



# Role of staple cereals in human nutrition: Separating the wheat from the chaff in the infodemics age

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## ABSTRACT

**Background:** Staple cereals always have been important dietary components, yet recent debates on their role in human diets are riddled with myths and misinformation.

**Scope and approach:** This article examines the informational controversies, particularly about wheat, and reviews the evidence. The discussion centers on three nutritional cereal debates: i) ‘empty calories’, ii) over-consumption, and iii) how ‘free-from’ fads confound dietary transitions.

**Key findings and conclusions:** This article makes two principal points, that i) advances in nutrition are a complex, slow process, and that ii) they can be easily confounded and undone by misinformation. Hence we suggest that more consumer-oriented work is needed—including behavioral approaches and political economy—in order to improve the quality of information, communication and dietary decision making. There is a clear need to tackle nutritional misinformation given the costs of inaction and the need to formulate a coherent agri-nutrition agenda.

## 1. Introduction

A recent article in *The Lancet* lamented how a ‘tidal wave of information’ about Covid-19 has hampered public health efforts by blurring the lines between truth and fiction (Lancet, 2020). The World Health Organization (WHO) used the term ‘infodemic of misinformation’ to characterize the fast spread of misleading or fake reports in an overabundance of (mis)information that has not abated (WHO, 2020). The significance of managing knowledge, advice and education for better health care is important not just for pandemic times, but also for the medium- and long-term issues of food security, nutrition, and health.

Advances in nutrition science continue to emerge and nutrition recommendations continue to adapt. Varying views and theories from a multitude of sources lead to an overabundance of misleading information, so the public becomes confused about what constitutes a good diet. Whereas there is general agreement on the importance of eradicating hunger in all its forms, scientific opinions differ on the relative importance of different—and hence competing—strands of agri-nutrition research (Gödecke et al., 2018; Lenaerts & Demont, 2021; Pingali, 2015). The paradoxical co-existence of different forms of under- and overnutrition adds to misunderstanding, not least because the popular

media and general public generally prefer to consider one problem at a time, resulting in limited ‘issue-attention cycles’ (Stoian & Donovan, 2020). Indeed, since the 2000s the malnutrition focus has shifted from the eradication of hunger to dietary diversity to combat micronutrient malnutrition. More recently, interest has increased in overnutrition (Popkin et al., 2020). Perceived wisdom and confirmation bias can further obfuscate matters, including the indicator choices for food insecurity/hunger that guide most popular and policy discussions (Barrett & Bevis, 2015). Commercial interests of the agri-food industry, social media platforms and diverse influencers add to the toxic mix of misinformation.

Knowledge changes over time and context specificity add to the complexity of communication around nutritional issues. In 2015 the global community agreed on an ambitious international development agenda for 2030 that revolves around 17 Sustainable Development Goals (SDGs; UN, 2015). The notion of ‘zero hunger’ by 2030 (SDG2) has been widely used since to frame the challenges of hunger and micronutrient malnutrition. In past decades achieving zero hunger appeared within reach with food supplies high, food prices down, and the number of hungry people declining. Yet it now appears increasingly out of reach, with the number of hungry increasing and exacerbated by the Covid-19

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pandemic and associated economic fall-out. Covid-19 imposed restrictions on employment, markets and trade exerting multiple and complex impacts on food availability and access, plunging millions more people into food and nutritional insecurity. The hunger problem cannot be solved by merely increasing food supply, with increased recognition for the need to consider food access, utilization, and stability in addition to availability (Grote et al., 2021). Hunger tends to be associated with fragile states, conflict and population displacement further underscoring context specificity. The sustainability of current agri-food systems is increasingly questioned, including the need to stay within planetary agro-ecological boundaries, reduce environmental/land degradation and cope with increasing water scarcity (Grote et al., 2021; Sabaté & Soret, 2014; Willett et al., 2019). Climate change adds further challenges in terms of agri-food system adaptation and mitigation (Jones & Yosef, 2015).

