturated colours. Since highly saturated colours are likely to stimulate greater arousal in consumers (Gorn et al., 1997; Labrecque et al., 2013) marketers often use more saturated packaging to display unhealthy food. In this way, we are accustomed to a repeated exposure of unhealthy foods in packages with more vivid colours (Mead & Richerson, 2018).

**Colour Saturation and Weight Perception**

The ability to predict the weight of a given object is influenced by the daily contact we have with the physical world (Saccone, Goldsmith, Buckingham, & Chouinard, 2019). However, as the task of consciously judging the weight of a given object is uncommon in our daily lives, it does not play a decisive role in our development (Buckingham, 2014). Thus, consumers make weight judgments in a quick and automatic way, mobilizing very few resources to search for adequate information, generally leading to rather inaccurate judgments about the actual weight of a given object (Buckingham & Goodale, 2013; Folkes & Matta, 2004).

The perception of an object's weight has associated an expectation, or perceptual prediction of how heavy it is, and that expectation is influenced by factors such as its size, material, colour, and other attributes (Buckingham & Goodale, 2013; Ross, 1969). This expectation arises from past experiences and prior knowledge where there was contact and familiarization with objects of similar characteristics (Gordon, Westling, Cole, & Johansson, 1993).

The size of an object is one of the properties that most influences our perception of weight, since throughout our life, by our contact with the natural world, the association that the largest of two objects generally weighs more, is learned and reinforced (Buckingham & Goodale, 2010; Buckingham & Goodale, 2013). So, this statistical regularity present in our environment leads us to predict that the larger object exceeds the weight of the smaller object (Buckingham, 2014).

Concerning the property of colour, Alexander and Shansky (1976), interested in the issue of colours appearing to have a given weight, addressed the contribution of the three colour attributes to this perceptual process. Although the influence of colour on the apparent weight of an object is relatively small (DeCamp, 1917), only the attributes of colour saturation and value are determinant for colour weight perception, where perceived weight decreases as a function of value, but increases as a function of colour saturation (Alexander & Shansky, 1976).

Throughout several experiments using geometric objects and consumer products with various shapes and hues, the Hagtvedt and Brasel's (2017) study showed colour saturation influencing the perceived size of an object. In study one, a pair of cubes with high and low colour saturation were presented simultaneously on the computer screen, where participants had to choose which of the cubes looked larger. In study two, the participants estimated the size of various geometric figures with high and low saturated colours, while their attention was measured via eye tracking. In study three, the participants estimated the laptop's screen size, either of high or low colour saturation and then reported, using a scale, in what extent the laptop was attention-getting and captured their attention and how arousal they felt. In all studies, they concluded that consumers perceive objects with highly saturated colours of a larger size, relative to the same objects but of low saturated colours. According to their interpretation of the results, this effect arises because stimuli with highly saturated colours are more salient and intense, causing a greater arousal which, in turn, leads to greater attraction and capturing of attention; this greater attention to object with high saturated colour leads to the perception that the stimulus is bigger (Hagtvedt & Brasel, 2017). This relationship between perceived size and attention is bidirectional, since stimuli with a bigger size attracts more our visual attention (Pieters & Wedel, 2004), and stimuli that capture our attention are also perceived as bigger in relation to stimuli of the same size but which receive less attention (Folkes & Matta, 2004).

Similarity, Folkes and Matta (2004) examined how packaging can influence perceptions of product quantity. The packages that attract the most attention are perceived as containing a larger volume of product, compared to packages of the same size but that do not capture consumers' attention so much. This was verified for different packaging, placed in different contexts and with different contents.

So, the perceived weight of the products might play a role in the likeability for those products, since it is known, that larger portions, that tend to weigh more compared to smaller portions, are considered visually more attractive, induce a greater desire of consumption and are often selected more than smaller portions (Burger, Cornier, Ingebrigtsen, & Johnson, 2011; Sharpe, Staelin, & Huber, 2008). The reason behind favouring larger portions might be correlated with: visual illusions, such as the Delboeuf's illusion (1865, cited by Van Ittersum

& Wansink, 2012) which showed that when two identical circles are surrounded by circles of different sizes, one larger than the other, people perceive a different size of the inner circles. For example, when the same amount of soup is served on plates with different size edges, it creates the illusion that the smaller plate has more soup than the other; the increased value of money by the possibility of eating more; the desire to signal higher social status by eating larger portions; the actual hunger; and the bias calorie content estimations (Dubois, Rucker, & Galinsky, 2012; Fisher & Kral, 2008; Kral, 2006; Wansink, 2004).

**Aims and Hypotheses**

In order to assist and expand the knowledge regarding food colour saturation, the main objective of this research is to study how colour saturation of natural and cooked foods influences their perceived weight and likeability and explore if there is a mediational effect of the food perceived weight on food likeability. Thus, the methodology consists in presenting a set of images of edible (natural and cooked) and inedible products (objects), testing the role of colour saturation by varying the colour saturation levels of the displayed images (high colour saturation vs. low colour saturation).

The specific objectives of the present investigation are: 1) study the effect of colour saturation on the likeability, for both natural and cooked food products and objects, with different levels of colour saturation. We include the object's category with the status of fillers' stimuli, in order to mask the real purpose of studying the colour saturation in food; 2) corroborating that weight and size are associated measures, we used the assumptions from Hagtvedt and Brasel (2017)'s study to predict and investigate how colour saturation may influence the perceived weight of natural and cooked foods and objects. As their study was the first one to demonstrate a positive relationship between colour saturation and perceived size of objects, we decide to include in this analysis the object's category in order to validate this relationship; 3) since people tend to like foods that are perceived bigger, and in turn heavier, we want to explore if the impact of colour saturation on food likeability is mediated by the perceived weight of that food; 4) if colour saturation has, in fact, a positive impact on the perceived weight, then we want to study if people will choose more often smaller portions of high colour saturation, by the fact that those are perceived as having a bigger size.

Unlikely the majority of the previous studies, our study innovates by focusing on the colour saturation attribute alone, not limited to specific hues, like red or green. Also, we focus on colour saturation' impact on products preference and we included both natural and cooked food products, since these are the only two forms that we contact with food, to see if colour saturation impacts equally across them. It is also relevant to point out that we checked if this colour saturation impact, in both likeability and perceived weight, is extendable to other categories beyond food, such as objects. In the aforementioned literature, studies show that the impact of colour saturation on food preference is due to attentional and perceptual mechanisms, whereas in this work we propose the perceived weight as a possible mediating mechanism between colour saturation and likeability.

The hypotheses of the present study are as follow:

H1: People like more foods (natural and cooked) and objects with high saturated colours than with low saturated colours.

H2: Foods (natural and cooked) and objects with high saturated colours are perceived heavier than with low colour saturation.

H3: Colour saturation impacts food likeability mediated by the perceived weight of food.

H4: High colour saturation cooked foods are chosen more often in smaller than in larger portions.

CHAPTER I

# Method

## Overview

The methodology consisted of a questionnaire created in Qualtrics (www.qualtrics.com), divided into three phases. The informed consent and the instructions of the tasks were presented at first, with a cover story for studying the colour saturation in food.

The first phase intended to evaluate the likeability and perceived weight of edible and inedible products, with two different levels of colour saturation. For that purpose, we presented real images of natural and cooked food items, and images of objects, for which the colour saturation was manipulated, creating a low and a high colour saturation version. The approach to display food images, being methodologically simpler than the manipulation of real foods (Rodríguez-Martín & Meule, 2015), is a useful tool for the study of appetite and food behaviour, since we often contact and interact with food through visual cues (Woodward, Cameron, & Treat, 2016).

The second phase consisted on two online food simulations of real consumer situations: buying natural food products in a supermarket and preparing a plate with cooked food products in a self-service restaurant, again with food images of two different levels of colour saturation.

At last, the third phase aimed to assess the perceived healthiness of some edible products with two different levels of colour saturation. Between the first and second phases, sociodemographic data and control measures were collected, which served also as a distracting task. To conclude, we thanked the individuals for their participation and invited them to give their feedback regarding the experience, as well as their guess for the actual purpose of it. It was clarified that they would receive an email with the debriefing of the study. We also provided an email address if they would like to know more about the study or in case they had any question.

## Participants and control measures

A power analysis was performed using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) to determine the sample size needed to detect a medium effect (Hagtvedt & Brasel, 2017) using a repeated measures design. To detect an interaction effect with an alpha of 5%, and power at 80% (Mayr, Buchner, Erdfelder, & Faul, 2007), the required sample size was 33 participants. However, we were able to collect 48 participants of the university students' pool (ISCTE - Instituto Universitário de Lisboa), in exchange for one course credit. Of the total sample, 42 were female (82.50%). The participants' ages ranged from 17 to 27 years old ($M$ = 19.50; $SD$ = 2.33). Concerning nationality, one participant was Guinean (2.10%), another one Brazilian (2.10%) and the remaining were Portuguese (95.80%). About the place of birth, 43.80% were from Lisbon and the other 56.20% had a different place of birth, predominantly from the south of the country. The Mediterranean cuisine, as expected, was the predominant in the whole sample (100%) (Figure 1.1). According to the described nationality, place of birth and the typically diet practiced, we were able to ensure that participants were familiar and used to consume the food products we were going to present.

The height of the participants was in average 166 centimetres ($SD$ = 0.09). The determination of the mean height took only the responses of 39 participants, as nine participants indicated a 100 centimetres height and, therefore, these answers were not taken into the determination of the mean. The mean weight was 61.42 kilos ($SD$ = 13.57 kilos). The Body Mass Index was calculated for the 39 participants, that resulted in an average of 22.41 ($SD$ = 4.38), representing a sample within the healthy weight. Although very close to the normal range, eight participants were overweight and, despite some studies suggesting that overweight individuals have a large attentional deviation for foods with high calorie content (Castellanos et al., 2009), the methodology used in this study - the presentation of each image individually - allowed to account their responses.

We used the following criteria to include participation in this study: individuals with 1) no diagnosis of colour blindness or other uncorrected vision problems; 2) no diagnosis of attention deficit or eating disorders; 3) an omnivorous diet; 4) no weight loss regime at the time; 5) fluency in the Portuguese language. Only five participants reported having food allergies to lactose, chocolate, corn or strawberries. As none of the edible stimuli used in this experiment concerned these products, which could influence the answer of their likeability, the responses of these participants continued to be considered.

Especially relevant for our two simulation situations (the restaurant and the supermarket simulations), were the questions regarding the participants' eating out habits and buying fresh foods at the supermarket. Particularly because these data provide information regarding contact with natural foods, and estimation of weight. Most of the participants purchase natural foods (Figure 1.2) regularly or with some frequency, and only a minority (less than 20%) reported doing it only occasionally, rarely or never. Also, when questioned about the number of times per month they usually go out to eat (Figure 1.3), almost half of the participants reported eating out two to three times, around 40% reported eating out more often, and only around 10% eat out never or only once. This shows that the sample has the habit of eating out, being often in contact with situations that require decisions regarding food consumption and food preference, especially relevant for the restaurant simulation.

To control for the fact that participants who were worried about food appearance could perceive differently the likeability of the food with different colour saturations, we included a question about concerns regarding the food appearance, i.e., the naturalness versus the artificiality of foods. More than half of the participants reported to be always or often concerned about the food appearance, whereas only around 12% rarely or never cared about it (Figure 1.4).

Additionally, we also controlled for the fact that some participants may be more interested about or more familiar with food. Thus, data show that half of the sample refers visiting internet pages with food themes sometimes (Figure 1.5). Framing participants' interest in food (1 = *Nothing interested* to 10 = *Very interested*), a high level of food interest was reported (*M* = 7.63; *SD* = 2.25).

Overall, participants reported being concerned about their health, weight and diet, and about the impacts that their diet has in their health and weight (Figure 1.6).

We controlled for the level of hunger and thirst felt at the time of the study (1 = *No hunger/thirst* to 10 = *Very hungry/thirsty*), with participants being medium hungry and thirsty (*M* = 5.54, *SD* = 2.49; *M* = 5.19, *SD* = 2.39, for hunger and thirst respectively). The last meal/snack consumed, had been more than 4 hours before the study for most of the participants (Figures 1.7).

**Phase 1**

**Experimental design.** The experimental design was a 3 (stimulus: natural food items, cooked food items, objects) x 2 (colour saturation: high, low), with both factors within-participants. The option for a within-participants study allows a greater sensitivity of the experimental manipulation, since it reduces the entry of extraneous variables and makes it possible to do comparisons between the various phases of the study (Charness, Gneezy, & Kuhn, 2012).

**Procedure.** The experiment was registered in the Participation' System in Psychological Research (SPI) of the Department of Social and Organizational Psychology at ISCTE-IUL. Information was given about the objective and main tasks of the study, its duration, the credits assigned to the students, as well as the definition of the participation requirements. The study was conducted in a total of seven sessions of 60 minutes, with a maximum of seven participants each. This experiment was prepared and conducted in Qualtrics© (November 7-8, 2018).

Informed consent clarified that the study was about the evaluation of several images of edible and inedible products, for which the participants had to indicate the perceived weight and the likeability. Participants were also informed about anonymity, data confidentiality and that they could leave the study at any moment. Only those who agreed with this informed consent (Appendix A) could continue their participation in the study.

Then, initial instructions explained that several images of edible and inedible products would be presented, individually and for a very short time, preceded by a black cross, on the computer screen. For each image, they should evaluate the perceived weight of the item and indicate how much they like that product, through scales using the computer mouse. They were warned for the repetition of images and to give their answers spontaneously and quickly (Appendix B).

To familiarize the participants with the procedure, the experiment started with a practice trial, using two fixed non-food stimuli, which were not included in the analyses of the results. When the practice trial was completed, a set of 30 images selected for the study (12 natural food stimuli, 12 cooked food stimuli and 6 objects stimuli) was randomly presented on the computer screen, one by one, in both versions of high and low colour saturation. The selection of this number of trials was based on Hummel and colleagues (2017)' article, that adopts a similar paradigm, and enables the representativeness of the answers, while not being very fatiguing. Each trial began with the presentation of a black fixation cross, at the centre of a white background screen, for one second. After this, a stimulus was presented, also in the centre of a white background screen and for one second. Finally, the response scales to assess the perceived weight and the likeability for each stimulus were presented simultaneously, with no time counting for the responses, and randomized for each trial (Figure 1.9). Slider scales were used where the responses were given by varying the value of the bar, using the computer mouse. Also, the response to both scales was mandatory, and only then could the participants advance to the next trial, by pressing the respective button. The random presentation of the stimuli, of the colour saturation levels and of the two response scales was important to eliminate and control possible order effects, such as learning and fatigue, from one condition to another (Salkind, 2010).

