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Nutrients for Money: The Relationship between Portion Size, Nutrient Density and Consumer Choices

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Abstract

Overweight and obesity are major risk factors for chronic disease and in the past 40–50 years portion sizes of offered foods, especially energy-dense, nutrient poor varieties, have dramatically increased along with global rates of overweight and obesity. Studies have shown that offering larger portion sizes result in increased food intake, known as the ‘portion size effect’. This is likely due to consumption norms, the expected satiation and satiety of larger portions and the effect of unit bias. In addition, inconsistencies between serving sizes on nutrition information labelling compared to national dietary guidelines, makes it difficult for consumers to estimate and select appropriate portion sizes. Consumers find larger portion sizes more appealing due to their perceived value for money however, the nutritive value of the food is most often not acknowledged. Nutrient profiling models, which classify foods based on their nutrient density per unit cost may help consumers make healthier food choices. This narrative review aims to provide an overview of the portion size effect and discusses the application of nutrient profile score-based labels as a means of promoting nutrient density as value for money to influence consumer choices.

Keywords: energy density, nutrient density, portion size, portion size effect, serving size

1. Introduction

Globally, non-communicable diseases are the leading cause of mortality and morbidity, contributing to 73% of total deaths and 62% of disability adjusted-life years (DALYs) [1]. Overweight and obesity are a leading risk factor for the development of non-communicable diseases [2]. It is widely accepted that diet is a major contributor to an energy imbalance by which energy intake exceeds energy expenditure over an accumulative period of time, leading to the development of overweight and obesity [3]. Limiting the consumption of energy-dense, nutrient poor foods to manage energy intake is a strategy recommended for regulating body

weight and preventing non-communicable diseases [4, 5]. The energy density of food refers to the proportion of energy compared to the total mass weight (i.e. kilojoules per grams), which is influenced by the macronutrient and water content of the food [6].

Over the past 40–50 years, offered portion-sizes have significantly increased in food retail, restaurants and cookbook recipes [7–13]. Young et al. [7] reported that the portion size of energy-dense, nutrient-poor ready-to-eat foods exceeded government recommended standard serve sizes by up to 700% [14, 15]. This increase in offered portion sizes is driven by consumers seeking value for money. After taste, consumers regard price as the most important factor determining food choices. Larger portions appear more attractive by offering more food for a lower unit price [13]. From a producer's perspective, offering larger portions is therefore profitable. The cost of the extra food product is often negligible compared to the cost of the food packaging and offering a bigger unit may only slightly increase production costs. In addition, by offering a larger product, a producer can increase consumer satisfaction and is likely to have an advantage compared to a competitor offering smaller units. Therefore, in many settings, prices per gram are lower for large packages compared to small packages. This phenomenon is known as value size pricing.

Offering larger portions of foods to adults and children has been shown to increase the amount of food consumed and total energy intake [16, 17]. This relationship between offered portion size and amount of food consumed is known as the 'portion-size effect' [16–18]. Kling et al. [19] found that doubling the meal portion size offered to children aged 3–5 years increased energy intake by 24%. This study also found that increasing the energy density of the meal did not reduce amount of food consumed [19]. Therefore, serving larger portions of food, especially energy-dense, nutrient-poor varieties, in the long-term may be an important mediator for overweight and obesity and non-communicable diseases. The mechanisms underlying the portion size effect are unclear [20], however value for money has been identified as an incentive for consumers to choose larger portion sizes, which drives the marketing of larger packet sizes by food producers [13, 21]. Additional contributing factors such as appropriateness, unit bias, expected satiation and satiety, visual cues and bite size have also been identified and will be discussed later in this narrative review.

Consumers lack nutritional knowledge and skills to identify appropriate portion sizes and make healthy food choices [22, 23]. To overcome these barriers the European Commission proposed the concept of nutrition profiling, which categorises foods based on their nutritional composition [24]. Nutrient profiling has been used in a number of educational and regulatory strategies including translating nutrition information to consumers via front-of-pack labelling systems [25], identifying foods for re-formulation to improve nutrient density, directing food advertising to specific sub-populations, regulating where specific foods are distributed and informing tax policies of unhealthy foods [25, 26]. Nutrient profiling can also help consumers identify nutrient-dense foods for their unit price [27]. This application may help mitigate the portion size effect by shifting value to nutrients for money, rather than size for money [28].