The persistence of under- and overnutrition and its temporal, spatial and social heterogeneity reinforce the view that global food security and improved nutrition and health are complex problems. In the food security mix, staple cereals remain an important dietary component. Yet discussions on the role of staple cereals in human diets, both in popular media and academic circles, are riddled with bias and myths. This article examines some of the staple cereal controversies, particularly about wheat, and the human diet, and sets out the evidence about real benefits and drawbacks. We examine three persistent and popular nutritional misconceptions around staple cereals: i) they are assumed to provide only ‘empty calories’; ii) the assumption that people consume too many cereals; and iii) how ‘free-from’ fads confound dietary transitions. We conclude that, given the far-reaching consequences and costs of infodemics, what matters for achieving food security goals is accurate knowledge to resolve uncertainties about the contribution of staple cereals.

## 2. ‘Empty calories’?

Simplistic perceptions of foodstuffs guide some of the popular and policy discussions: staple cereal grains and roots-&-tubers are energy-rich; fruits and vegetables are healthy (vitamins, fiber); and legumes and animal products are protein-rich. These lines easily blur further whereby staple cereal grains (and roots-&-tubers) are equated with ‘empty calories’. Such unfortunate labeling is inherently problematic on at least three accounts.

First, it gives a negative connotation to calories. Yet the provision of sufficient energy is a key function of any food system. Without sufficient energy, people cannot function fully and other food groups such as protein are converted by the body to provide the needed energy. At worst, people starve. This undermines any attempt to enrich diets without first securing basic energy needs.

Second, it equates staple cereals with only providing dietary energy. In fact, they provide various macro- (carbohydrates, proteins, fats) and micro-nutrients (minerals, vitamins), as well as non-nutrient food components (dietary fiber, other bio-actives, phytochemicals—Poole et al., 2021). Staple cereals are not a panacea for balanced and healthy diets—but are a foundational component, often relatively affordable and providing more than dietary energy. Given their intake as staples, their contribution can be substantive in meeting dietary needs. A case in point is wheat: it provides a fifth of dietary calories and proteins in human diets globally (Shiferaw et al., 2013) and a fifth of dietary fiber in a country such as the United Kingdom (Shewry & Hey, 2015).

Third, the ‘empty calories’ concept originated from the energy associated with added sugar and solid fat in processed foods (Poti et al., 2014)—i.e. calories with no or few nutrients. This originated from the critique of highly processed foods—including fast-food, snacks, and sodas (Poti et al., 2014).

## 3. Are staple cereals over consumed?

The perception that people consume too many staple cereals has infused popular and policy discussions. This notion originated in the Global North but has gained further traction with the energy richness of staples and the association of obesity and diet-related non-communicable diseases with excessive energy intake. Cutting back on staple cereal intake (and other energy-rich food stuffs) is perceived as a simple solution to the obesity problem. In the meantime, the consumption of fruits and vegetables is glorified, with some elevated to ‘super foods’ as part of diet fads in North America and elsewhere. Official dietary guidelines worldwide point to the need for balanced diets from diverse food sources—not singling out any specific food category or nutrient. The challenge remains for the global consumer to ‘just follow’ the nutrition guidelines—as any behavioral economist will confirm. It may well be common knowledge what is best for the consumer—but that does not necessarily imply the consumer will behave accordingly (Kahneman, 2011), especially if there are alternative information narratives, more gratifying instinctive behaviors and debilitating affordability constraints to food access.

Adding to the complexity of clear messaging around staple cereal intake is the fact that benefits vary depending on the form in which they are consumed. Staple cereals are variously consumed, ranging from whole grains to highly processed products. There is a need to double the current intake of wholegrain foods (Springmann et al., 2020) and for these to be given a more prominent role in nutrition strategies. Cereal milling and processing often reduce or remove protein, fat, fiber, minerals and vitamin. Thus, whereas cereal grains in general contain important amounts of nutrients and bioactive components, processing affects the levels retained (Dewettinck et al., 2008). In its extreme, this can lead to so-called ‘ultra-processed foods’, typically low in healthy- and high in unhealthy components, which are energy-dense—yet satisfying to consume, hyper-palatable, and with a long shelf-life (Monteiro et al., 2018). Terminology can further obfuscate matters. A case in point is the common use of ‘cereals’ as a synonym for ‘breakfast cereals’, which typically are highly processed and high in added sugars.