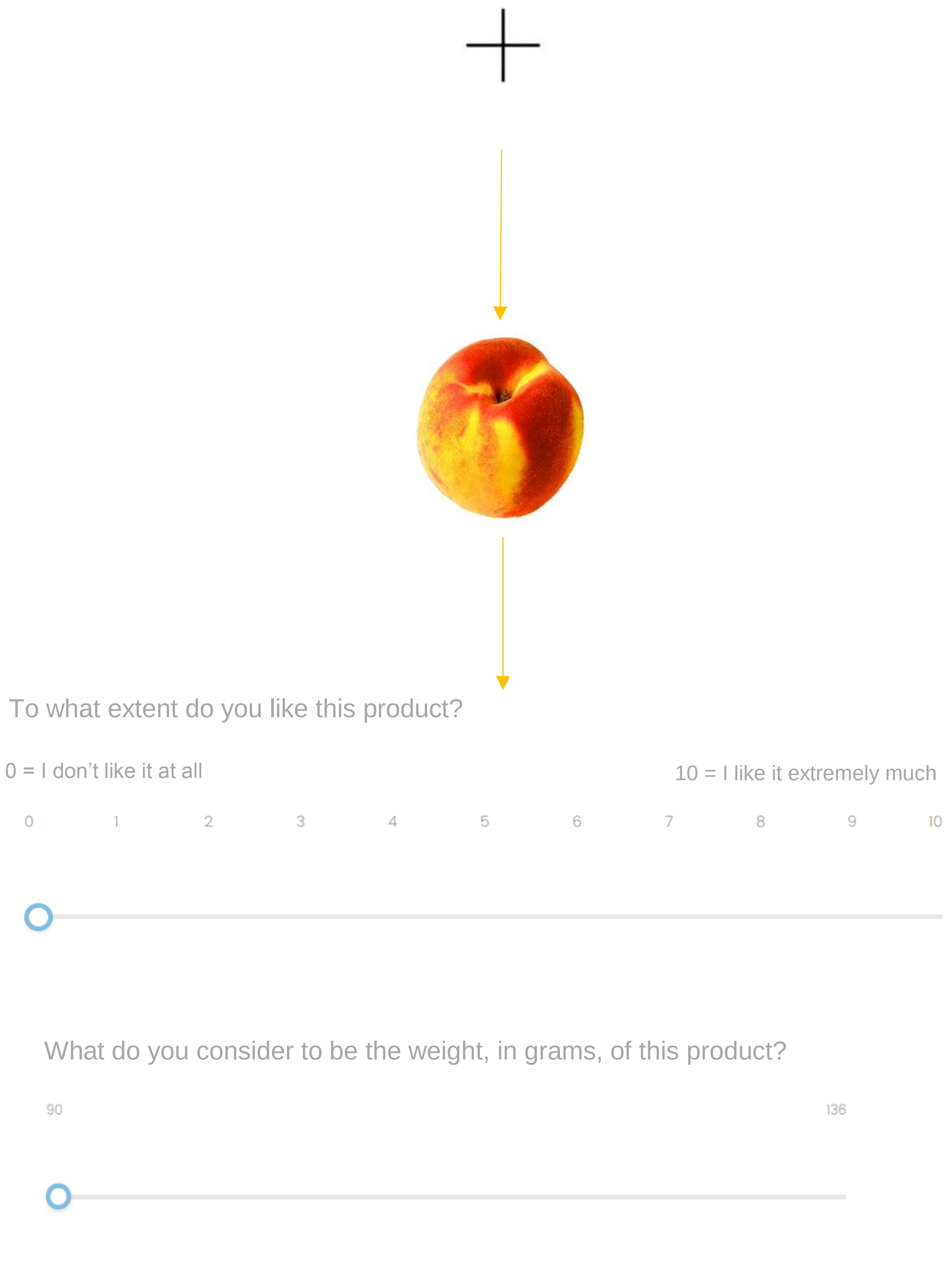


*Figure 1.9.* Schematic illustration of the experimental procedure and example stimuli.

At the end of the first phase, participants filled out the sociodemographic questionnaire and control measures, with all the questions randomized (Appendix C and Participants and control measures). This worked also as a distractive task between the first and second phases of this experiment.

**Dependent variables.** The dependent variables were the likeability for the items presented and their perceived weight.

***Likeability***. For each item participants reported in a 11-point Likert scale how much they liked each item (*To what extent do you like this product*), ranging from 0 (I do not like it at all) to 10 (I like it extremely much). New variables were created with the means obtained for the likeability, for the high and low levels of colour saturation, of natural foods, cooked foods and objects.

***Perceived weight***. Participants were also asked to report the perceived weight (in grams) of each item (*What is the weight (grams) of this product?*). Given that our food items differed greatly on their weights, each item was standardized within an interval based on its average weight - information obtained on several supermarket websites - ranging ± 20% of the average weight for the extremes (Figure 1.10). These extremes where the only values shown in the response scale, as a reference to help the participants with the weight estimation. Thus, taking the example of an *onion*, of which its average weight is 180gr (midpoint), the interval was anchored between 144gr (- 20%) and 216 (+ 20%). Considering the interval, participants had to estimate the perceived weight for each item. To compute a consistent index of perceived weight across items, we subtracted the estimated value by the average weight of the item (e.g., if a participant reported the perceived weight of an onion being 198gr: 198 – 180 = 18) and divided it by the maximum value of the deviation (20% of 180gr = 36; thus, 18/36 = 0.50), creating an index between -1 and 1. The value of zero means that participants perceived the weight of the item exactly as average. Positive values mean that participants perceived the item as weighting more than average; negative values mean that participants perceived the item as weighting less than average.

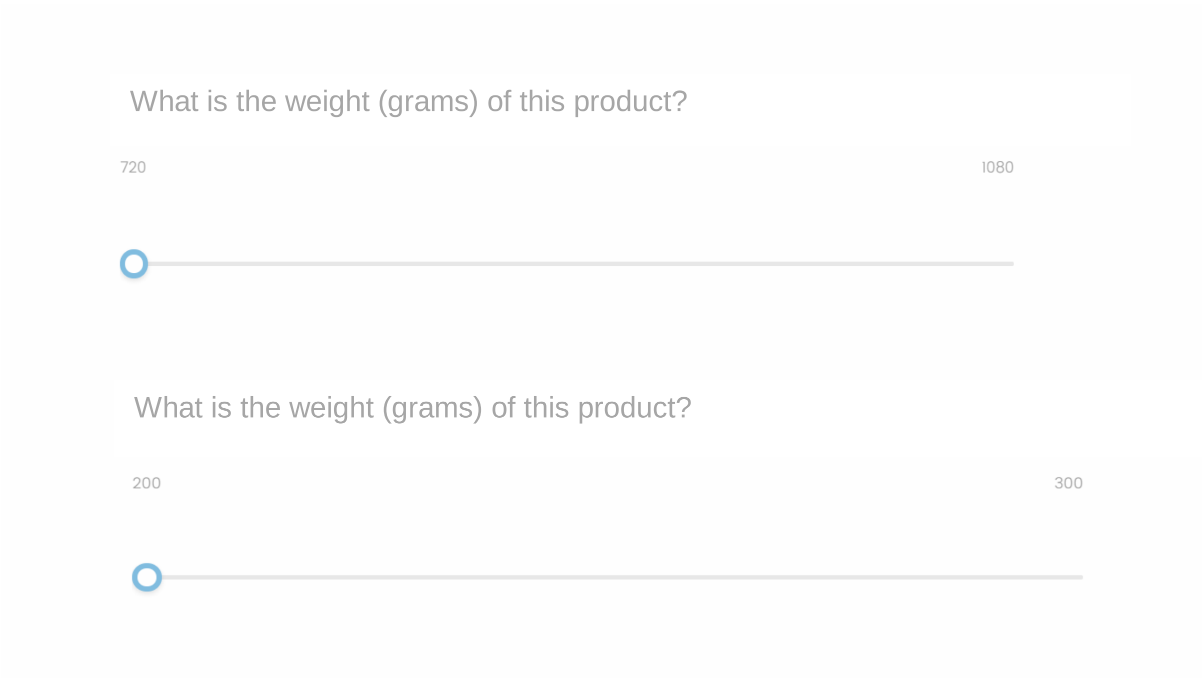


*Figure 1.10.* Examples of weight scales used in the experiment for a cantaloupe (above) and for a raw beefsteak (below).

**Stimulus Materials.** For the selection of different types of items, we used real 3D photographs of the Food Pics database by Blechert, Meule, Busch and Ohla (2014), for which access and use was authorized by the authors. We opted by using an already existing database because the existence of a standardized and validated image library allows the replication of studies and improves the comparability of results between investigations and populations (Rodríguez-Martín & Meule, 2015). This database, validated for an adult German-speaking (Germany, Austria and Switzerland) and United States population (N=1988), includes 568 coloured images of edible products and 315 images of inedible products, with a resolution of 600 x 450 pixels. As for the edible products, this database integrates images of foods from different types of cuisines, making it possible to use them in various countries and populations, that have a different feed (Jensen, Duraccio, Barnett, & Monroe, 2016). All images are standardized with a white background, with a viewing distance of approximately 80 centimetres, and a simple figure-background composition. We used eight objects of the images of inedible products of this database (Appendix D) with the status of fillers' stimuli, in order to mask the real purpose of studying the colour saturation in food.

For the edible set of images to be used in this experiment, we considered the validation that Prada, Rodrigues, Garrido and Lopes (2017) made of a subset of 210 edible images of the Food Pics database for the Portuguese population (N=307) . Since Portugal traditionally follows a Mediterranean diet (Dernini & Berry, 2015), Prada and colleagues (2017) only used the edible images typical of this cuisine. For our study, images composed by more than one food product (e.g., fruit salad) and images of beverages, sweets, cereals, cheeses and sushi, that involve a composite of several food products, were avoided. From the remaining, we considered two different sets of images: those from natural foods (with no degree of processing) and those from cooked foods. Also, we chose images from three food groups: fruits, vegetables and animal products. All images selected and the set of images created scored, in the validation for Portugal, a high and similar average (>5) for the dimensions of Liking, Familiarity, Desire to Eat and Frequency of Consumption (Appendix E), for their strong association with food consumption preferences (Drewnowski & Hann, 1999). Thus, the condition of natural foods comprised 12 stimuli of three food groups (Appendix F): fruits (cantaloupe, kiwi, peach and almonds), vegetables (cauliflower, zucchini, squash and onion) and animal (eggs in egg board, salmon, raw chicken and raw beefsteak). The condition of cooked foods also included 12 stimuli from two food groups (Appendix G): vegetables (French fries, potatoes wedges, cooked carrots and cooked peas) and animal (roasted canard, roasted chicken, cutlet, salmon, shrimp, hamburger, pizza and spaghetti Bolognese). So, for this first phase, we counted with a set of 30 images.

The Adobe Photoshop CC 2017 was used to manipulate the levels of the colour saturation of the selected set of images, keeping constant the remaining properties, namely size, shape, value and hue (Hagtvedt & Brasel, 2017). This software helps with the optimization and control of the measures of colour attributes, by enabling the introduction of specific numerical values for hue, saturation and value (Elliot & Maier, 2014). For each image was created a low colour saturation version, this is, a level below the normal (-50) and a high colour saturation version, with the colour saturation above the normal one (+50) (Figure 1.11). See more on Appendixes D, F and G. All materials were created in JPEG format and RGB mode.

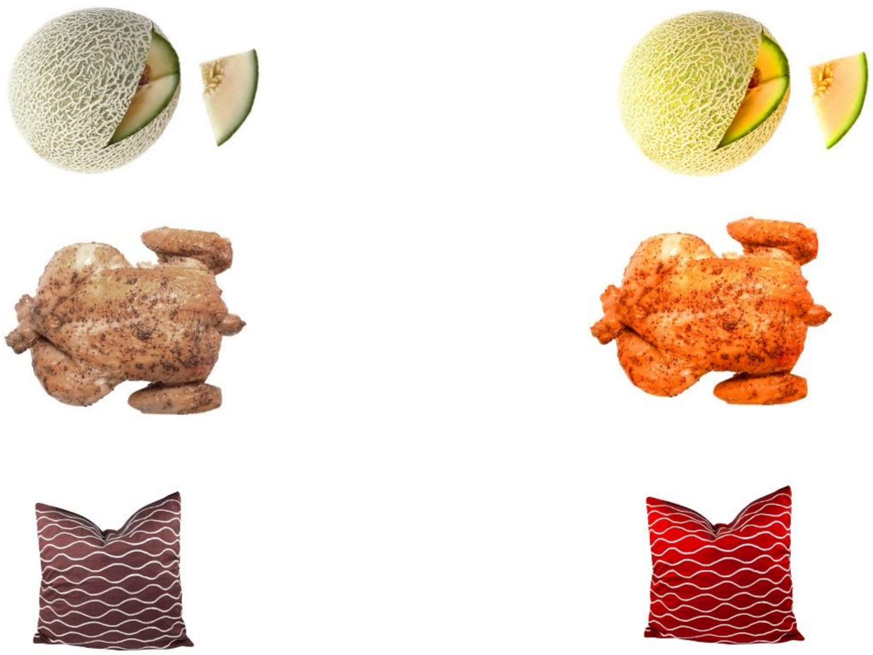

*Figure 1.11.* Examples of the type of stimuli (natural foods, cooked foods and objects) used in the experiment.

**Phase 2**

The objective of this phase was to verify if the results obtained in Phase 1 would be replicated in online simulations of real consumer situations, namely a supermarket and restaurant simulation. We did so in order to increase the ecological validity of our study. The supermarket simulation covered only natural food stimuli, whereas restaurant simulation only included cooked stimuli. The presentation order of the supermarket simulation and the restaurant simulation was randomized.

**Supermarket simulation.**

***Experimental design.*** This part of the experiment was a single factor within-participants experimental design, with the only factor being the colour saturation (high versus low).

***Procedure.*** For this simulation, created in Qualtrics, a set of eight food products, in their version of high and low colour saturation, were randomly and simultaneously presented in a four-column configuration in a white background, with no time counting. Participants were instructed to select, with the computer mouse, six from the 16 products shown, that they would want to place in their simulated grocery shopping cart. Once this selection was done, participants had to press the go forward button, and then the six products selected were shown, for the participants to estimate the weight, in grams, of one unit of each product. This was done by inserting a value, by typing the computer keyboard, in a box text below each stimulus (Appendix H).

***Dependent variables.*** The dependent variables were the food choice and the perceived weight of the products selected.

*Food choice.* We consider the variable of food choice based on the decisions made by the participants, accordingly to their likeability for those products. These choices could fall on products of high or low colour saturation, so we proceeded to sum the totality of choices that fell on products of high colour saturation and the sum of the totality of choices regarding only the products of low colour saturation.

*Perceived weight*. The perceived weights (in grams) reported for the food items selected by the participants, that were averaged separately for the total of low colour saturation products selected, and for the total of high colour saturation products selected.

***Stimulus Materials.*** Eight food stimuli (apple, banana, pear, orange, tomato, potato, mushrooms and broccoli) were used (Appendix I) from the set of Food Pics database validated for the Portuguese population (Prada et al., 2017), different from the ones used in the first phase, but according to the same selection criteria (Appendix J). Fruits and vegetables products were the only stimuli considered, as these are frequently bought from supermarkets. In addition, we ensured that the natural vegetables presented in the supermarket simulation had a homologous version in the restaurant simulation, as a cooked product. The measures of the colour saturation levels in this simulation were determined as in the first phase.

### Restaurant simulation

***Experimental design.*** This part of the experiment was a single factor within-participants experimental design, with the only factor being the colour saturation (high versus low).

***Procedure.*** In this simulation, created in Qualtrics, all the stimuli were presented in a single column, with no time counting, in the same order for all participants, which started with the carbohydrates group (n = 5), followed by the animal group (n = 4), and finishing with the vegetables group (n = 4). Participants had the instruction to scroll down with the computer mouse to see all the 13 stimuli. For each stimulus, both colour saturation versions of the smallest portion size were presented at first, followed by both versions of the next bigger portion size, and finishing with both colour saturation versions of the biggest portion size. We took into account the balancing of the colour saturation version presented at first for each portion size. The task was presented as participants composing the dish for their lunch, as if they were in a self-service restaurant, where they should choose five food products from the 13 shown. They should also decide the portion-size they wanted for the stimuli they have chosen. To do this, they would simply have to drag, with the computer mouse, the images of the food products, and respectively portion-size, to the area designed as “your dish” (Appendix K). In addition, in the text box below each portion size selected, participants provided an estimate of the weight, in grams, by typing the computer keyboard.

***Dependent variables.*** The dependent variables were the food choice and its perceived weight.

*Food choice.* We consider the variable of food choice based on the decisions made by the participants, accordingly to their likeability for those products. These choices could fall on cooked products of high or low colour saturation. Therefore, we proceeded to sum the totality of cooked products with high colour saturation chosen and the sum regarding the totality of products of low colour saturation chosen. We also sum the totality of products chosen, as a function of each portion size, regarding both levels of colour saturation.

*Perceived Weight*. We averaged the estimated perceived weight for the total of low colour saturation products selected, and the average of the estimated perceived weight given for the total of high colour saturation products selected. We also averaged the estimated perceived weight as a function of each portion size, again taking into consideration both levels of colour saturation. To help with the interpretation of the data, portions were aggregated into two single sizes: Small and Big. Thus, the smaller portions presented, i.e., sizes 1 and 2, were grouped into the same level (small), and the larger portions, i.e., 3 and 4, were grouped into the same level (big).

***Stimulus Materials.*** Because we were interested, in this simulation, in considering the size of the food portion, the database used for the selection of items to Phase 1 and to the supermarket simulation was not adequate. Thus, for the restaurant simulation we used images from the Atlas Abu Dhabi Food (2014) which, in addition to being available for free, integrates several cooked foods typical of the Mediterranean diet and comprises eight portion size options. From this Atlas, 13 stimuli were selected from three food groups: vegetables (mushrooms, broccoli, peas and carrots), animal (pork loin, steak, fish and fillet of fish) and carbohydrates (fried potatoes, roasted potatoes, white rice, spaghetti and noodle). For each stimulus, we use four portion-sizes out of the eight options (indexed in the Atlas with the numbers .1, .3, .5, .7; Appendix L) so the experiment was not too long. For each portion-size of each stimulus, a high colour saturation version and a low colour saturation version were created. Given that a different data basis of images was being used, the colour saturation values were now 25 below or above the standard image (instead of ±50, as in Phase 1 and in the supermarket simulation). This was due to the reduced quality of the images, that gave a wrong appearance to the food if the same high and low colour saturation measures of the previous phases were used.