The scope of this narrative review is to define the portion size effect, discuss the underlying mechanisms of the phenomena and identify the limitations of using a portion size approach when making food choices. This review will define nutrient profiling and its application for consumers, with a particular emphasis on the use of Nutrient Profile models in identifying nutrient-dense foods for their unit price.

2. Defining the ‘Portion Size Effect’: offered and consumed amounts of food

Understanding the definition of a ‘portion size’ and where the term sits in relation to other health terminology is a key challenge for consumers and food manufacturers [29, 30]. Definitions on what is considered a ‘portion size’ oscillate between the amount of food consumed at a single eating occasion and the amount of food served by an individual, food-outlet or manufacturer [31]. The distinction between a ‘portion size’, a ‘serving size’ and a ‘serve’ is also unclear, with the terms found to be used interchangeably on food labels to describe the recommended amount of product to eat [32]. For the purpose of clarity, this review will discuss ‘portion size’ as defined by Benton et al. [31] as the amount of food offered to consumers (of all ages) as well the amount of food selected and consumed. Portion size is then clearly distinguished from a ‘serving size’ which is defined as ‘the amount (e.g. grams, millilitres) of a food or beverage item listed on the nutrition information label and specified in national dietary guidelines for consumers’ [31].

Evidence indicates that serving larger portions increases the amount of food consumed in a specific meal and also subsequent energy intake [20]. This association has been termed the portion size effect [20]. Evidence indicates that offered food portion sizes can contribute to a difference in energy intake [33] however, the relationship is curvilinear. Doubling the amount of food offered can lead to a 35% increase in consumption but as portions continue to increase the portion size effect decreases [16]. This indicates that when conservative and excessive portion sizes of food are offered, additional factors such as physiological satiety cues and consumption norms may be stronger predictors for the amount of food consumed [16]. Contributing factors to the portion size effect will be discussed below.

2.1 Contributing factors to the portion size effect (PSE)

2.1.1 Appropriateness or consumption norms

The concept ‘appropriateness’ is a widely cited explanation for the portion size effect [13, 34]. This concept explains that portion sizes perceived as ‘appropriate’ or normal provide an important cue for determining how much food will be consumed [35, 36]. Lewis et al. [37] examined food portion sizes in relation to social and personal norms using 12 food computer-based images presented in 17 different portion sizes. Adults (aged 18–60 years) ($n = 60$) responded more or less to each image to indicate their portion size preference or perceived portion sizes of others [37]. Overall, this study found that portion sizes for personal norms exceeded social norms for most foods [37]. Personal norms for portion size were found to be significantly larger in obese individuals compared to lean individuals ($\beta = 0.076$, $p = 0.026$), especially in males ($\beta = 0.177$, $p < 0.001$) [37]. Personal norms were also larger for foods with a higher liking rating ($\beta = 0.142$, $p < 0.001$) [37]. Other studies have also confirmed that portion size norms are influenced by weight status and gender, as well as socio-demographics, childhood experiences and personal motivational factors including dietary restraint [38–40]. Further evidence suggests that individuals perceive a wide range of portion sizes related to a particular food to be the ‘norm’, which suggests that significant confusion exist around estimating appropriate portion sizes [23].

2.1.2 Unit bias

Herman et al. [36] suggested that the amount of food consumed may not only be influenced by the portion size, but also by the number of units or single servings

presented by food packaging (e.g. 1 can of soft drink, 1 packet of chips). Studies have shown that individuals consume smaller amounts when food is divided into several smaller units rather than fewer larger units [41]. Geier et al. [42] described these phenomena as ‘unit bias’. Other factors may also drive the amount of food consumed including cost, availability and convenience of the food unit size [42].