There has been limited success in creating a more nuanced understanding of the complex dietary contribution of cereal foodstuffs to challenge the persistent association of staple cereals with dietary concerns (Brouns et al., 2019). Further obfuscating matters are the non-uniform definitions and labeling of wholegrain foods (e.g. sometimes still containing 49–74% of refined grain—Jones et al., 2020). We refer to wholegrain foods here as foods primarily derived from un-refined grain which retains the original micronutrients which can thus include wholegrain bread (containing entire grains) as well as wholemeal bread (based on milled whole grains - Dowling, 2018). Un-processed whole grains may have more health benefits than so-called processed wholegrain foods which often have had content such as fiber removed and then replaced in less a nutritious form (Poole et al., 2021). Interpretation and comparison of wholegrain research studies is also confounded by variability in methods and reporting (Sawicki et al., 2018), inconsistent results between studies, and selective reporting (Jones et al., 2020).

Cereal grain processing can also enhance nutritional value. For one, the level, bioactivity, and bioavailability of food components can be modified through processing variations (e.g. use of yeast or sourdough, fermentation time, baking conditions—Brouns et al., 2019; Dewettinck et al., 2008). Processing also allows for fortification: enriching refined grain products to improve intake of vitamins (folate, other B) and/or minerals (zinc, iron—Jones et al., 2020). Such processing benefits could imply trade-offs with wholegrain foods. In the end, dietary guidelines supported by research still call for a mix of wholegrain and refined-grain foods (Jones et al., 2020). Food fortification is widely mandated for enhancing nutrition and cereals are an almost ubiquitous food for this purpose.

Staple cereals have important health attributes. Whole grains are

widely associated with reduced risk of non-communicable diseases (e.g. cardiovascular disease, type 2 diabetes, colon cancer—Brouns et al., 2019; Shewry & Hey, 2015). However, wheat also contains components that can produce adverse reactions in susceptible persons: e.g. autoimmune responses to gluten, like celiac disease and associated conditions (e.g. dermatitis herpetiformis and gluten ataxia); and others like wheat allergy; non-celiac wheat sensitivity; and irritable bowel syndrome (IBS) associated with non-digestible rapidly fermentable carbohydrates (i.e. fermentable oligo-, di-, mono-saccharides and polyols – FODMAPs—Biesiekierski, 2017; Brouns et al., 2017; 2019; Pietzak & Kerner, 2012). Care is thus needed in interpreting data from gluten- and wheat-related studies with due consideration for all wheat components (Biesiekierski, 2017). These adverse health reactions are clearly problematic for susceptible individuals, yet their incidence affects a minority (e.g. celiac disease affects an estimated 1%—Biesiekierski, 2017; Mattioli et al., 2019). In any case, this broadens the agenda to health and wellbeing (i.e. SDG3, beyond SDG2—Poole et al., 2021; Shewry et al., 2016).

Questions about the adequate intake of staple cereals should not ignore the reality that undernutrition remains a key challenge for large swathes of poor across the globe. Cereal grains still provide the most accessible and affordable macro-nutrients (energy and protein) to the global population (Poole et al., 2021). This was underscored during the 2007-08 global food crisis and the subsequent socio-political fall-out during the Arab Spring. Staple cereal prices, especially of the daily bread in northern Africa, were at the core of the food crisis. Stability of staple food prices and access thereby remain key concerns for local to global efforts to ensure food security. Despite complacency again having set in, concerns remain about the next breadbasket failure and fallout thereof.

Staple cereals play a key role in sustainable and diverse agri-food systems and diets. The role of whole grains therein is increasingly acknowledged. The affordability of and access to diverse nutritional diets is also increasingly questioned (Hirvonen et al., 2020). For instance, the affordability of many fruits and vegetables remains a challenge for many—as do their year-round and spatial availability. Lack of affordability and access is responsible for the phenomenon of ‘food deserts’, or more precisely, ‘nutrient deserts’ where consumers’ diets are consistently insufficient for health. In addition, culinary traditions in some contexts offer limited scope for rapid or major increases in the consumption of fruits and vegetables among lower income urban and peri-urban consumers (Penny et al., 2017). Wholegrain cereals thereby provide an affordable and accessible nutritional foundation.