**Phase 3**

The objective of this phase was to perceive if colour saturation of food has an impact on its perceived healthiness, that may influence food likeability.

**Experimental design.** This part of the experiment was a single factor within-participants experimental design, with the only factor being the colour saturation (high versus low).

**Procedure.** In this task, also created in Qualtrics, six images (three of high colour saturation and three of low colour saturation) of edible products were presented, individually and randomly, in the centre of a white background computer screen. The image and response scale appeared simultaneously, with no time limit, and the response was given on a slider scale, varying the bar using the computer mouse. As soon as the participants gave the answer, they clicked on the respective button to move to the next image (Appendix M).

**Dependent variable.** The dependent variable was the perceived healthiness for each food product shown.

***Perceived Healthiness.*** For each item participants reported in a 10-point Likert scale how healthy the item was (*How healthy do you think this product is?*), ranging from 1 (Not healthy) to 10 (Extremely healthy). New variables were created with the averages obtained for the perceived healthiness for the high and low levels of colour saturation.

**Stimulus Materials.** From the images set of edible stimuli, both natural and cooked, already presented in Phase 1 and in supermarket simulation, Qualtrics randomly selected a subset of six stimuli for each participant. Three of the items were necessarily of low colour saturation and the other three of high colour saturation, with the same measures of colour saturation levels (±50). The items of low and high saturation could refer to the same food product, due to the randomization.

CHAPTER II

## Results

We conducted separate statistical analysis for each research question and phases of our study using the Statistical Program for Social Sciences (SPSS) version 24.0.

### Descriptive statistics and intercorrelations

The dependent variables of the Phase 1 of this study were the likeability and the perceived weight for each item presented. We proceeded to analyse the correlations between these dependent variables and all the control variables (Table 1), to assess the strength of association between these variables and the direction of that relationship. We used the Pearson rank correlation, since our data follows the requirements to use this parametric test: being our $n > 30$, we can assume a normal distribution of the variables and being the scale of the variables interval, they can be treated as continuous (Salkind, 2010). There is only a significant and moderate positive relationship ($r = .36$, $p = .012$) between the likeability and the age of the participants. The likeability is not significantly correlated with any other variables of interest, as it can be seen in Table 1. Also, the perceived weight is not significantly correlated with the likeability for the products ($r = .20$, $p = .18$) neither by any of the control variables (Table 1).

Table 1

*Pearson Rank Correlations Between the Dependent Variables (Likeability and Perceived Weight) and the Control Measures*

| | **Likeability** | **Perceived Weight** |
|---|---|---|
| Likeability | | .20 |
| Perceived Weight | .20 | |
| Perceived Health | .21 | .11 |
| Age | **.36*** | .11 |
| Weight | .15 | .01 |
| BMI | .12 | .04 |
| Number of times, per month, the sample goes out to eat | -.03 | .12 |
| How often does the sample buy natural foods | -.10 | .04 |

| | | |
|---|---|---|
| How concern is the sample regarding food appearance (artificiality vs naturalness) | -.13 | .03 |
| How interested is the sample about food | .22 | -.05 |
| How often does the sample visit pages sharing photos of foods | .14 | .21 |
| Concerns about diet, health and weight | .12 | -.01 |
| Level of hunger during the experiment | .24 | .13 |
| Level of thirst during the experiment | .05 | -.27 |
| Time since the last meal consumed | .11 | .04 |
| Time since the last snack consumed | -.22 | -.09 |

*Note.* The values correspond to the Pearson correlations between the dependent variables and the control variables measure in the distraction task ($n$ = 48)

*. Correlation is significant at level 0.05 (bilateral)

**The effect of colour saturation on likeability**

With the objective to study the effect of colour saturation on food likeability, we investigated the hypothesis that people like more natural and cooked food products, as well as objects, with high saturated colours (vs. low saturated colours). In order to study this effect, a GLM Repeated-Measures ANOVA was performed, with a 3 (stimulus: natural food items, cooked food items, objects) X 2 (colour saturation: high, low) within-subjects factorial design.

The results showed a statistically significant main effect of colour saturation on the likeability, $F(1, 47) = 17.29$, $p < .001$, $\eta_p^2 = .27$, suggesting that participants reacted differently to the likeability of the products depending on colour saturation. Overall, participants liked more the high saturated products ($M$ = 5.77, $SE$ = 0.15) when compared to the low saturated products ($M$ = 5.46, $SE$ = 0.11). The main effect of type of stimulus was also statistically significant, $F(2, 94) = 30.32$, $p < .001$, $\eta_p^2 = .39$. Generally, participants reported higher levels of liking for the cooked food items ($M$ = 6.60, $SE$ = 0.19), followed by the natural food items ($M$ = 5.30, $SE$ = 0.17, $p < .001$) and by the objects ($M$ = 4.94, $SE$ = 0.25, $p < .001$), but natural food items did not significantly differ from objects ($p$ = .147). These two main effects were then qualified by a statistically significant interaction effect of colour saturation by stimulus type, $F(2, 94) = 15.11$, $p < .001$, $\eta_p^2 = .24$. Pairwise comparisons showed that colour saturation only exhibited different likeability patterns for food related items and not for objects. Specifically, for natural food items participants liked more the high saturated items than the low saturated items ($p$ = .007). Similarly, for cooked food items participants reported a higher likeability when the stimuli were high saturated in colour when compared to stimuli which were low saturated in colour ($p$ < .001). On the contrary, no differences were found to be significant for objects according to colour saturation ($p$ = .747) (Figure 2.1).

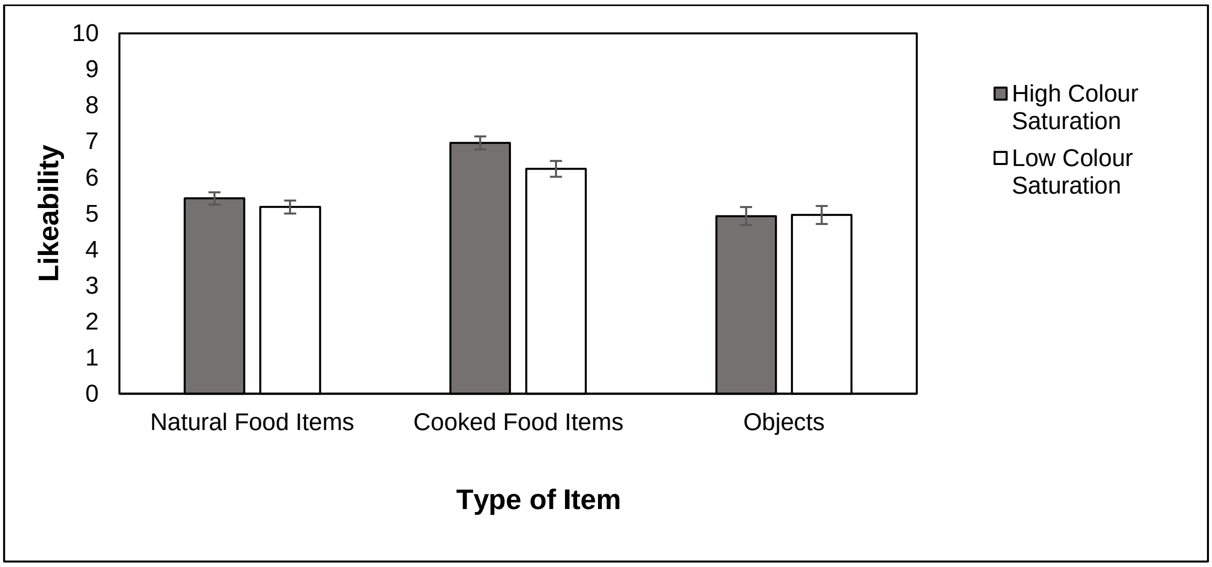


*Figure 2.1.* Likeability for edible and inedible products regarding both levels of colour saturation ($n$ = 48). Bars represent standard errors.

In sum, the colour saturation produced a significant effect on the likeability of the products, but only for the edible ones, both natural and confectioned.

Considering that the age of the participants was significantly correlated with the likeability, we conducted the same analysis controlling for age. Results revealed that even after age was entered as an additional independent variable (control), colour saturation affects significatively the likeability of both natural and cooked items, but not of objects, as stated in the previous analysis, $F(2, 92) = 4.10$, $p = .030$, $\eta_p^2 = .08$.

**The effect of colour saturation on the perceived weight**

With the objective to study the effect of colour saturation on the perceived weight, we investigated the hypothesis that natural and cooked food items and objects with high saturated colours (vs. low saturated colours) were perceived heavier. In order to study this effect, a GLM Repeated-Measures ANOVA was again conducted, with a 3 (stimulus: natural food items, cooked food items, objects) X 2 (colour saturation: high, low) within-subjects factorial design.

The main effect of type of stimulus was statistically significant, $F(2, 94) = 12.11$, $p < .001$, $\eta_p^2 = .21$. Generally, participants reported a higher perceived weight for the objects ($M = -0.27$, $SE = 0.04$), followed by the cooked food items ($M = -0.15$, $SE = 0.04$, $p < .001$) and by the natural food items ($M = -0.15$, $SE = 0.04$, $p < .001$), but cooked food items did not significantly differ from natural food items ($p = .77$). Remember that the negative values of the mean in each stimulus type, imply that participants perceived the items as weighting less than their real average weight. The results did not show any statistically significant main effect of colour saturation on the perceived weight, $F(1, 47) = 1.54$, $p = .22$, $\eta_p^2 = .03$. Furthermore, there was no statistically significant interaction effect of colour saturation by stimulus type, $F(2, 94) = 0.69$, $p = .50$, $\eta_p^2 = .02$ (Figure 2.2).

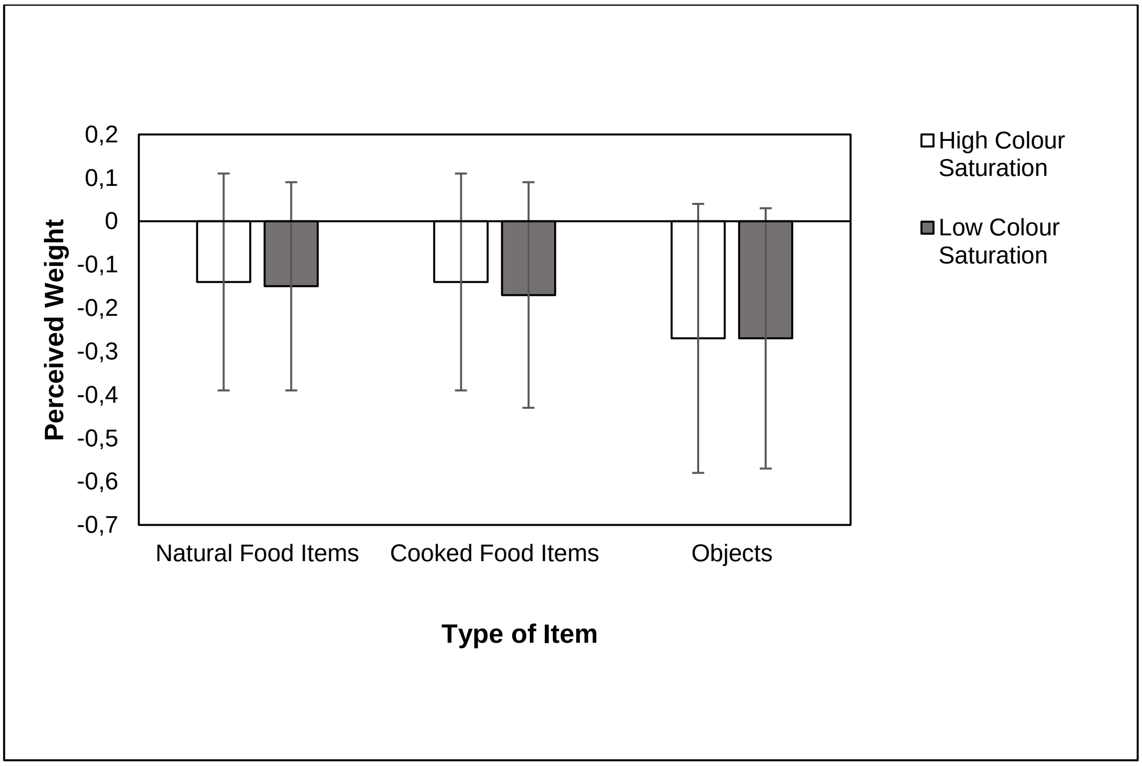


*Figure 2.2.* Perceived weight for edible and inedible products regarding both levels of colour saturation ($n = 48$). Bars represent standard errors.

In sum, colour saturation does not produce any difference on the way weight is perceived for both, edible and inedible products.

**Perceived weight as mediator**

Concerning our predicted model of mediation, this was impaired due to inexistence of a statistically significant effect of colour saturation on the perceived weight and any statistically significant correlation between the perceived weight and the likeability (Table 1, p.29).

**Supermarket Simulation**

For the data of the supermarket simulation, we investigated the hypothesises that participants would choose/like more and make higher weight estimates for the high colour saturation food products (vs. low colour saturated products). For this, we compared the number of natural products selected of high saturated colours and of low saturated colours, as well as the perceived weight given for the products chosen (of high colour saturation vs. low colour saturation).

Overall, 135 natural products of high saturated colours and 153 natural products of low saturated colours were chosen across all participants. So, participants chose an average of 2.81 (*SD* = 0.89) foods of high colour saturation, and an average of 3.19 (*SD* = 0.89) foods of low colour saturation, with a mean difference of 0.38 between conditions. A Paired Sample T-Test revealed the absence of a significant difference between the experimental conditions, $t(47) = 1.46$, $p = .15$, $d = .21$, so we cannot concluded that the colour saturation level has an effect on food choice in this supermarket simulation.

For the total of products chosen in the high colour saturation condition, participants perceived an average weight of 105.68 grams (*SD* = 89.03), whereas for the products selected in the low colour saturation condition, the average perceived weight was 109.02 grams (*SD* = 91.21). There was a mean difference of 3.35 grams between the conditions. A Paired Sample T-Test revealed the absence of a significant difference between the experimental conditions, $t(47) = 0.35$, $p = .73$, $d = .05$ so we cannot conclude that the level of colour saturation has an impact on the perceived weight of the natural food in this simulation.

**Restaurant Simulation**

For the data of the restaurant simulation, we investigated the hypothesises that participants would choose/like more and make higher weight estimates for the high colour saturation food products (vs. low colour saturated products).

To test the first hypothesis, we conducted a Chi-Square Test of Independence[1]. The results revealed a significant association between colour saturation and food selection, $\chi^2(160) = 227.26$, $p < .001$, where cooked products of high colour saturation were 1.88 times more frequently chosen (i.e., preferred) than cooked products of low colour saturation. Specifically, through the analysis of the crosstabulation table (Table 2), we verified that participants chose a total of 347 high colour saturation cooked foods as opposed to 185 low colour saturated cooked foods.

Table 2

*Number of Counts for Each Portion Size Selected, With the Respective Level of Colour Saturation in the Restaurant Simulation*

| | | Portion Size | | |
|---|---|---|---|---|
| | | Small | Large | Total |
| Level of Colour Saturation | High | 229 | 118 | 347 |
| | Low | 99 | 86 | 185 |
| Total | | 328 | 204 | 532 |

Regarding the perceived weight, for the small portions the average perceived weight in the high colour saturation condition was 563.30 grams (*SD* = 644.73), whereas the average perceived weight in the low colour saturation condition was 338.97 (*SD* = 406.25). There was a mean difference of 224.93 grams between the conditions. A Paired Sample T-Test showed that the difference between the two experimental conditions was significant, $t(26) = 2.79$, $p = .010$, $d = .63$. So, the level of colour saturation produces an effect on the perceived weight for the small portions, where the portions of high colour saturation were perceived heavier.

Regarding the big portions selected by the participants, the average perceived weight for the high colour saturation was 563.62 grams (SD = 497.93), and the average perceived weight for the low colour saturation was 519.00 (SD = 604.27). There was a mean difference of

[1] These results were analyzed considering the total sample. Although only 15 participants performed this simulation properly, accordingly to the instructions given to choose only 5 out of the 13 products presented, the results of this group match those of the total sample.

44.62 grams between the conditions. A Paired Sample T-Test did not show a significant difference between the experimental conditions, $t(12) = 0.30$, $p = .77$, $d = 1.34$. So, we cannot conclude that the level of colour saturation produces an impact on the perceived weight for the big portions.