2.1.3 Expected satiation and satiety

Expected satiation may also be an important determinant of the portion size selected [20]. Expected satiation is defined as the feeling of fullness that a food or meal is expected to provide immediately after consumption by an individual [20]. Expected satiety is influenced by learnt behaviours and macro-nutrient content of the food [43] and is directly related to food familiarity, whereby familiar foods are expected to be more filling [43]. Expected satiation also varied across food groups (e.g. vegetables, fruit, dairy) with energy-dense nutrient-poor foods being perceived to have a lower expected satiation ratio [43]. Foods with a lower expected satiation are often served in larger portions [44].

2.1.4 Visual cue

It has been suggested that visual cues such as dishware size, are used as a reference point for judging the amount of food to be consumed. Therefore, larger dishware might promote larger portion size selection and greater food consumption [45]. A meta-analysis (8 publications and 9 experiments) indicated there is some evidence to suggest that larger dishware is associated with greater food consumption, however, this relationship was not statistically significant ($p = 0.28$, 95% CI $-0.35, -0.00$) and a high level of heterogeneity was present across the studies [46]. Furthermore, the rim width of the plate may also impact on an individual’s ability to estimate the portion size ($p < 0.01$) [47]. Currently, there is insufficient evidence to determine the impact of visual cues on portion size and food consumption.

2.1.5 Bite size

Emerging evidence suggests that larger portion sizes increases the amount of food consumed per bite [48–50]. It is hypothesised that larger bite sizes may result in reduced oral exposure time (i.e. an amount of food has less exposure time in the mouth) and less responsiveness to physiological satiety signals and therefore contribute to greater food consumption [51].

3. The ambiguity of nutrition labelling and serving sizes

Food product labelling provides consumers with nutritional information to help them make informed choices. A systematic review, including 36 studies showed that different types of food labels on packages influence consumed portion sizes with effects varying from increased to decreased intake (34).

Worldwide regulations for nutrition labelling on foods products differ considerably. In some countries (e.g. member states of the EU), nutrients listed on the nutrition label must be provided per 100 grams or millilitres, whereas other countries (e.g. US, Brazil) require the nutrient content per serving and some countries require both (e.g. New Zealand, Thailand) [52]. Furthermore, in some countries (e.g. US, Canada), standard serving sizes are defined for specific foods by regulatory bodies, whilst in others (e.g. Australia, New Zealand) food manufacturers define their own

serving sizes [52]. Evidence suggests that portion sizes are altered by food manufacturers to present a more favourable nutrition profile for their product, especially for 'unhealthy foods' that are energy-dense and nutrient-poor [53–55].

Some national dietary guidelines (e.g. Japan, Austria) specify standard serve sizes for specific foods within a food group on one eating occasion, as well as the total number of standard serves to be consumed per food group per day [56]. An important point of confusion for consumers is that the labelled serving size of packaged food can vary significantly to the standard serve sizes defined by national dietary guidelines [29]. For example, Yang et al. [57] analysed the nutrition labels of 4046 packaged foods in Australian supermarkets and found that only 24% adopted serving sizes that were similar with the standard serve sizes specified in the Australian Dietary Guidelines. Furthermore, Chan et al. [58] reported that at least 80% of Canadian packaged food ($n = 1406$) did not adopt the Canada's Food Guide Recommended Serving Sizes. These inconsistencies and confusing terminology prevent consumers from correctly interpreting nutrition labelling and making informed choices about appropriate portion sizes [57]. A systematic scoping review of studies conducted between 2010 and 2019 has found that consumers have a poor understanding of the labelled serving size [59]. Consumers frequently interpreted the labelled serving size as the recommended standard serve sizes specified within dietary guidelines for healthy eating rather than a typical consumption unit that is set by the manufacturer or other regulatory authority. A detailed discussion and review how consumers interpret the labelled serving size on food packages and how this information influences consumption behaviour was provided in the studies by Van der Horst et al. [59] and Bucher et al. [60].