#### 4. Dietary transitions or ‘free-from’ fads?

Earlier work has linked economic growth and urbanization with the nutrition transition (Drewnowski & Popkin, 1997). The dietary shifts have been associated with the increased intake of highly processed foods, including convenience foods (Barrett & Bevis, 2015; Popkin et al., 2020). Such shifts often also imply reduced micronutrient density of staple foods, which consumers may not adequately compensate for (Barrett & Bevis, 2015). The search for sustainable diets has been spurred by questions about the nutrition transition and the sustainability of current agri-food systems (Willett et al., 2019), combining nutrition and global sustainability, with socio-economic and environmental dimensions (Meybeck & Gitz, 2017). This has also re-ignited interest in the potential of plant-based protein (Loveday, 2020; Sabaté & Soret, 2014), be it as direct whole grain intake or in various processed forms. Returning to diets based on plants is posed as an acceptable alternative and foundation for a more sustainable food future and improved health and social justice outcomes (Sabaté & Soret, 2014). For diverse reasons, vegetarianism continues to gain popularity in the Global North and among specific population segments (including youth). These dietary shifts appear genuine structural transitions that have far-reaching consequences for human nutrition, health, and the associated agri-nutrition agenda.

The nature of other dietary shifts can be more challenging to qualify. Whole grains are a case in point. Over a decade ago an article opened with ‘whole grains are back’ (Edge et al., 2005, p. 1856). Some people now ingest only whole grain and avoid all refined-grain foods over increased concerns and awareness of highly processed products (Jones et al., 2020). Yet whole grains have long puzzled consumers, including challenges to fully understand their benefits and to identify wholegrain foods at purchase (Jones & Engleson, 2010). Moreover, to further incentivize purchase and consumption wholegrain product formulations must be easily stored and appetizing, and accurately labeled. Indeed, whole grain consumption remains far short of advised intakes despite concerted promotional efforts (Rebello et al., 2014).

Efforts to change food consumption behavior have been variously characterized as ‘hard’ interventions (e.g., economic incentives—subsidies, taxes, tariffs—and mandates/regulation) vs. ‘softer’ behavioral approaches (e.g., education, campaigns, ‘nudges’—Osman & Nelson, 2019; Vandenbroele et al., 2020). For long, changing consumer food attitudes and behaviors has been largely ineffective. For instance, the effectiveness of posting nutritional information (e.g. calories) to influence consumer decisions remains unsubstantiated (Fisher, 2018). The relative ineffectiveness of most approaches has spurred an interest in psychological research on food attitudes, preferences and choices (Osman & Nelson, 2019) and behavioral approaches (Vandenbroele et al., 2020). Behavioral economics research is one such approach and variously includes the use of ‘nudges’—non-obtrusive interventions—to entice behavioral change and improve food choices. For instance, consumers typically operate in a complex food environment, and an intervention may slightly adapt the food choice architecture at the time of decision making (Vandenbroele et al., 2020). Overall, nudging generally proves promising in terms of increasing healthier food choices (Arno & Thomas, 2016; Vecchio & Cavallo, 2019). Since 2006 there has been a boom in nudging research to enhance food choices, including studies looking into wholewheat bread (van Kleef et al., 2018) and wholegrain pasta (Sogari et al., 2019). Much of the recent nudging research is still focused on the Global North, particularly the United States, and there is a need to replicate results in more diverse settings (Arno & Thomas, 2016). Longer term studies are also necessary to assess the potential for significant and permanent changes in food purchasing and consumption. Still, behavioral approaches offer promise to provide new much-needed prospects to change the whole grain consumption habits of consumers.

Such changes also call for an integrated multi-sectoral approach across the whole food-supply chain including production and processing (Augustin et al., 2016). For instance, to improve whole grain consumption habits, more appetizing and more clearly labeled products are needed (Jones & Engleson, 2010). There are, however, profit vs nutrition trade-offs, a situation aggravated by the uneven power distribution in the food supply chain (Poole et al., 2020). This underscores the need to consider the political economy of dietary change. Earlier work has highlighted how industrialization of agriculture and food processing, and food chain structures affect power relations and the potential chain transformation or regeneration (Fine, 1994). More recent work reiterates the relevance of political economy considerations: high path-dependency, change resistance, industrial lobbying and power imbalances can undermine food system reforms and call for concerted efforts across private- and public sector and grassroots organizations (De Schutter, 2017). Profit considerations can also incentivize dietary change. For instance, advantages of ancient species of wheat are being re-considered, opening new value chain and marketing opportunities (Kulathunga et al., 2020).