To verify if cooked items would be chosen more often in smaller portions when they were presented with a high saturation colour (vs. larger portions), we conducted a Chi-Square Test of Independence. The results revealed a significant relation between colour saturation and portion sizes, $\chi^2(1) = 7.95$, $p = .005$. Specifically, the likelihood of choosing smaller (vs. larger) portions when cooked items were presented in high saturated colours was 1.69 times more frequent than when cooked items were presented in low saturated colours (Table 2, p.35).

**The effect of colour saturation on the perceived healthiness**

In order to confirm that the colour saturation effect on the likeability is not better explained by the food perceived healthiness, we explored if there were any differences in the perception of healthiness of food items according to their colour saturation, by computing a Paired Sample T-Test, with the only factor being the colour saturation (high versus low).

For the food products in the high colour saturation condition, participants perceived an average healthiness of 6.91 (*SD* = 1.40), whereas for the food products of low colour saturation the average perceived healthiness was 6.73 (*SD* = 1.70). There was a mean difference of 0.18 between the conditions. A Paired Sample T-Test revealed the absence of a significant difference between the experimental conditions, $t(47) = 0.64$, $p = .53$, $d = .09$, so we cannot conclude that the level of colour saturation has an impact on the perceived healthiness of food products.

In sum, there are no differences in the perception of healthiness of the food items according to their colour saturation.

CHAPTER III

## Discussion

This study aimed to examine the effect of colour saturation on food likeability and food perceived weight, and the mediational role of the later over the former. To accomplish that aim, we analysed the impact of two different levels of colour saturation (high vs. low) of natural and cooked foods.

We expected that the manipulation of colour saturation levels on edible and inedible products would lead participants to report different levels of likeability towards them. Evidence in the literature has already shown that individuals have a general propensity to prefer high saturated colours given the greater feelings of excitement, attraction and arousal elicited (Gorn et al., 1997; Guilford, 1934; Guilford & Smith, 1959). In the food context, the greater amount of pigment of more saturated colours leads to: an association with fruit maturation, freshness and non-contamination (Lee et al., 2013); the intensification of the foods perceived flavour, taste and overall quality (Dubose et al., 1980; Francis, 1995; Saluja & Stevenson, 2018); and enables the products to stand out more in the environment (Egusa, 1983; Labrecque & Milne, 2011; Labrecque et al., 2013) provoking a greater arousal, capturing more the consumers visual attention and facilitate the food recognition in their memory (Michael & Gálvez-García, 2011; Mizzi & Michael, 2014; Wang et al., 2018).

Our results showed that highly saturated colours produce a significant and positive effect on food likeability, as so individuals reported to like more both natural and cooked products with high colour saturation (when compared to the low colour saturated products), as expected. So, food items displayed in a high level of colour saturation appear to be the most effective to increase food likeability. The size of this effect, in Phase 1, was greater for the cooked foods items, which matched with the food choices made in the restaurant simulation in Phase 2, where cooked products of high colour saturation were more frequently chosen than cooked products of low colour saturation. We predicted this difference in likeability to be accounted by a difference in the perceived weight of the food items, according to their level of colour saturation, however, that was not verified (this is discussed further below). This positive effect of colour saturation on food likeability, might thus be related with a possible higher perception of food quality, higher expected flavour and taste, facilitated by the greater amount of pigment, and/or by the greater capture of attention in the high colour saturation condition, that leads these foods to be perceived as more attractive, pleasant and appetizing (Paakki et al., 2018). However, since we did not use a control condition - an experimental condition of stimuli with the conventional/typical colour saturation - we are not able to conclude whether it actually is the high colour saturation that enhances food likeability for the aforementioned reasons, or if it is the low colour saturation that diminishes this likeability. Since foods with low colour saturation may have been perceived as atypical due to their discolouration, and in turn incite the perception of possibly danger, low quality and weird taste (Clydesdale, 1993), it may have consequently decreased the preference for these products. Our methodological decision to not include this control measure was based on the fact that consumers tend to prefer products that have colours that are congruent with their conceptual memory (Wei et al., 2012) so, if we used the original stimuli and made the comparison with the versions created, the one with the conventional colour would most likely be preferred by the norm of contact with it. However, for a better and proper interpretation of the results and to bridge this limitation, it is fundamental to replicate this study with the inclusion of this baseline condition, so we can understand the real direction of colour saturation on food likeability.

Regarding the supermarket simulation, the choices made by the participants revealed no significant differences in the preference for natural foods of high and low colour saturation. A possible explanation for the absence of the effect in this simulation might be due to the nature of the tasks performed. Because, instead of the participants giving their opinion about the likeability of various products in Phase 1, in the simulations they had to make choices. Thus, as the dependent variables and tasks were different between phases, there is a possibility that the task of simulating food selection activated different attitudes and behaviours towards the food products, particularly for this simulation. Although, this was not true for the restaurant simulation, perhaps because we used stimuli from a different database and a different colour saturation measure, that may have given rise to different perceptions of the cooked stimuli and different patterns of food selection. However, in the future it would be important to use stimuli from the same database for both simulations, in order to guarantee the standardization of the stimuli used, but it is yet necessary to create a new database that comprises different portion sizes and validate it for the Portuguese population. Also, the introduction of the distractive task between the first and second phases, might have instigate the feeling that we were assessing participants' diet habits and their concerns about food appearance, that in turn might have influenced their food choices in the simulations. This arises from the fact that most of the participants reported, in the latter part of the experiment, that they believe the purpose of this study was to evaluate their eating habits, as well as the study of food colours, and possible impacts of colours on their health and diet. So, we should have collected this data at the very last part of the experiment to prevent the influence of participants' choices in the simulations.

Also, by the attentional process already proposed, where vivid and intense stimuli are more detectable for our attention, thus leading to a greater arousal and a greater likelihood of choosing that product (Wang et al., 2018), we expected participants to like more the high colour saturated objects. But, unexpectedly, results revealed that there were no significant differences in participants' likeability for the object's category regarding the colour saturation levels. As there are no studies about the sensorial perceptions that colour saturation elicits on objects, it becomes difficult to understand why this effect does not influence the likeability for that category. The lack of literature on this subject limit the in-depth reasoning over the results. However, we believe it is plausible that food items contain some intrinsic attributes that favour likeability through colour saturation, and the perception of those properties are non-existent in the object's category. Hereafter, to give us some useful insight to understand this outcome that colour saturation only impacts the likeability for food-related categories, rather than the objects, it is important to develop a future study focusing on the qualitative and quantitative evaluation of both edible and inedible images, in each version of high and low colour saturation, in a range of multiple sensory dimensions, for example: aesthetics; security; acceptability; recognition/familiarity; usefulness; desire to consume; frequency of consumption; visually assessed satisfaction; satiety; liking; arousal; attention-getting; tastiness; healthiness; among other dimensions relevant to the perception of each item. By doing so, we might be able to justify why, in this experiment, colour saturation affects food items, and not objects, and identify the attributes that contribute to such difference. Since the proposed attentional mechanisms did not lead to the preference for objects with more intense and vivid colours, we can conclude that the sensorial perceptions elicited by the greater amount of pigment are much stronger in determining preference/likeability; So, for the object's category, the perceived sensory attributes might have not differed greatly between both colour saturation versions.

Furthermore, we expected that by manipulating the colour saturation levels of both edible and inedible products would lead participants to report different values of weight estimations. Once again, expecting a higher perceived weight for the products in the high colour saturation condition because, according to Hagtvedt and Brasel (2017), stimuli that are more salient and intense cause a greater arousal and attraction in the consumer's, capturing their attention more, which, in turn, leads to the perception that the stimulus is bigger. Since there is a positive relation between size and weight, as so the largest of two objects generally weighs more (Buckingham & Goodale, 2010, Buckingham & Goodale, 2013), we expected that these attention processes would create a weight bias, as so the highly saturated items would be perceived as heavier.

Against our hypothesis, our results show that colour saturation does not have a significant impact on the perceived weight of the edible and inedible products, impairing the mediation model proposed. The effect was also not detected in the supermarket simulation, where there were no differences in the weight estimations between the two-colour saturation conditions. A possible justification for these results may be people's poor ability to make weight estimations (see Buckingham & Goodale, 2013). The means of the perceived weight responses provided by the participants, show that they tend to underestimate the weight of the items, even with the help of a weight' anchor. Therefore, this misperception of the real weight of the foods, pending to weight underestimation, might contribute to the increase of food waste. Also, some answers reveal a lack of sensibility for weight of isolated items (e.g. one single apple weighing 300 grams); to this might have contributed the young age of our participants that made more unfamiliar to them the task of weighing products, very usual in the supermarket context.

However, for the restaurant simulation, the colour saturation had the expected effect on the perceived weight of the smaller portions: the smaller portions of high colour saturation were perceived as heavier compared to the lower colour saturation. In addition, and as expected, more high colour saturation cooked foods were chosen for smaller portions over larger portions. Our interpretation of these results is that, since the cooked foods of high colour saturation are perceived as heavier, people do not feel the need to choose the larger portions, feeling satisfied with the perceived size of the smallest portion.

Regarding the category of objects, there was also no significant impact of colour saturation on the perceived weight of the products. Since the proposed psychological mechanisms were based on the Hagtvedt and Brasel (2017) study, who used a perceived size measure rather than a perceived weight measure, this may have invalidated the replication of those results. Thus, one of the main limitations of this study involved methodological problems in measuring the weight variable. We opted for a weight measure, instead of a size measure, because it is more strongly correlated with food attributes that might be relevant for people, and because it is correlated with size. However, as people make fairly inaccurate judgments of weight, the possibility of testing the predicted mediation model became compromised. Thus, it would be relevant to make a new future study that uses a different methodological approach, analysing instead the perceived size measure.

Finally, we explored in what extent the likeability for edible products could be dependent on food perceived healthiness. But there was no difference in the perceived healthiness between food products with high and low colour saturation. So, it was not verified the possibility of a given level of colour saturation of foods not being liked either because they would be considered artificial (due to the perception of colour additives), or the discolouration of not well-conserved foods and consequent health ‘impacts, were not verified. We cannot discard the possibility that foods we currently have contact with are already quite saturated, which means that over time we have become accustomed to high levels of colour saturation presented in foods, and this representation is becoming relatively normal in our memory. Another implication of this result is that it allows us to conclude that the measure of colour saturation used in this study is perceived as natural by the participants.

Addressing other limitations besides the ones we have been pointing out, some participants did not strictly complied to the task instruction in the restaurant simulation, where most of the participants choose more that the five items that the instructions requested. Moreover, given the multitude of factors that influence colour perception, and our current knowledge about them, it is not yet possible to guarantee a precise and complete control in colour research (Committee on Colourimetry of the Optical Society of America, 1953, cited by Elliot, 2015). So, the essential steps that must be embraced to enable a more precise and efficient colour research, using the technology available at the moment, is the control for the colour attributes, just as we did, and the visualization condition (Elliot, 2015).

Despite the limitations, our findings have major implications, insofar stakeholders can develop strategies to promote a more sustainable diet for our health and for our environment, by changing the colour saturation of food in its communication, for example, in food images on supermarkets sites, in food images on advertisements and flyers, in food images used in restaurant menus, among others. There is a pressing need for a change in the mentality and eating habits of consumers in order to reduce meat consumption and adopt a more plant-based diet, since this change proves to be fruitful for environmental sustainability (Bryngelsson, Wirsenius, Hedenus, & Sonesson, 2016). Health organizations have called the need to limit the consumption of meat, especially the red and processed ones, for the health risks associated, namely, heart disease, obesity and diabetes (Boada, Henríquez-Hernández, & Luzardo, 2016). Here, plant-based diets have been shown to be the key in helping to alleviate these health problems, especially obesity (Campbell & Campbell, 2005). In Portugal, obesity already affects more than a quarter of children and adolescents and more than half of the adult population (Direção-Geral da Saúde, 2017). It is therefore a problem well rooted in the developed countries and so efforts must be taken to prevent this epidemic and improve the eating habits of individuals. In addition to the health context, it is known that meat consumption is a significant trigger for environmental destruction by the high emissions of greenhouse gases and reactive nitrogen (Westhoek et al., 2014), which has become, nowadays, increasingly more evident through global warming. Thus, the reduction of meat consumption and the transition to a more plant-based diet constitute a method of intervention to achieve a more sustainable environment and lifestyle (Machovina, Feeley, & Ripple, 2015; Schösler, de Boer, Boersema, & Aiking, 2015; Zur & Klöckner, 2014). In this way, the results of the present study may be potentially facilitative of this transition, by promoting the use of more saturated colours in the communication of organic fruits and vegetables, typical of the plant-based diet, fighting against obesity and improving eating habits. On the other hand, processed and animal products should be communicated with low colour saturation, in order to reduce their consumption and their consequent harmful impact on the environment.

In the future, it would be interesting to replicate the first phase of this study using the eye tracking technique, to study the role of attentional processes in the effect of saturation in food likeability. In addition, in the course of the selection of real 3D food photographs properly validated, we came across the absence of a database with foods typical of the vegetarian diet. For this reason, we restrict our study to omnivorous' people. So, it would be interesting in the future to create and validate a database with images of foods typical of the vegetarian diet (tofu, seitan, lentils, grain, soybean...) in order to be able to include the study of this population in the food context. Would also be interesting to continue studying the impact of colour saturation in a multiplicity of other contexts, such as how the colour saturation of garments has an impact on the perceived weight of its users. But, still in the food context, the colour saturation should continue to be an important subject of study and development in order to find successful strategies to be used in public welfare and environmental communication, consequently helping to promote better eating habits and, perhaps, helping to give a step closer towards a more sustainable world, and avenge the Amazon forest.

## Conclusion

The present dissertation addresses the impact that colour saturation plays in food likeability and perceived weight, by varying the colour saturation levels of the displayed images (high colour saturation vs. low colour saturation). This study represents a contribution to the scientific community for a better understanding of the importance of considering the perceptual aspects of colour saturation on eating behaviour - that ultimately shapes consumers' food preferences and choices.

Our findings point out that colour saturation impacts significatively food likeability, with a greater preference for high colour saturated food products, both natural and cooked products, as expected by past research. This outcome can help stakeholders to better understand the underlying mechanisms of colour saturation on the likeability/preference towards food products, so they can direct their communication policies and interventions with the goal of promoting social responsibility for a more sustainable and healthier behaviours. Furthermore, only in the restaurant simulation, we find a significant impact of colour saturation on the perceived weight, where the smaller portions of high colour saturation were perceived as heavier; and high colour saturation cooked foods were chosen more for smaller portions over larger portions: this shows a possible tool to prevent or diminish food waste by inciting, trough high colour saturation, individuals' preference for smaller portions, by the illusion that they are eating more, but be an adequate size to their needs.

Overall, our results bring some interesting insights and potentially highlights regarding food preference, that might be of significance to marketing, especially for food retailers. Although some methodological issues still need to be addressed in future investigations, we aspire that this investigation opens a path for other colour researches, because there are a lot of details still to be uncovered on this topic, and it is more important than ever to assist and expand the knowledge for a healthier society and world.