Most national dietary guidelines do not provide standard serve size recommendations in weight or metric cups for 'unhealthy' energy-dense, nutrient-poor foods [61]. Furthermore, the definition of energy-dense, nutrient-poor foods is often ambiguous. For example, the Eat Well Guide, describes energy-dense, nutrient-poor foods, as foods 'high in' fat, salt and sugar without providing quantitative criteria [56]. Consequently, these factors prevent consumers from clearly distinguishing foods of high and low nutrient density as well as estimating appropriate portion sizes.

4. Nutrient profiling

Consumers often perceive larger portion sizes to be of greater value for money, without considering the nutritive value of the foods in relation to cost [62, 63]. In 1894, the nutrition scientist, Wilbur Atwater, was the pioneer for recognising the need to educate consumers about choosing cost-effective nutrient-dense foods and provided a legacy of studies which contributed to the development of nutrient profiling models [64].

Nutrient profiling is an emerging field of nutrition research that aims to classify foods based on their nutrient density using numerical scores or qualitative classifications [65, 66]. Nutrient profiling models calculate the energy and macro and micronutrient content per specified unit [67]. Nutrients typically chosen for nutrient profiling models include protein, dietary fibre, calcium, iron, vitamin A, C and D, which are defined as shortfall nutrients, while saturated fatty acids, total sugars and sodium are identified as nutrients to limit [67]. Foods which contain a higher proportion of shortfall nutrients compared to energy are defined as nutrient-dense, while foods that contain a higher proportion of nutrients to limit compared to energy, are defined as energy-dense, nutrient-poor foods [65].

Depending on the nutrient profiling model used, the nutrient content of a food may be expressed using standard units, which include per 100 g, 100 kcal or per

serve. The standard unit chosen for a model will affect the nutrient density classification [66]. For example, using the standard unit per 100Kcal for foods low in energy such as fruit and vegetables, may result in the nutrient density being classified as disproportionately high in relation to the amounts typically consumed [66]. Another challenge in the field is the validation of nutrient profiling models [65, 68]. A recent systematic review of 78 profiling models identified that only 58% had performed validity testing [67]. The World Health Organisation (WHO) has developed and tested a draft guideline which specifies a series of tests that should be completed for the validation of nutrient profiling models [69]. However, these guidelines are not yet publicly accessible.

4.1 Application of nutrient profiling for consumers

Nutrient profiling has a wide range of applications related to public health including both educational and regulatory strategies [65]. Nutrient profiling can be used to help consumers make healthier food choices by translating nutrition information via front-of-pack labelling systems on food packaging, supermarket shelf labels and through smart-phone applications [25]. Regulatory applications of nutrient profiling have been analysed by Raynor et al., [26] using the '4Ps' of Marketing Theory; Product, promotion, place and price of foods. In applying this theory, nutrient profiling can be used to; identify foods for re-formulation to improve the nutrient-density (product), direct food advertising to suitable sub-populations (promotion), regulate where specific foods are distributed (place) and taxation of unhealthy food (price) [26]. A systematic review indicated that the most common regulatory applications for nutrient profiling were for school food standards or guidelines ($n = 27$), food labelling ($n = 12$) and the regulation of food marketing to children ($n = 10$) [67]. More recently, nutrient profiling has been used as a criteria for the taxation of energy-dense, nutrient-poor foods [70]. For example, in Mexico an 8% taxation has been enforced for foods with an energy density of >1151 KJ (275 kcal)/100 g such as cakes, pies, cookies, chips and snacks [71]. Further development and analysis of these applications in the future will be important for optimising their impact on diet quality of consumers.