Staple cereals have taken center stage in dietary debates—from outright anti-grain stances, to diets avoiding certain types of grain (e.g. ‘ancient’ vs ‘modern’ grains; ‘hulled’ vs ‘naked’ wheats [Kulathunga et al., 2020; Longin et al., 2016]; wheat in general), to diets avoiding certain components (e.g. gluten, FODMAPs—Brouns, 2018; Jones et al., 2020; Shewry et al., 2016). Grains in general or specific grains/components are thereby singled out as the root cause of specific

diseases and obesity (Brouns, 2018). This in turn leads to specific diets and food products. For instance, to treat gut disorders the low-FODMAPs diet was launched in 2001 (Fedewa & Rao, 2013). Despite the safety and efficacy controversies related to the low-FODMAPs diet (Fedewa & Rao, 2013), the promotion and marketing of the low-FODMAP diet and FODMAP-free foods has surged, with the associated publicity only increasing (Brouns et al., 2017). Recent archaeological evidence now suggests that the original ‘paleo’ diets included a substantial component of starches derived from cereal grains, and were not the ‘hunter-gatherer’ diet idealized in some current popular and commercial dietary misinformation (Curry, 2021). Thus it turns out that ‘free-from’ products are a novel ideal.

Gluten-free takes a particularly prominent role in dietary debates and consumer mindsets. Gluten is a complex mixture of related proteins, the main storage protein of wheat grains and gives wheat bread and other processed foods their leavening capacity. It is long acknowledged in the scientific literature that the gluten-free diet is a critical medical treatment for individuals suffering from celiac disease (Jones, 2017; Reilly, 2016). Still, there are varying definitions of thresholds and food labeling (Biesiekierski, 2017; Mattioni et al., 2019). The gluten/wheat related health conditions are still relatively rare, albeit increasing, likely a reflection of increased awareness in the scientific community (Reilly, 2016). However, these changes have been dwarfed by the disproportionate growth of the gluten-free food industry (Reilly, 2016). From being a relatively rare health condition, ‘gluten-free’ thereby now exemplifies dietary fads (Brouns, 2018; Jones, 2017; Pietzak & Kerner, 2012; Reilly, 2016). More controversial is the liberal use of the ‘gluten-free’ label, from gluten-free bottled water to even beyond the food industry. The gluten-free movement illustrates how initial dietary misinformation can grow into a multi-billion-dollar business in less than a decade (Jones, 2017). Social and popular media coverage has variously associated health problems to the consumption of wheat (Brouns et al., 2019). This, in turn, led to a surge in the avoidance of wheat/gluten-based foods, even among those with no diagnosed medical condition (Brouns et al., 2019).

Gluten-free thereby exemplifies the infodemics of nutritional and health misinformation. Strong beliefs in popular/social media and the wider population are interspersed with evidence and lingering scientific uncertainties. This provides a fertile ground for pseudo-science and myths/disinformation. This further builds on, and aggravates, a general lack of consumer understanding, widespread popular misunderstandings on probability and prevalence of disease, and nutrition and health fads. The alternative dietary views of celebrities and science have been variously highlighted (Glaser, 2019), further igniting conspiracy theories, coverage in popular books/blogs/media and marketing misuse (Brouns, 2018). Indeed, fake news participants may be variously motivated by financial and/or political interests (Lancet, 2020).