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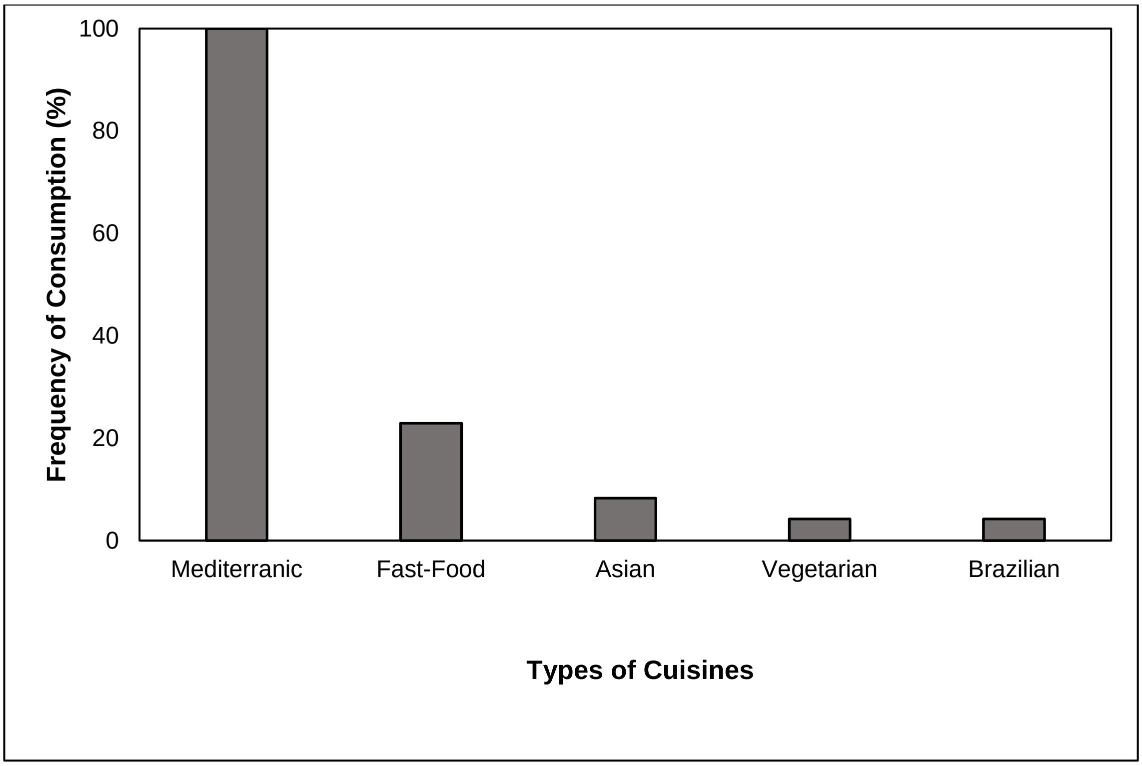



*Figure 1.1.* Type(s) of cuisine(s) usually consumed (more than 4 times a week) by the sample ($n$ = 48).

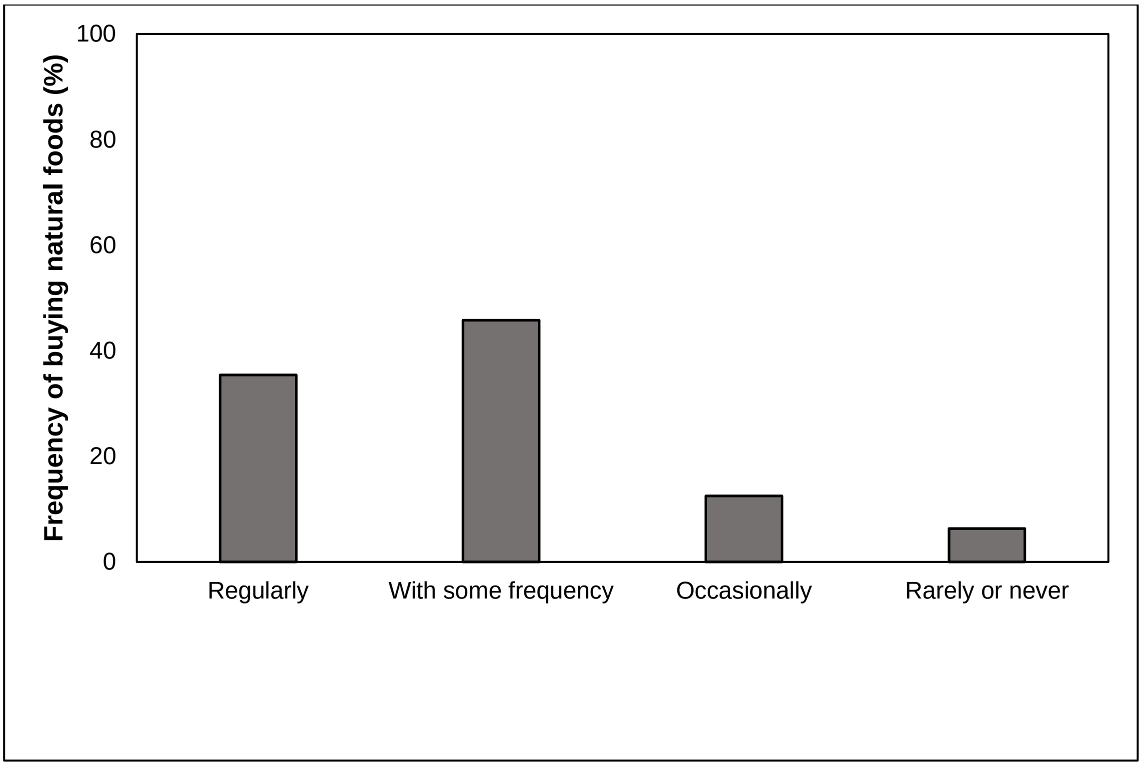



*Figure 1.2.* Frequency of buying natural foods (fruits, vegetables; *n* = 48).

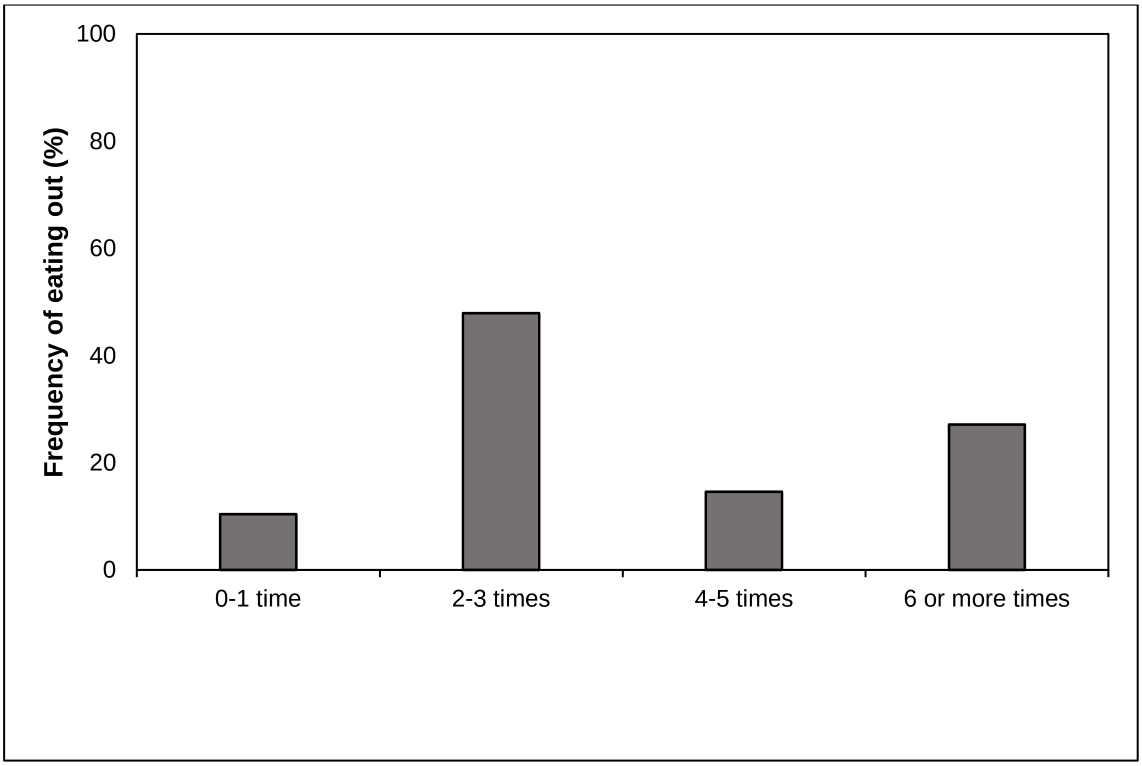



*Figure 1.3.* Number of times, per month eating out ($n$ = 48).

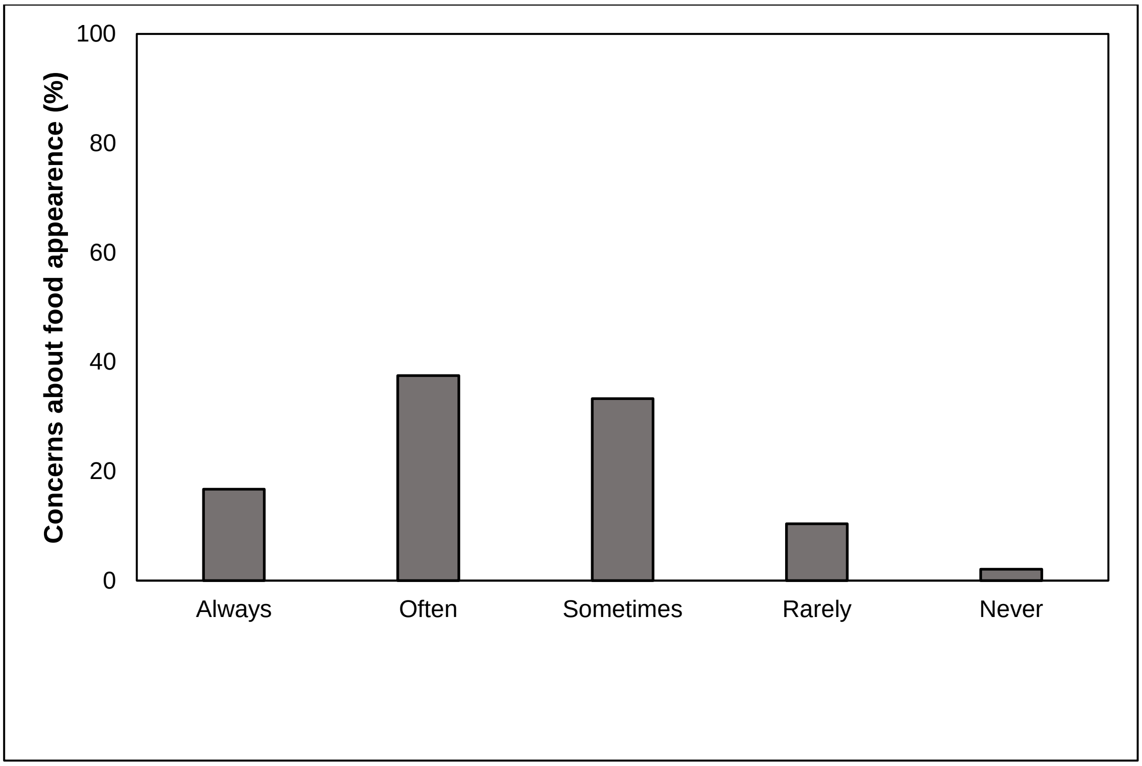



*Figure 1.4.* Concern about food appearance ($n$ = 48).

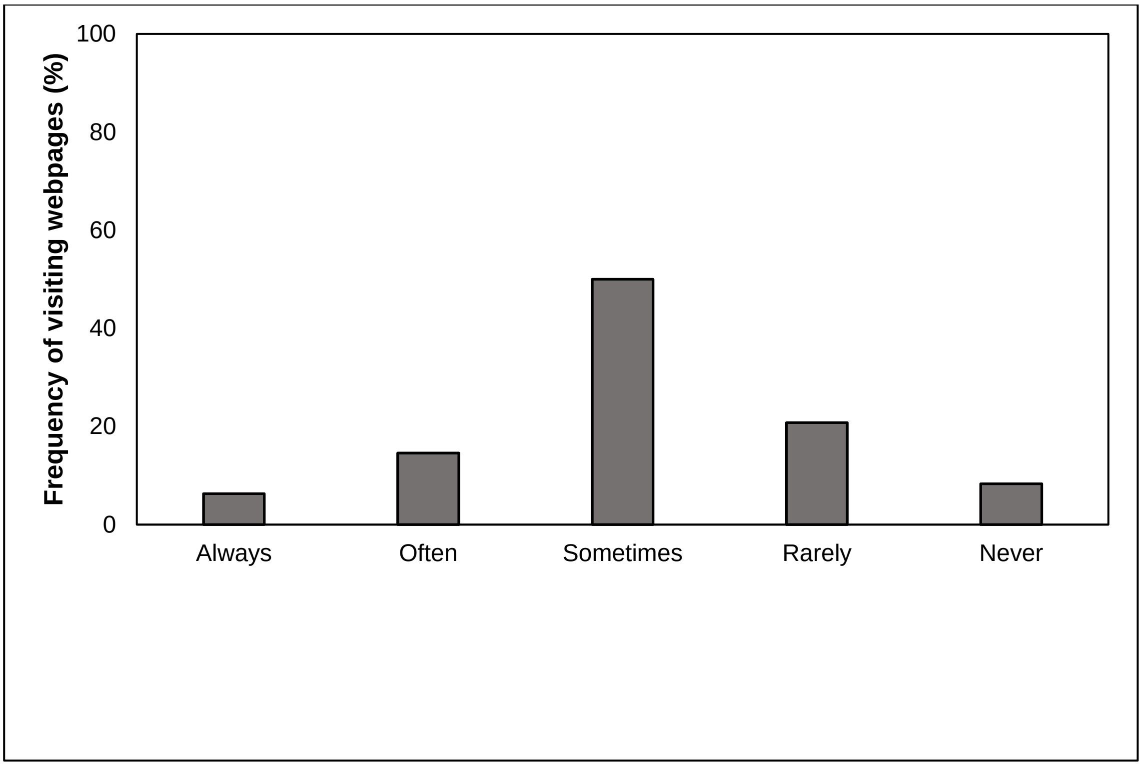



*Figure 1.5.* Frequency of visiting webpages (Facebook, Instagram, Blogs, etc.) sharing photos of foods (*n* = 48).

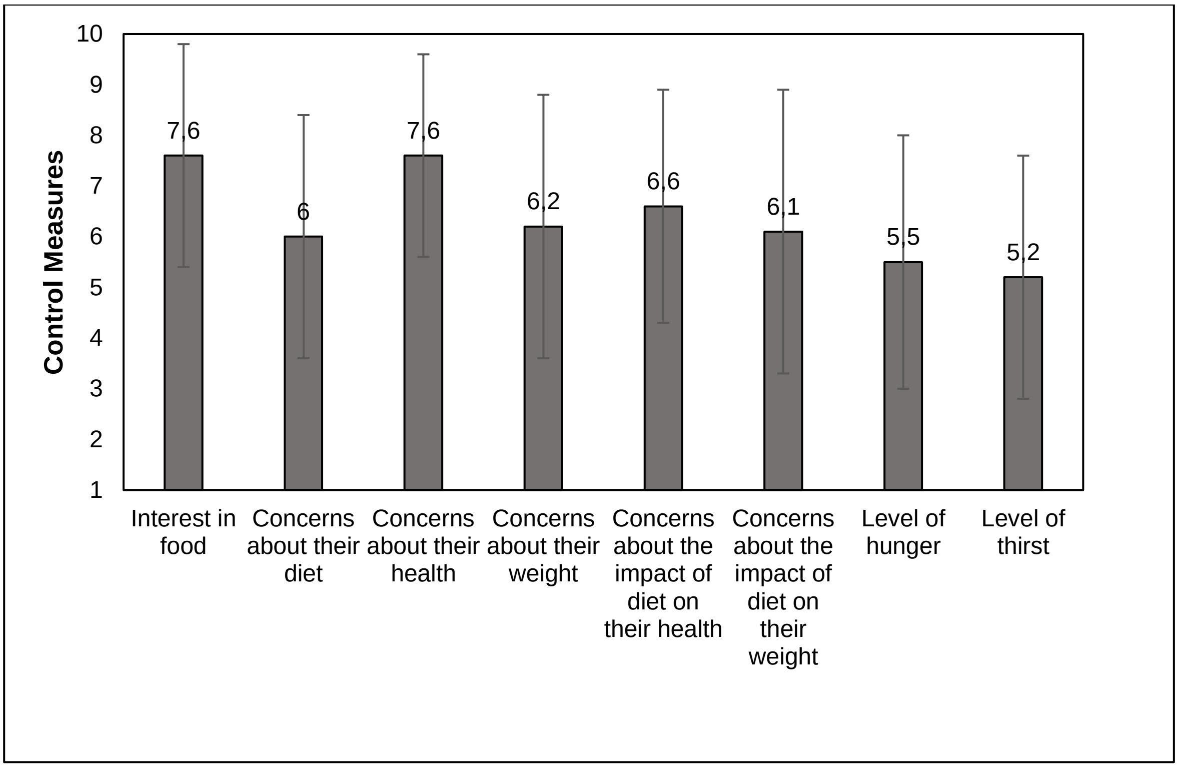



*Figure 1.6.* Control variables with a 10-point Likert scale, about the sample interest in food (1 = *Nothing interested* to 10 = *Very interested*), concerns about their health, weight and diet and about the impacts that their diet have in their health and weight (1 = *Nothing concerned* to 10 = *Very concerned*), and the level of hunger and thirst during the experiment (1 = *No hunger/thirst* to 10 = *Very hungry/thirsty*) (n = 48).