Research reports positive findings in regard to the effectiveness of nutrient profile scores for helping consumers make healthier food choices. As an example, the recent 5-year review of the Australian Health Star Rating reported that 70% of Australian consumers agreed that this voluntary front of pack nutrient profile logo helped them to identify healthier options within the same food category [72]. It was also found that two thirds reported that the label influenced purchasing decisions and that the label was driving product reformulation [72]. Furthermore, a randomised controlled trial of adults ($n = 11,981$) indicated that the use of the Five-Colour Nutrition Label enabled participants to choose foods of higher nutritional quality, including less saturated fat and sodium ($p < 0.05$) [73]. Although, significant challenges remain, nutrient profile scores could be used to promote the sales and consumption of healthier foods by consumer education and regulation. Nutrient Profiling Indices could also help identify foods that are both healthy and affordable [28, 63, 65]. Drewnowski et al. [28] demonstrated this by cross-referencing the Nutrient Rich Food Index with the US Department of Agriculture (USDA) nutrient composition and food prices data sets. The study demonstrated that foods could be characterised according to nutrients per dollar, helping consumers identify affordable, nutrient-dense foods [28], highlighting an area whereby nutrient profiling may contribute to the mitigation of the portion size effect by educating consumers on the nutritive value of foods and shifting preference for large portion sizes to high nutrient-density (**Figure 1**).

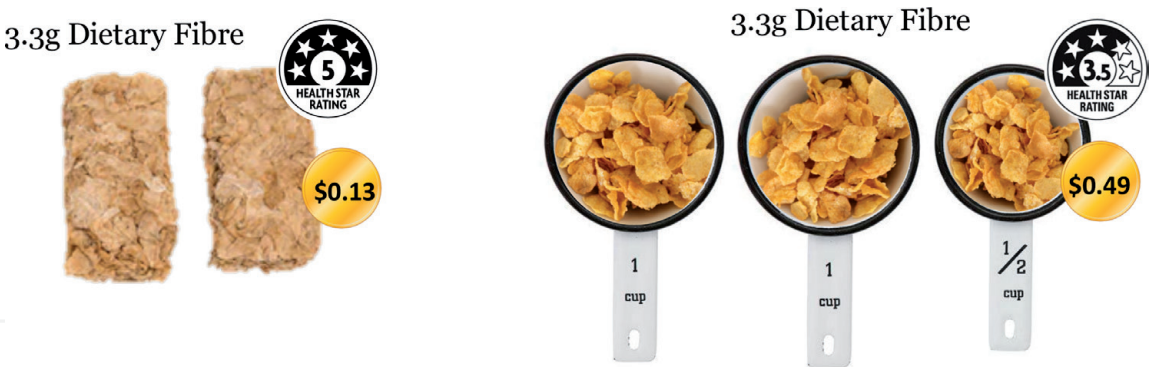


Figure 1.
Fibre for money. This figure visually represents the volume and cost of two different cereal types of providing 3.3 g dietary fibre each. It demonstrates that to match the amount of fibre in a single serve (30 g) of Weet-Bix, consumers must eat approximately 2.5 cups (82.5 g) of corn flakes to reach the equivalent amount of dietary fibre. This larger portion would cost consumers 3.7 times more, demonstrating the value in emphasising nutrients for money rather than volume for money.

5. Conclusion

It is clear that larger portion sizes contribute to greater food consumption and higher energy intake, known as the portion size effect. However, consumers have difficulty in identifying appropriate portion sizes due to inconsistencies between the serving sizes of packaged foods compared to standard serving sizes defined by national dietary guidelines. In addition, consumers find larger portion sizes more appealing due to greater perceived value for money but often do not consider the nutritive value of the food. Pricing strategies were suggested to be an innovative way to counteract the portion size effect [21]. However, experimental research suggests that equalising unit prices alone may not be sufficient to counteract the effect of larger offered portions [74].

Nutrition profiling has been implemented for public health initiatives including food labelling, food standards and guidelines and the regulation of food marketing. Front of pack labels that are based on nutrient profile scores such as the Health Star Rating help consumers to identify healthier foods. However, these labels could be developed further to better assist consumers in identifying foods of high nutrient-density per unit cost. Further development of food labelling, consumer education and public health efforts are needed to promote nutrient density as the value for money, which should be driving product development. Specifically, future research is needed to evaluate the long-term impact of nutrient profile scores in real-life contexts (e.g. purchasing behaviour in supermarket) rather a controlled laboratory setting. The ability of nutrition profiling initiatives to effectively communicate nutrition messages to different target groups warrants further investigation. This body of evidence will be important for informing global industry reformulation and food policy development, which has the greatest potential to impact on consumer food choices and dietary intake.

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