There is a continued need to better enable consumers to distinguish whether information is based on scientific evidence or on ill-founded assumptions/beliefs (Brouns, 2018). Indeed, the persistence of dietary fads and spurious unscientific knowledge suggest that the nutrition and health communities have been largely unsuccessful in challenging these with a more nuanced understanding of the complex dietary contribution of cereal foodstuffs (Brouns et al., 2019). While such education/information may create awareness, it does not necessarily encourage consumers to change their behavior as variously illustrated by (social) marketing (Hastings & Domegan, 2014) and behavioral economics (and associated tensions between the conscious and subconscious, with many habits arising from subconscious behaviors – Kahneman, 2011). Finally, improved nutritional understanding only goes so far and may fail to create demand for healthier foods. More purposive demand-creation of wholegrain foods thereby also merits further attention.

## 5. Discussion

The present paper challenges some perceived wisdoms and popular debates around staple cereals. We reviewed the associated debate and arguments to separate realities and myths—or the grain from the chaff. There clearly is a lot of misinformation and confusion about staple cereals, but this much is clear: these cereals can be nutritious, they are what most of the global population—especially the poorer strata—eat as a normal part of their diet, and these benefits are often overlooked. At the same time, some concerns—some genuine for the relatively limited number of affected individuals—have been blown out of proportion and fueled dietary hype, with widely underrecognized costs and implications.

The paper focused on three questions. The empty calories was probably the easiest question to answer with a resounding ‘no’. Although staple cereals remain a key source of dietary energy, they also provide other macro- and micro-nutrients and non-nutrient bioactive food components. And being staples, these can make up a significant proportion of the dietary intake of these nutrients/components, and cannot be easily replaced in diets. Whether people consume too many staple cereals is more context specific—albeit there is wide scope to enhance whole grain consumption. Whether observed dietary changes and associated concerns are a genuine nutrition transition or a fad depends on the focus. There are genuine dietary changes happening that clearly merit rethinking the agri-nutrition agenda. Dietary ‘free-from’ fads tend to be more transitory—but still also merit our attention given the damage they can do.

Misinformation compromises the formulation of a coherent agri-nutrition agenda. Nor should cereal concerns originating in the Global North undermine food security in the Global South. Yet assessing the appropriate implications for the agri-nutrition agenda is not aided by the complex dietary contribution of cereal foodstuffs and trade-offs. Indeed, it remains a challenge how we can reconcile all cereal-related dietary concerns. Some contradictions may be easier to tackle, for instance, it remains inconsistent to consider wheat as ‘empty calories’ while vilifying its gluten (a protein) content. Others pose trickier trade-offs such as the cost considerations of the underlying trade-offs. Ideally, healthy diets should be as least restrictive as possible. Dietary restrictions are cumbersome and can impose a substantive financial/economic burden to consumers in terms of higher prices for food products (Lee et al., 2007). Such restrictions can be particularly challenging for wheat, given the prevalence of wheat-derived foods (bread, pasta, breakfast cereals—Fedewa & Rao, 2013). The proliferation of nutritional and quality standards for food products worldwide also imposes costs: it can be challenging to comply with these standards to begin with, particularly across international food markets, but there are also increasing accreditation and certification costs, with questions about their effectiveness and cost (Trienekens & Zuurbier, 2008). Finally, there are other important trade-offs to dietary restrictions, such as the nutritional costs (e.g. gluten as an important dietary protein source for the world’s poor) and environmental costs (e.g. the potential of plant-sourced protein as a substitute for animal-sourced protein).

At the same time inaction is costly too, not least in terms of allowing self-reinforcing spurious unscientific and harmful knowledge to proceed unabated. These lead to a vicious circle whereby infodemics lead to confusion; and the confusion further reinforces infodemics. In many ways ‘gluten-free’ exemplifies the challenge of containing infodemics.

Based on the current situation we see the following three interrelated recommendations as potential ways forward:

1. Get our nutritional evidence straight: It seems like straightforward scientific housekeeping: create and act on the evidence base. We all should better acknowledge that there are scientific uncertainties where knowledge of the adverse effects of staple cereals is imperfect, whereas we emphasize the scientific certainties. For instance, more studies are needed to determine the nutritional adequacy of various

component-free diets (Fedewa & Rao, 2013). There is much scope to better handle trade-offs and (un)certainities. A challenge thereby is the complexity of the nutrition agenda and to address the evident biases. Publication bias and the quest for novelty can leave (un) resolved issues. Confirmation bias can aggravate polarization and distrust. Science communication can oversimplify otherwise too complex messaging. Commercial interests can result in selective and biased research and reporting, and potential public-private sector divides. Such divisions undermine the credibility of the evidence base and can ignite infodemics. Staple cereals are not the panacea for food security, human nutrition, and well-being. But they are a nutrition foundation that cannot be ignored or discarded. In the end, staple cereals and ‘nutrient-rich foods’ are complementary for human nutrition (e.g. Rebello et al., 2014) and require additional research and resources to resolve scientific uncertainties. Increased attention for one thereby should not replace the other (Poole et al., 2021).