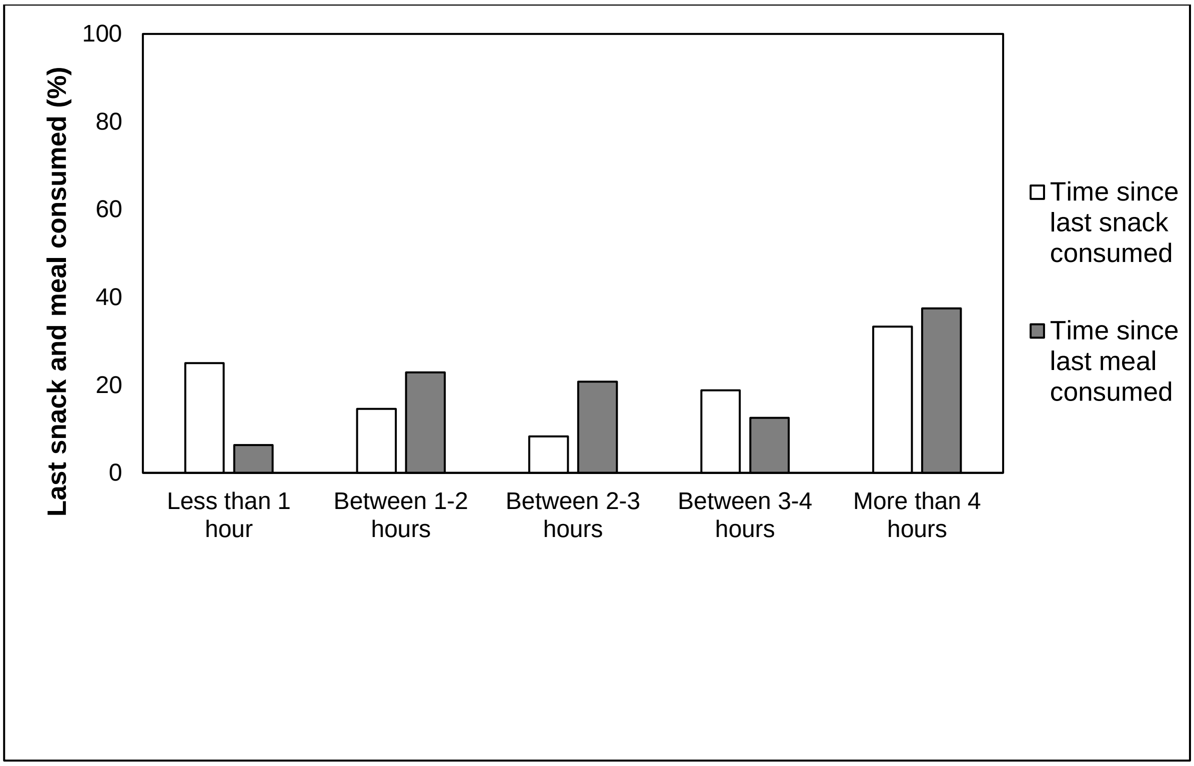



*Figure 1.7.* Time since the last snack and meal before participation (*n* = 48).

Appendix A – Study survey (informed consent)

**Consentimento Informado**

A presente investigação faz parte de uma Dissertação de Mestrado em Psicologia Social e das Organizações do ISCTE-IUL.
A sua participação é completamente voluntária e não envolve qualquer risco.
Tem o direito de desistir a qualquer momento, sem qualquer penalização.
Caso queira desistir, os dados recolhidos a seu respeito serão eliminados.
Este estudo é completamente anónimo e em caso algum serão identificadas as respostas individuais dos/as participantes.
Será pedido que preste atenção a várias imagens de produtos comestíveis e não comestíveis, sobre as quais lhe serão feitas perguntas, no que concerne o tamanho e a preferência pelos produtos apresentados. Este estudo tem duração de, aproximadamente, 60 minutos.
Caso deseje obter informações adicionais sobre o mesmo, poderá contactar a investigadora responsável (Maria Rocha) através do e-mail: mllra@iscte-iul.pt

Caso aceite participar no estudo deverá assinalar a opção "Dou o meu consentimento, aceito participar no estudo"

Caso contrário assinale a opção "Não dou o meu consentimento, não desejo participar no estudo"

- ○ Dou o meu consentimento, aceito participar no estudo.
- ○ Não dou o meu consentimento, não desejo participar no estudo.

## Appendix B – Study survey (instructions)

Na primeira fase do estudo, ser-lhe-ão apresentadas várias imagens de produtos comestíveis e não comestíveis. Em cada ecrã vamos pedir que avalie uma imagem quanto ao **tamanho do produto** apresentado e, também, que indique o **quanto gosta** desse produto. Cada imagem será apresentada **por muito pouco tempo**, antecedida por uma cruz preta e, por isso, pedimos que esteja com o máximo de atenção. As suas respostas serão dadas imediatamente a seguir, através de escalas, utilizando o rato do computador.

É provável que se aperceba da repetição de imagens, mas não se preocupe, tal é propositado para dar robustez ao estudo.
Não existem respostas certas nem erradas, por isso, dê a sua resposta de forma espontânea e rápida.

Alerto-lhe, ainda, que **não é possível usar o botão retroceder** sob pena de inviabilizar a gravação dos dados, por isso, esteja atento na apresentação das imagens.

Antes de começar terá a oportunidade de **treinar** o procedimento. Qualquer dúvida não hesite em chamar a investigadora.

# Appendix C - Study survey (sociodemographic data and control measures)

Antes de passar à fase seguinte do estudo, peço-lhe, por favor, que responda com sinceridade às seguintes questões.

Qual é o seu sexo?

- ○ Feminino
- ○ Masculino
- ○ Outro

Qual é a sua idade?

Qual é a sua nacionalidade (país onde nasceu)?

Qual é a sua naturalidade (cidade em que nasceu)?

Qual é a sua altura (em centímetros) aproximada?

Qual é o seu peso (em quilogramas) aproximado?

Responda, por favor, às seguintes questões:

| | 1= Sem fome/sede | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10= Com muita fome/sede |
|---|---|---|---|---|---|---|---|---|---|---|
| Qual é o seu nível de fome neste exato momento? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Qual é o seu nível de sede neste exato momento? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Quantas vezes por mês costuma ir comer fora:

- ○ 0-1 vez
- ○ 2-3 vezes
- ○ 4-5 vezes
- ○ 6 ou mais vezes

Na sua opinião o quão interessado/a é por comida?

| 1= Nada interessado | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10= Muito interessado |
|---|---|---|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Qual (quais) é (são) o tipo de cozinha(s) que habitualmente come (mais de quatro vezes por semana):

- ☐ Mediterrânica (Portuguesa)
- ☐ Asiática
- ☐ Brasileira
- ☐ Fast Food
- ☐ Macrobiótica
- ☐ Vegetariana
- ☐ Outra

Responda, por favor, às seguintes questões:

| | 1= Não me preocupo nada | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10= Preocupo-me muito |
|---|---|---|---|---|---|---|---|---|---|---|
| Em que medida se preocupa com o impacto da sua alimentação na sua saúde? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Em que medida se preocupa com a sua saúde? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Em que medida se preocupa com o seu peso? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Em que medida se preocupa com a sua alimentação? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Em que medida se preocupa com o impacto da sua alimentação no seu peso? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Possui alguma alergia alimentar? Em caso afirmativo, por favor, especifique.

- ○ Não
- ○ Sim

Responda, por favor, às seguintes questões:

| | Menos de 1 hora | Entre 1-2 horas | Entre 2-3 horas | Entre 3-4 horas | Mais de 4 horas |
|---|---|---|---|---|---|
| Quanto tempo passou desde a sua última refeição completa? | ○ | ○ | ○ | ○ | ○ |
| Quanto tempo passou desde o seu último lanche? | ○ | ○ | ○ | ○ | ○ |

Tem por hábito comprar alimentos naturais (frutas, vegetais, peixe, etc.)?

- ○ Nunca
- ○ Raramente
- ○ Ocasionalmente
- ○ Com alguma frequência
- ○ Regularmente

Costuma visitar páginas (Instagram, Facebook, Blogue, Revistas) que partilham fotografias de comida?

- ○ Nunca
- ○ Raramente
- ○ Às vezes
- ○ Quase sempre
- ○ Sempre

Sente que se preocupa com o aspeto dos alimentos, isto é, com o grau de naturalidade (Vs artificialismo) dos produtos alimentares?

- ○ Nunca
- ○ Raramente
- ○ Às vezes
- ○ Quase sempre
- ○ Sempre

Appendix D – Objects' pictures presented in Phase 1, with both levels of colour saturation. The first column regards the high colour saturation stimuli manipulation and the second column displays the low colour saturation versions of the stimulus

Appendix E – Evaluation of the images used in phase 1 according to four dimensions in the validation process for the Portuguese population

| Stimuli Number | Image description | Food category | Liking | Familiarity | Frequency of Consumption | Desire to Eat |
|---|---|---|---|---|---|---|
| | | | Mean | Mean | Mean | Mean |
| | Natural | | | | | |
| 389 | Cantaloup | Fruits | 6.81 | 7.13 | 5.52 | 6.00 |
| 413 | Kiwis | Fruits | 7.20 | 8.53 | 6.90 | 6.80 |
| 453 | Peach | Fruits | 8.25 | 8.03 | 6.47 | 7.34 |
| 539 | Almonds | Fruits | 7.63 | 7.27 | 5.80 | 6.83 |
| | Total by category | | 7.47 | 7.74 | 6.17 | 6.74 |
| 343 | Eggs in eggboard | Animal | 8.45 | 9.58 | 7.61 | 6.94 |
| 409 | Salmon | Animal | 8.17 | 8.77 | 7.20 | 7.27 |
| 541 | Chicken, raw | Animal | 7.60 | 8.17 | 7.33 | 6.83 |
| 544 | Beefsteak, raw | Animal | 6.42 | 8.61 | 6.10 | 6.10 |
| | Total by category | | 7.66 | 8.78 | 7.06 | 6.79 |
| 249 | Cauliflower | Vegetables | 6.23 | 9.06 | 6.03 | 5.77 |
| 367 | Zucchini | Vegetables | 6.73 | 9.17 | 7.43 | 6.00 |
| 433 | Squash / pumpkin | Vegetables | 5.67 | 7.33 | 5.87 | 4.97 |
| 438 | Onion | Vegetables | 6.06 | 9.38 | 7.94 | 4.91 |
| | Total by category | | 6.17 | 8.74 | 6.82 | 5.41 |
| | Cooked | | | | | |
| 45 | Hamburger | Animal | 7.07 | 8.40 | 5.00 | 6.13 |
| 73 | Spaghetti bolognese | Animal | 7.03 | 7.53 | 5.27 | 5.90 |
| 131 | Pizza | Animal | 8.37 | 8.70 | 5.70 | 7.37 |

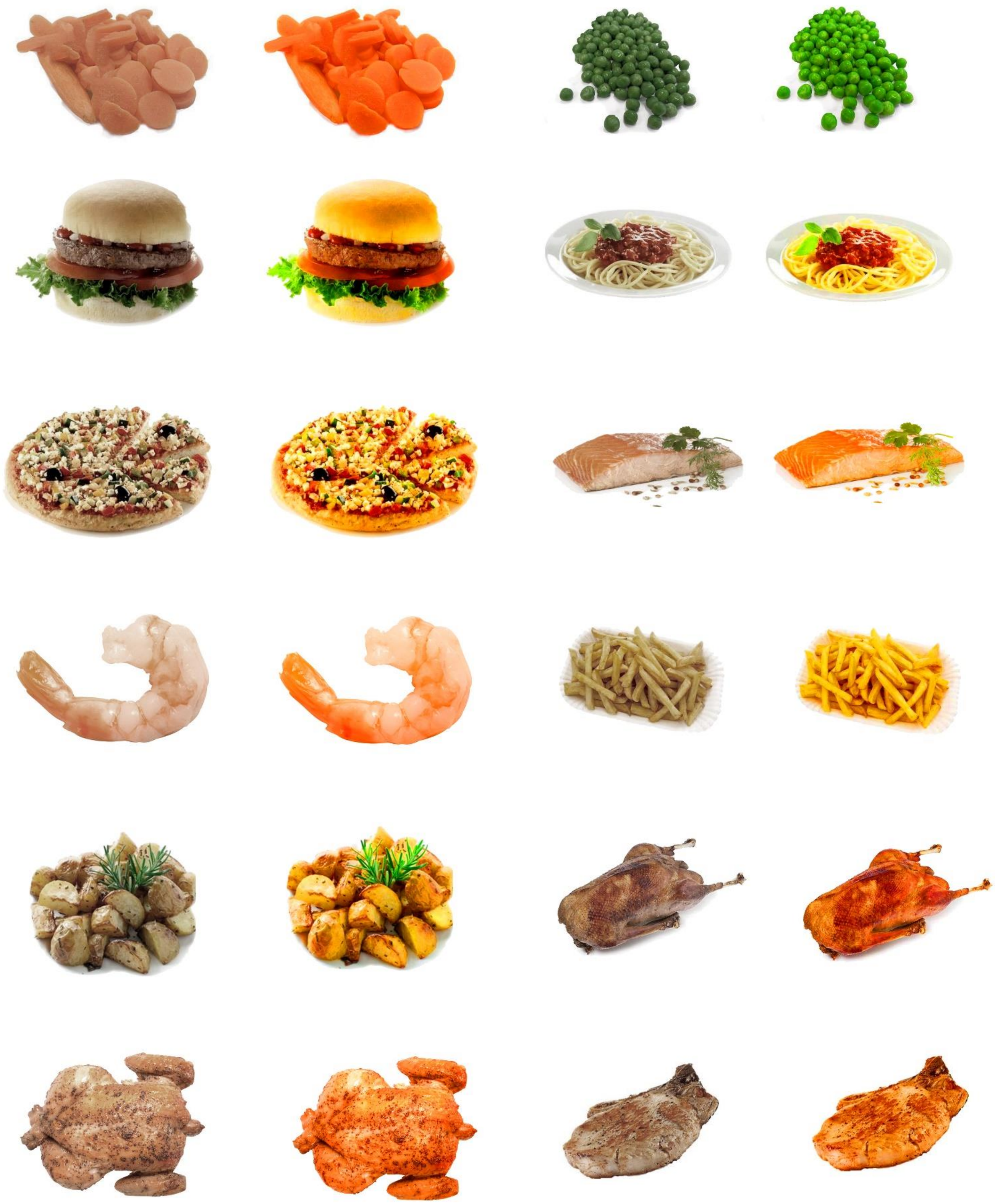
| | | | | | | |
|---|---|---|---|---|---|---|
| 307 | Salmon | Animal | 8.74 | 8.52 | 7.71 | 8.06 |
| 319 | Canard roasted | Animal | 7.77 | 8.87 | 7.43 | 6.77 |
| 545 | Shrimp | Animal | 8.66 | 8.22 | 6.63 | 8.41 |
| 546 | Chicken, roasted | Animal | 7.60 | 8.53 | 7.43 | 7.23 |
| 562 | Cutlet | Animal | 7.93 | 9.13 | 7.10 | 7.20 |
| | Total by category | | 7.90 | 8.49 | 6.53 | 7.13 |
| 317 | Potatoe wedges | Vegetables | 7.53 | 7.81 | 6.06 | 6.44 |
| 46 | French fries | Vegetables | 8.90 | 9.45 | 5.55 | 7.26 |
| 361 | Carrots, cooked | Vegetables | 7.81 | 9.19 | 7.45 | 6.87 |
| 424 | Peas cooked | Vegetables | 7.43 | 9.33 | 6.63 | 6.30 |
| | Total by category | | 7.43 | 933 | 6.63 | 6.30 |

*Note.* The values correspond to the means scored for each image used in Phase 1, for the dimensions of Liking, Familiarity, Frequency of Consumption and Desire to Eat, during the validation of this images for the Portuguese population. $n$ = 307

Adapted from “Food-pics-PT: Portuguese validation of food images in 10 subjective evaluative dimensions”, by M. Prada, D. Rodrigues, M. V. Garrido, and J. Lopes, 2017, *Food Quality and Preference*, *61*, pp.15–25.

Appendix F – Natural food items presented in Phase 1, with both levels of colour saturation

Appendix G - Cooked food items presented in Phase 1, with both levels of colour saturation

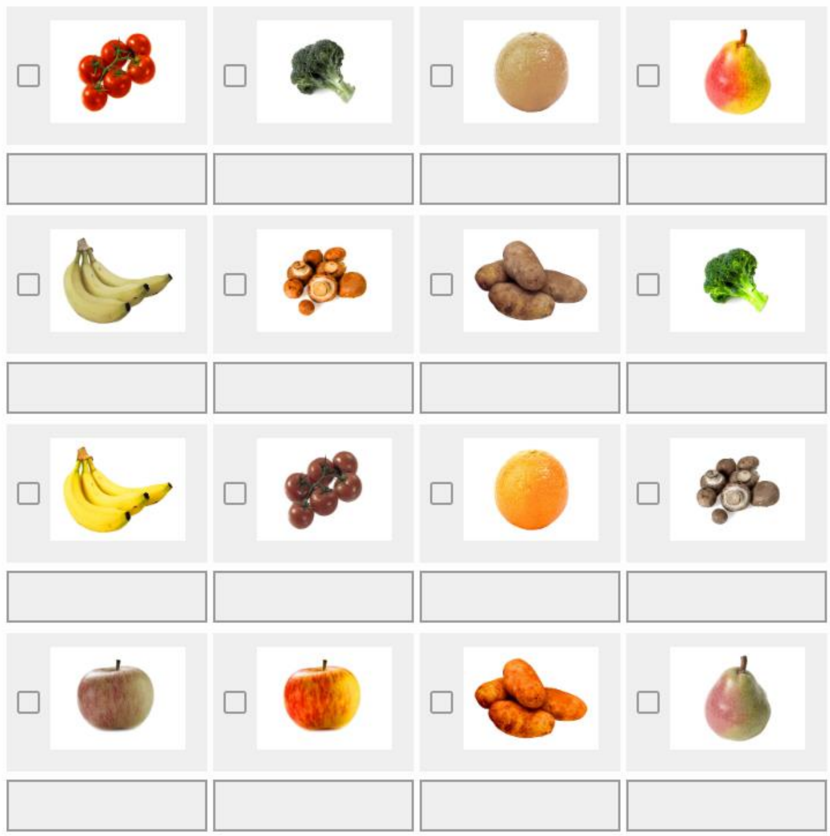


## Appendix H – Study survey (supermarket simulation)

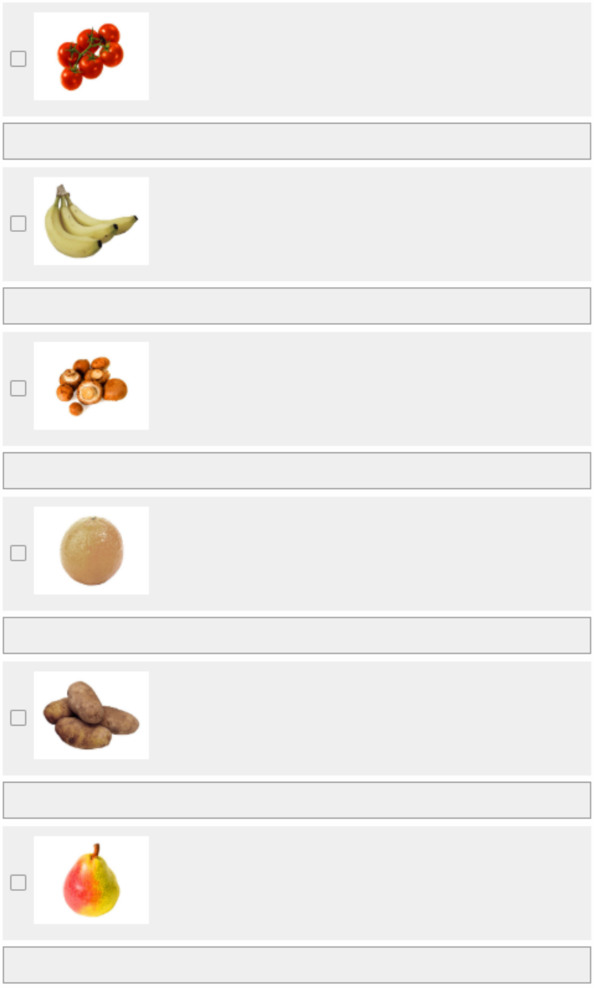
Imagine que está no **supermercado** a comprar **vegetais** e **frutas** para a sua semana.

Quais dos seguintes produtos apresentados (maçãs, pêras, bananas, laranjas, tomates, brócolos, cogumelos e batatas) colocaria no seu **carrinho de compras**, sabendo que só tem dinheiro para um total de **SEIS variedades** de produtos alimentares.

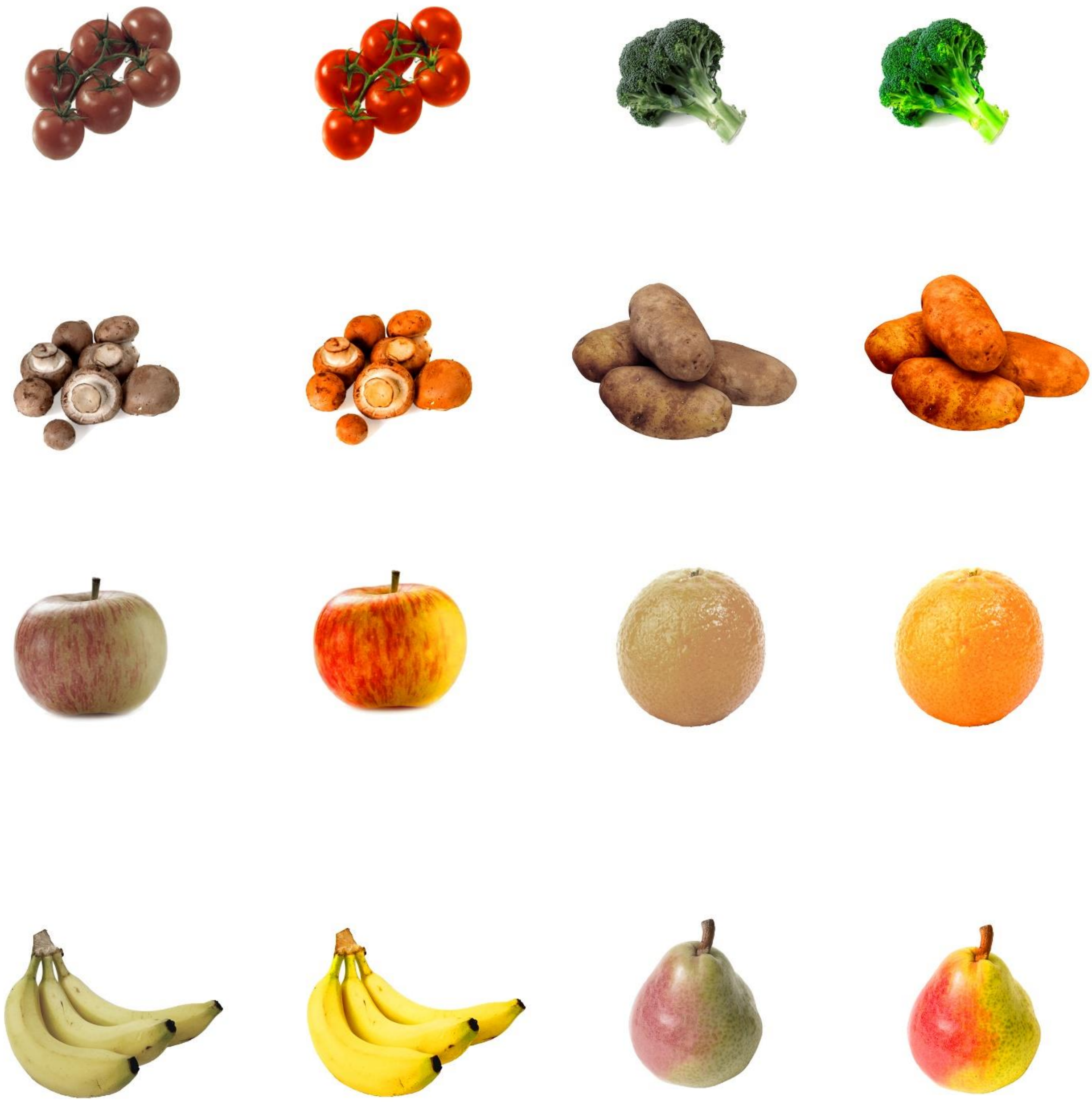
Indique, também, na caixa de texto referente aos produtos que selecionou, o **número de unidades** que pretende levar.



Aqui estão os alimentos que selecionou para o seu carrinho de compras. Imagine, agora, que vai **pesar** na balança do supermercado a quantidade de alimentos que escolheu. Por favor, dê uma **estimativa do peso**, em **gramas**, da **unidade** de cada produto alimentar que escolheu, na caixa de texto respetiva.
Por exemplo, se tiver escolhido levar 3 maçãs, deverá referir o peso estimado para **apenas uma** maçã.



Appendix I - Natural food items presented in the Supermarket Simulation in Phase 2, with both levels of colour saturation



Appendix J – Evaluation of the images used in the supermarket simulation according to four dimensions in the validation process for the Portuguese population

| Stimuli Number | Image description | Food category | Liking | Familiarity | Frequency of Consumption | Desire to Eat |
|---|---|---|---|---|---|---|
| | | | Mean | Mean | Mean | Mean |
| 192 | Apple | Fruits | 8.79 | 9.58 | 8.48 | 8.09 |
| 365 | Orange | Fruits | 8.77 | 9.43 | 8.03 | 8.00 |
| 379 | Banana | Fruits | 7.63 | 9.07 | 7.40 | 6.77 |
| 402 | Pear | Fruits | 8.40 | 8.87 | 7.73 | 7.40 |
| | Total by category | | 8.40 | 9.24 | 7.91 | 7.57 |
| 197 | Tomatoes | Vegetables | 7.30 | 9.33 | 7.67 | 6.67 |
| 250 | Broccoli | Vegetables | 7.87 | 9.16 | 7.52 | 6.94 |
| 263 | Mushrooms | Vegetables | 7.53 | 8.23 | 7.20 | 6.70 |
| 346 | Potatoes | Vegetables | 7.23 | 8.77 | 6.42 | 6.35 |
| | Total by category | | 7.48 | 8.87 | 7.20 | 6.67 |

*Note.* The values correspond to the means scored for each image used in the supermarket simulation, for the dimensions of Liking, Familiarity, Frequency of Consumption and Desire to Eat, during the validation of this images for the Portuguese population. $n$ = 307
Adapted from "Food-pics-PT: Portuguese validation of food images in 10 subjective evaluative dimensions", by M. Prada, D. Rodrigues, M. V. Garrido, and J. Lopes, 2017, *Food Quality and Preference*, *61*, pp.15–25.

## Appendix K – Study survey (restaurant simulation)

Imagine que está num **restaurante self-service** a compor o prato para o seu almoço.

Ser-lhe-ão apresentados produtos de **três grupos alimentares** [Hidratos de carbono (arroz, esparguete, macarronete, batatas fritas e batatas assadas), Proteínas (bife, lombo, peixe e filete de peixe) e Vegetais (cenoura, ervilhas, brócolos e cogumelos)]. Só poderá escolher **até CINCO** produtos alimentares **do mesmo** grupo **ou combinação** de grupos alimentares. Pode, ainda, decidir qual o **tamanho** da sua **porção** dentro das escolhas que fez. Para tal, basta **arrastar** com o rato do computador as imagens dos produtos alimentares que pretende para a zona do "seu prato" respetiva.

Peço-lhe, também, que na caixa de texto por baixo da imagem que representa o que deseja consumir, dê uma **estimativa do peso**, em **gramas**, da quantidade representada.

O que irá comer?