2. New approaches needed to tackle consumer (mis)understanding and response: The nutritional complexity and evidence of infodemics mean that we clearly have been largely unsuccessful in enhancing consumer understanding and improving consumer nutritional behavior. Whereas a balanced diet may appear a simple matter for consumers to absorb, the lack thereof undermines our assumptions and impact pathways that often have been too simplistic. This calls for a better understanding of consumer perceptions and behavior, but also of the socio-economic and environmental factors that facilitate the spread of misinformation (Lancet, 2020). Consumer education clearly is not the panacea (Hastings & Domegan, 2014; Kahneman, 2011). Behavioral approaches merit more attention to better understand and influence consumer nutritional behavior (Osman & Nelson, 2019; Vandenbroele et al., 2020). This includes the need to go beyond short-term behavior change given the dynamic nature of behavior and ascertain we change people’s habits and achieve sustainable behavior change.
3. Need to better incorporate the political economy of agri-food systems: The political economy of agri-food systems has private industry and public sector dimensions that are often ignored for being simply too complex or challenging to influence. However, ignoring it will not break the impasse around staple cereals. We need to better understand the political economy—and see how best to address such interests and relations to enable change (De Schutter, 2017). The vested interests can be substantive in terms of winners vs losers in dietary debates with varying power relations between stakeholders. In a divided scientific and consumer field, agri-food system stakeholders like the processing industry can cherry-pick and propagate the most useful results and thereby kindle infodemics, or at least undermine the most damaging calls to action. In much of such political economy thinking the consumer is not necessarily king, but more of a pawn—igniting further conspiracy theories on the consumer side. What is clear is that there are political economy issues at play in agri-food systems in general, and staple cereals in particular, of which we still have limited understanding. To achieve nutritional enhancements, we clearly need to better incorporate and deal with the interests of the processing and manufacturing sector starting with transparent partnerships and improved understanding. Demand-creation for healthier foods including wholegrain foods may merit further attention in this regard by enhancing market prospects.

Taken together, the three recommendations should provide the basis of a strategy to tackle some of the nutritional infodemics—past, present and future. They highlight the need for a combined global effort involving multiple stakeholders, including the nutritional R&D community, consumers, agriculture and industry, and government—with policy facilitating an enabling environment. In many ways we thereby need to heed recent lessons. A salutary reminder is that augmenting

information is not the key to quell infodemics (Lancet, 2020). Concerns about misinformation in nutrition and health and the lack of fact-checking have long been present, with the term ‘infodemiology’—the science behind managing infodemics—first being used in 2002 (Lancet, 2020). If anything, the varied handling of the Covid-19 pandemic shows how we have clearly not perfected the scientific-popular interface. Indeed, infodemics call for the need to deal with often mutually reinforcing trends in the wider population: their widespread reliance on social media and ‘influencers’ as sources of information; their general mistrust of experts and science; and their apprehension of government and political responses (Lancet, 2020).

## 6. Conclusion

Staple cereals continue to play an important nutritional role. However, advances in nutrition are a complex, slow process that can be easily confounded and undone. Staple cereal nutrition research is far from resolved with two important implications. First, increased attention to new(er) areas such as ‘nutrient-rich foods’ should not replace other continued nutritional research needs. Second, whereas we need more nutritional research as foundation, we clearly also need different types of research, development, and partnerships, including better communication, and more attention to behavioral approaches and the political economy. In the end, the Covid-19 pandemic should provide the much-needed wake-up call to tackle nutritional infodemics which have slower, but still major implications for food security, human health, and well-being across the globe.

## Declarations of competing interest

None.

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