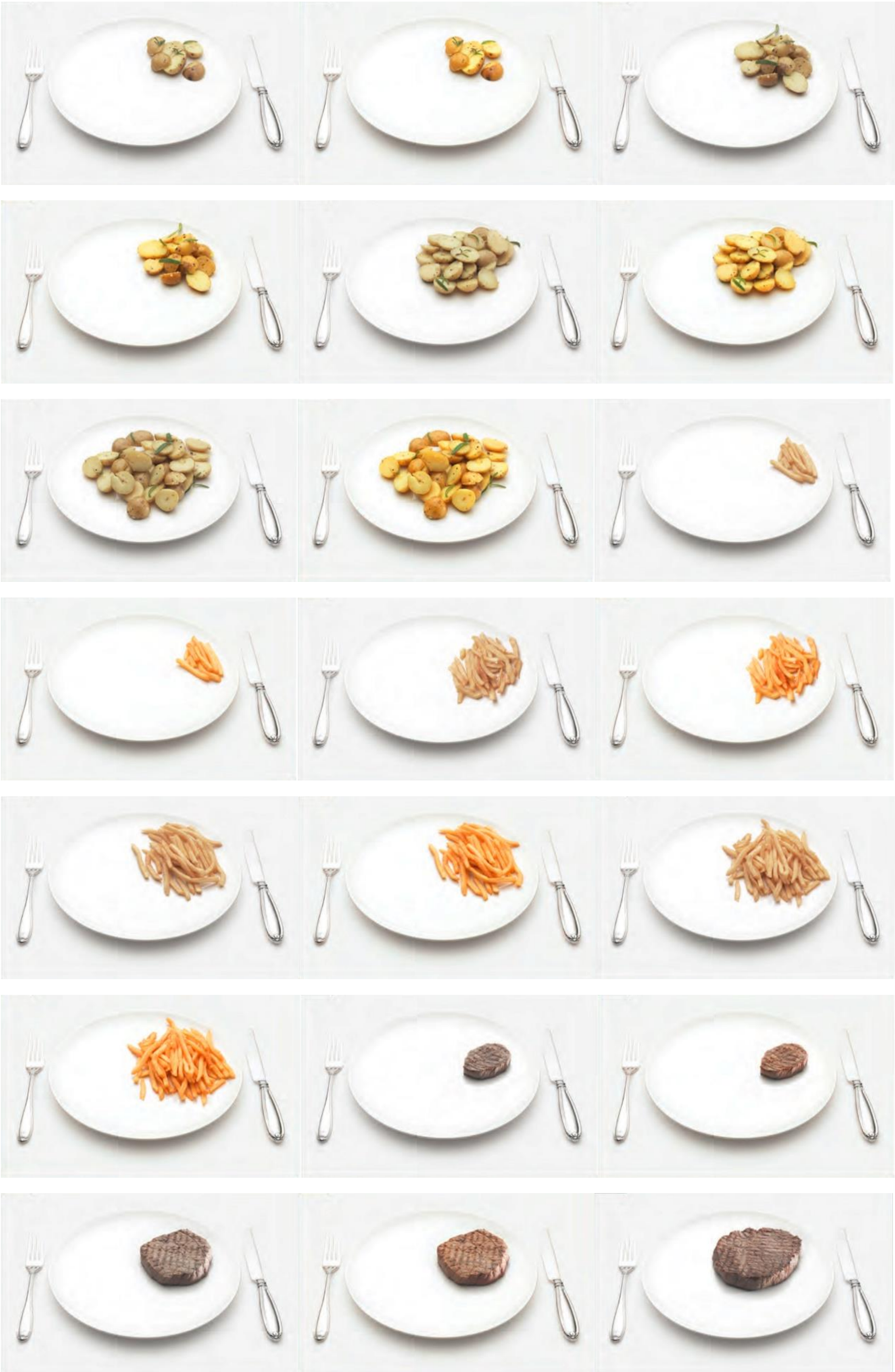
Arroz

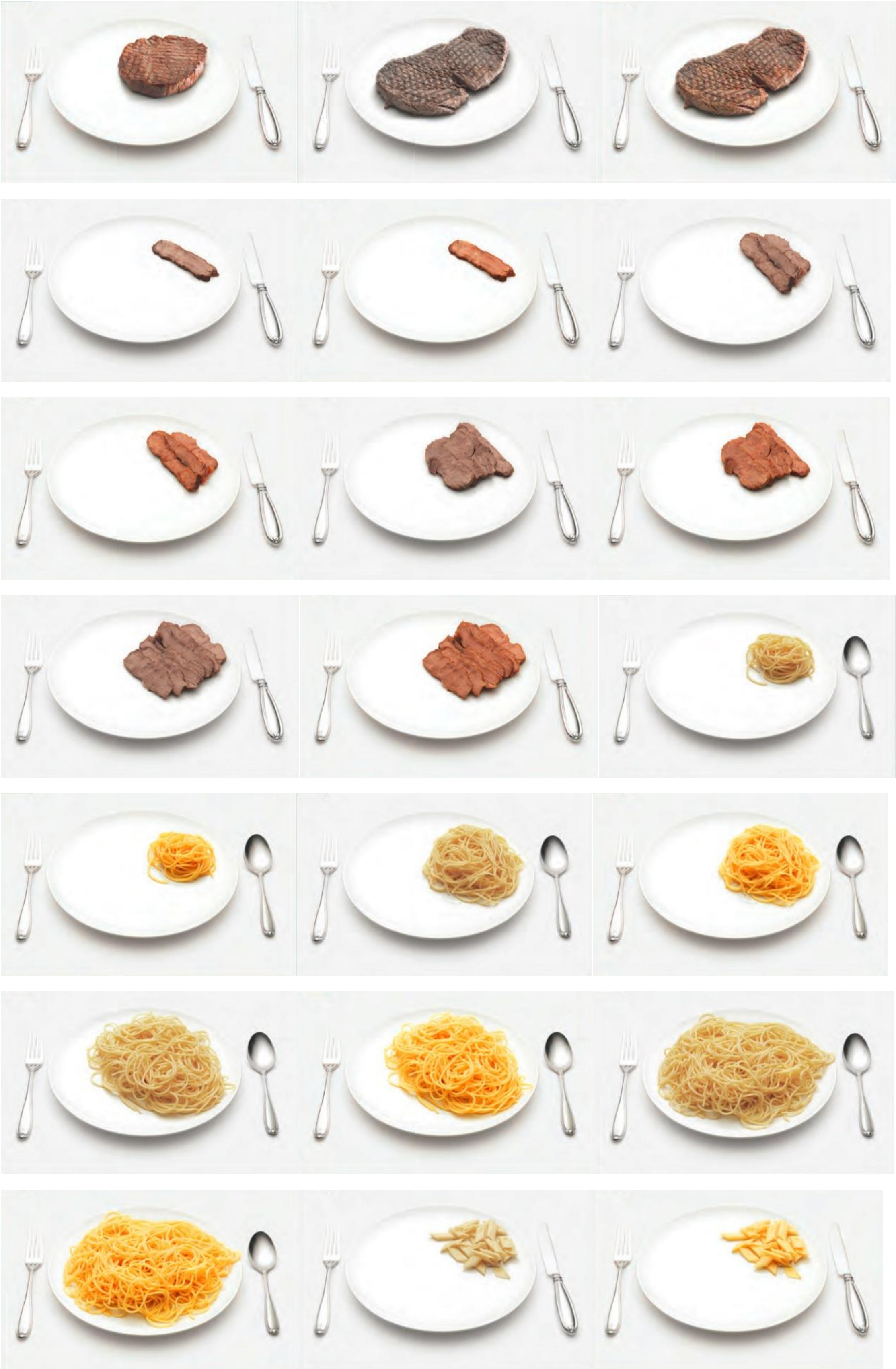
(Não se esqueça de arrastar para a zona do "seu prato" a imagem que melhor representa o que quer consumir, **até o máximo de 5 produtos**, e de estimar o peso, em gramas, da quantidade por si escolhida, digitando o número na caixa de texto respetiva. Basta fazer scroll-down para ver todas as possibilidades de produtos alimentares. Se pretender uma das imagens referentes às porções maiores, deverá usar a roda do rato do computador para ajudar a arrastar a imagem para a zona do "seu prato".)

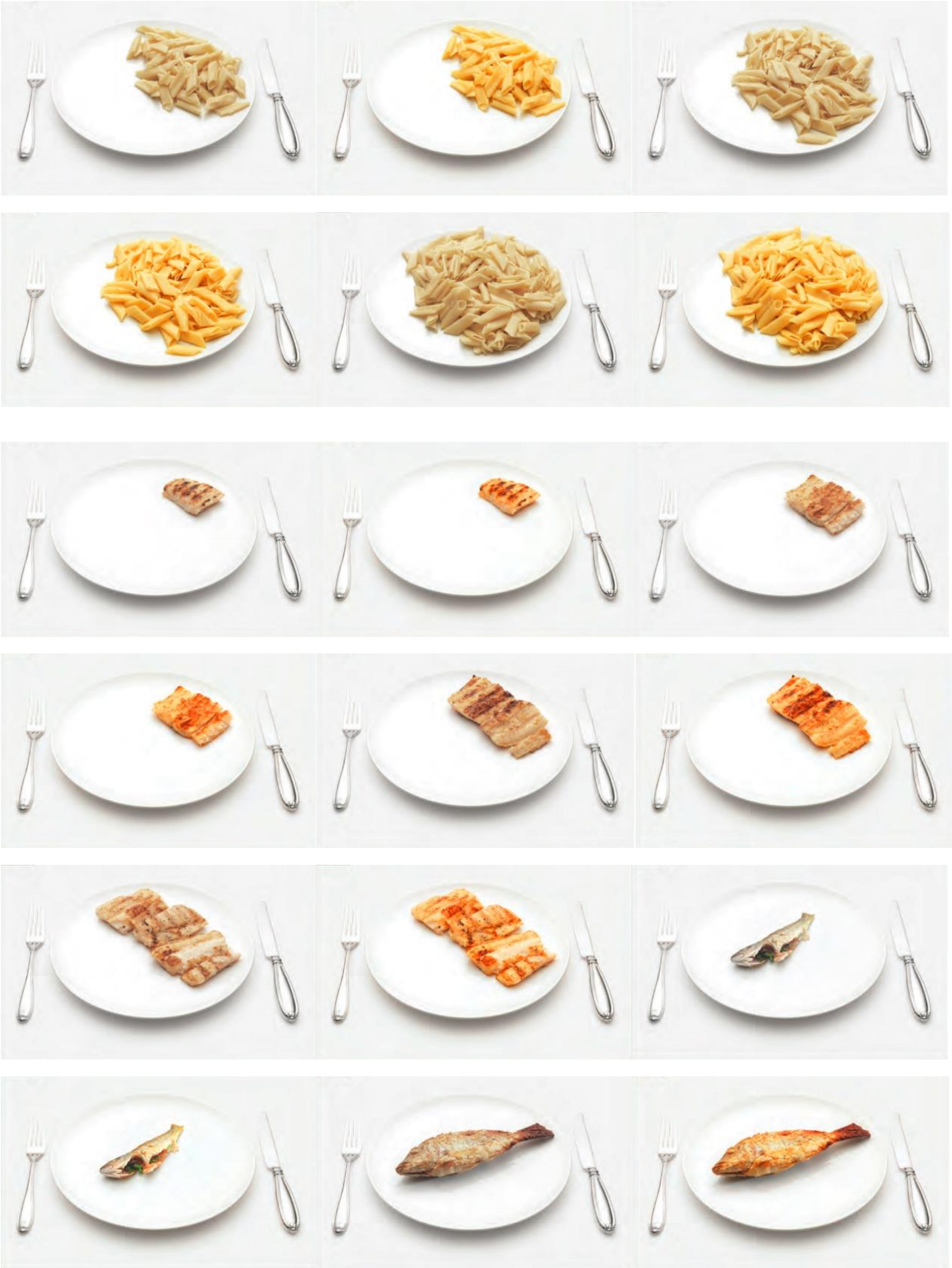
Itens

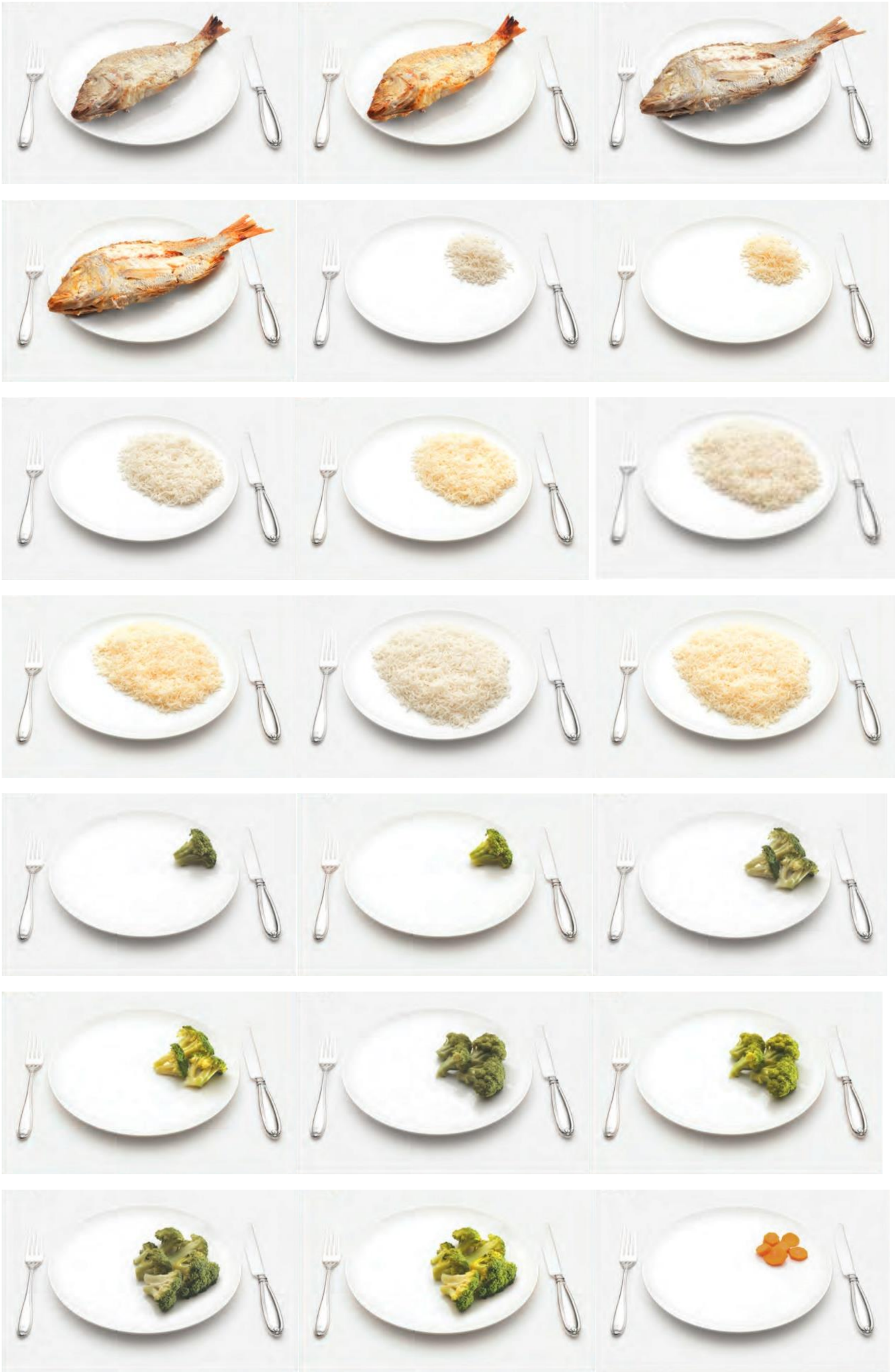
O seu prato

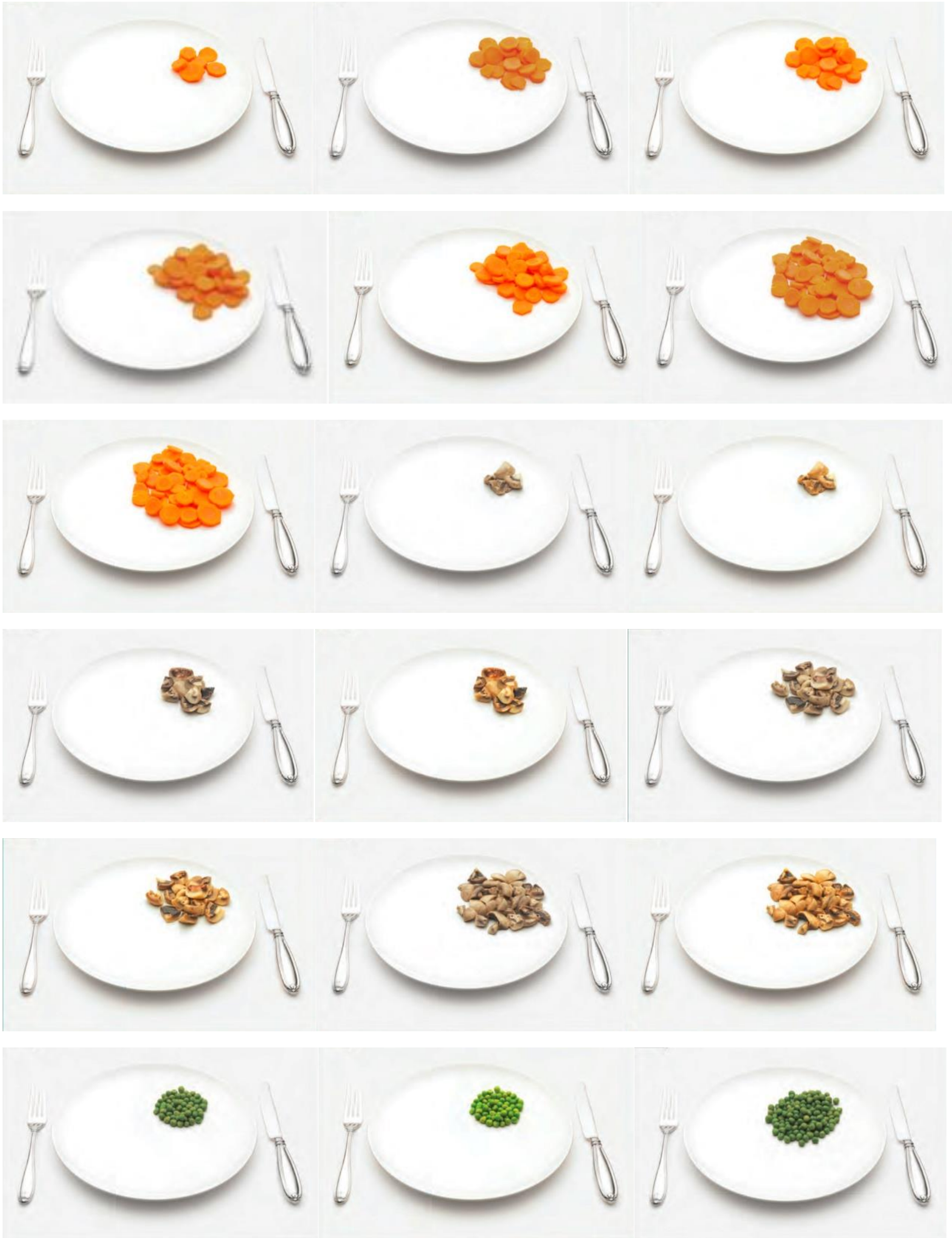
Appendix L - Cooked food items presented in the Restaurant Simulation in Phase 2, with both levels of colour saturation and the four portion sizes options

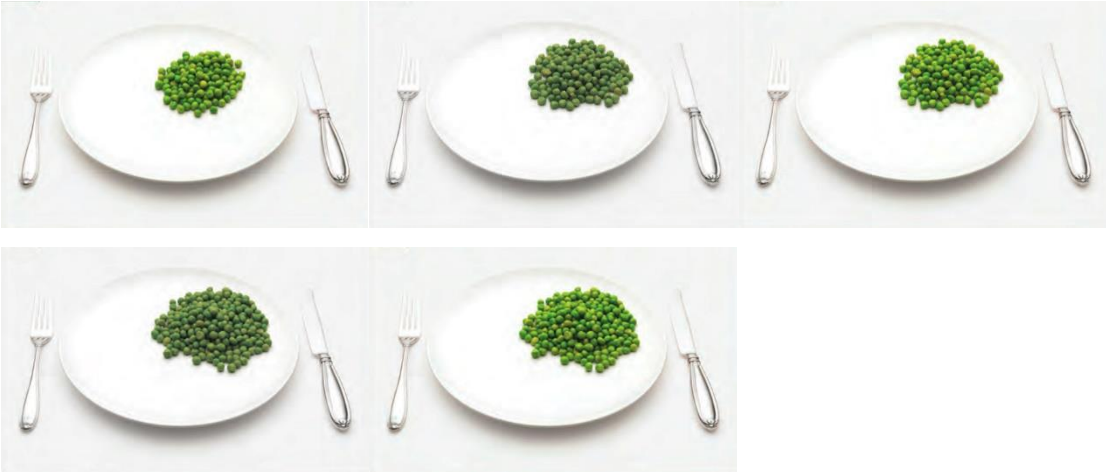












Appendix M – Study survey (Phase 3)

Nesta **última** fase, peço-lhe que dê a sua opinião sobre a **saudabilidade** (qualidade do que é saudável) de seis produtos alimentares, anteriormente, apresentados.

O quão saudável considera este alimento?

| 1= Nada saudável | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10= Muito saudável |
|---|---|---|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |