Nutritional Condition and Nutrient Intake Predict Moral Condemnation of Food Wasting

Misiak Michal [a,b], Butovskaya Marina [c], Sorokowski Piotr [a]

[a] IDN Being Human, Institute of Psychology, University of Wroclaw, Poland

[b] School of Anthropology and Museum Ethnography, University of Oxford, United Kingdom

[c] Institute of Ethnology and Anthropology, Russian Academy of Sciences, Russia

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Corresponding Author: Michał Misiak, IDN Being Human, Institute of Psychology, University of Wroclaw, ul. Dawida 1, 50-527 Wroclaw, Poland; michal.misiak@uwr.edu.pl

Abstract

People believe that food wasting behaviour is immoral. This judgment could be partially driven by increasing awareness of global environmental threats associated with the current scale of food waste. Recent research indicates that moral judgments of food wasting behaviour may also reflect higher levels of food insecurity — potentially serving an adaptive role in harsh environments. In our research, we tested this hypothesis at both the population and individual levels. The study was conducted among individuals from subsistence-economy populations: the Hadza hunter-gatherers (n = 72) and the Datoga pastoralists (n = 70), where levels of food insecurity are higher than in industrialised populations. To infer about food insecurity at the individual level, we analysed body composition, muscle strength, and nutrient intake. We found that individuals who had lower levels of muscle strength and those who consumed less calorie-dense foods judged food wasting behaviour as more immoral. These findings show that food wasting moral judgments reflect the short-term nutritional condition and current nutrient intake. We also found that individuals with greater muscle mass—likely shaped by activities associated with food provisioning—judged food-wasting behaviour as more immoral. The study supports the idea that food wasting moral judgments are shaped by food insecurity and points to some novel social factors that may also influence these judgments.

Keywords: food wasting, morality, Hadza, Datoga, handgrip strength, bioimpedance

People morally condemn food wasting behaviour (Misiak et al., 2020; Misiak et al., 2018). Our moral reasoning is rooted in affective psychological processes, partly shaped by cultural learning (Greene & Haidt, 2002). It leads some of us to believe, that food is not a commodity to be squandered. Moral judgments of food wasting behaviour are triggered when we witness, for example, someone deliberately destroying perfectly good food, playing with it, or letting it spoil (Marczak et al., 2019). Negative attitudes towards people who waste food can emerge as early as five years of age, and by the age of ten, individuals tend to share less food with people who waste it (Sorokowska et al., 2020). Food wasting behaviour may also elicit emotional re-actions, such as guilt and disgust, motivating people to behave prosocially and avoid moral transgressions (Marczak et al., 2019; Parizeau et al., 2015). While there are good reasons to believe that individuals experience moral outrage witnessing others waste food, it is not entirely clear why entire cultures maintain food wasting behaviour as a vice.

People's moral judgments of food wasting behaviour reflect the environmental problems associated with the current amount of food loss and waste (FAO, 2019; Gustavsson et al., 2011; IPCC, 2018). These problems range from deforestation (Houghton, 2012), and water shortages (Chapagain & James, 2013), to increased methane emissions (Melikoglu et al., 2013). Some people express their commitment to cutting down on food waste, seeing it as *the right thing to do* in the face of environmental problems (Graham-Rowe et al., 2014). There is also a real opportunity to target these environmental concerns to influence how people approach wasting food (González-Santana et al., 2022). However, it is important to note, that merely being aware of the environmental problems might not be the only reason why some people morally condemn wasting food.

To judge food wasting behaviour as immoral due to its contribution to global environmental threats, one needs to be aware of these threats. Yet, food wasting behaviour is morally condemned among the people for whom this knowledge is not easily available. Misiak, Butovskaya and Sorokowski (2018) demonstrated that food wasting behaviour was morally condemned among people in non-industrialised populations. Their study found that Maasai pastoralists, and Yali horticulturalists, as well as the citizens of the industrialised country, Poland, morally condemned food-wasting behaviour. The authors proposed a hypothesis that moral judgments concerning wasting food could function as a cultural adaptation to ecological challenges, as the variations in these moral judgments seemed to correspond with levels of food insecurity. The Maasai population, which faces a heightened vulnerability to

malnutrition, exhibited strong moral disapproval of food wasting behaviour. In contrast, the Poles, who benefit from advancements in the modern food industry, showed the least concern about wasting food.

According to the logic of cultural evolution, populations facing ecological challenges may develop adaptive social norms (Chudek & Henrich, 2011; Mesoudi, 2021). For example, Chinese communities historically cultivating rice, necessitating cooperation for managing irrigation on flat floodplains, compared to wheat cultivators that did not need to promote cooperation to the same extent, developed stronger norms promoting loyalty and nepotism (Talhelm et al., 2014). Let us apply this reasoning to the issue of food wasting behaviour. If a population experiences a shortage of calorie supply or lives in conditions where access to calories is not predictable, it would be advantageous for individuals within that population to morally condemn food wasting behaviour. Cultural norms that portray wasting food as immoral behaviour may lead individuals to exhibit increased motivation to efficiently manage surplus food, refrain from binge eating, or share excess food with those undernourished. These behaviours would then be sustained, as they prevent social repercussions for violating a moral norm (Henrich et al., 2006; Misiak et al., 2019).

Beyond cultural evolution and social norms, it is conceivable that food insecurity plays a role in shaping moral judgments through our evolved psychological mechanisms. Individuals who undergo adversity may adapt their psychological functioning to cope with challenging circumstances in their lives. (Frankenhuis & Nettle, 2019). This includes moral reasoning (Elbæk et al., 2023) and prosocial behaviour (Piff et al., 2010). Previous research suggests that individuals experiencing food insecurity may be more prone to accumulating fat as a buffer against starvation (Nettle et al., 2017). They are also more likely to opt for calorie-dense foods (Nettle et al., 2019). Folwarczny and colleagues demonstrated that this preference might be triggered simply by cues of seasonal food shortages (2022) as well as cues of anticipated food scarcity caused by climate change (2021).

Individuals may adjust their psychological functioning in response to hunger itself, as the sensation of hunger rearranges priorities and coordinates psychological processes to obtain food (Al-Shawaf, 2016). Previous studies have demonstrated that hungry people are more likely to prioritize their self-interest to alleviate their deprived state, even if it results in moral transgressions (Williams et al., 2016; Yam et al., 2014). In this case, individuals experiencing hunger should be more inclined to condemn food-wasting

behavior, as it aligns with their self-interest. It could be that food insecurity, through the sensation of hunger, leads individuals to perceive wasting food as immoral, as this behaviour directly limits their access to food and prolongs their hardship.

In the current study, we investigated whether a higher level of food insecurity—both at the population and individual levels—is associated with moral condemnation of food wasting behaviour. We conducted our study with two distinct subsistence-economy populations: the Hadza, who are nomadic hunter-gatherers, and the Datoga, who are semi-nomadic pastoralists.

The Hadza primarily acquire their food through hunting and gathering. They have established a cultural norm of food sharing, which may discourage individuals from wasting food surplus (Marlowe, 2004; Misiak et al., 2019). They consume the meat of hunted animals, tubers, berries, honey, and, due to progressing market integration, maize (Fragiadakis et al., 2018; for more information on the Hadza, see: Blurton Jones, 2016; Marlowe, 2010).

Datoga pastoralist subsistence is more predictable than that of the Hadza, resulting in a higher level of food security. Their primary sources of calories include maize and animal products provided by herds of cows, goats, and sheep. Additionally, they engage in the exchange of animal products with neighbouring agriculturalists for other foods, such as grains (Sellen et al., 2017). The presence of large herds of animals serves as a buffer against environmental disasters and is intergenerationally transmitted—individuals inherit herds from their kin (Borgerhoff Mulder et al., 2010). Based on our observations, some Datoga individuals choose to abandon the pastoralist lifestyle and move to cities (e.g., Karatu) to work as guides, agricultural labourers, or in hotel services (for more information on the Datoga, see: Butovskaya, 2012; Muller et al., 2009). This kind of mobility is much more limited among the Hadza. Those Datoga individuals who have family and friends residing in the town can depend on their connections to secure food assistance in the event of food shortages.

In this study, we aimed to investigate whether moral judgments of food wasting behaviour function as a cultural adaptation to the challenges of food insecurity. At the population level, we hypothesised that the Hadza, given their greater vulnerability to food shortages, would judge food wasting behaviour as more immoral compared to the Datoga. Our hypotheses also considered that individuals with worse nutritional conditions would judge food wasting behaviour more harshly. This would further extend the concept of psychological mechanisms dedicated to responding to food scarcity and hunger.

Material and Methods

Participants

The study was conducted in the August of 2018 among two non-industrialised neighbouring populations from northern Tanzania, where food insecurity is a prevalent concern— Hadza hunter-gatherers (n = 72; M age = 34.1; SD = 13.8; 31 women) and the semi-nomadic Datoga pastoralists (n = 70; M age = 35.8; SD = 14.3; 40 women). These two populations almost do not rely on industrially produced food. Upon arriving at the camp/bomas, we contacted the group leader and extended an invitation to participate in the study, specifying that only adults and sober individuals could take part. All the leaders we contacted agreed to host the study at their camp/boma. Once our research station was set up, individuals who met our conditions (being an adult and being sober) approached us one by one, expressing their interest in participating.

The sample size was not determined before the study. Data collection was restricted by the timeframe of our expedition. A sensitivity analysis indicated that our sample allowed us to conduct a multiple linear regression with seven predictors, and to look for small effects (f^2 = 0.16) with an alpha level of 0.05 and 95% power (Faul et al., 2009).

The study complied with the Declaration of Helsinki on Biomedical Research Involving Human Subjects and the data collection protocol was approved by the Commission for Science and Technology of Tanzania (COSTECH) and the Institute of Psychology, University of Wroclaw Ethics Board. The participants were informed that they could quit the study at any time and—due to the illiteracy of most participants—gave their oral consent to participate. The study was conducted in Ki-Swahili in both populations.

The database is available online (https://osf.io/T4KP9).

Measures

Food Insecurity at the Populational Level

The subsistence style of each population allowed us to infer the level of food insecurity at the population level. Previous research has shown that the Datoga generally have a better nutritional condition compared to the Hadza (Alvarado et al., 2019). Nowadays, the Datoga are more integrated into a local market and rely on their herds, which function as buffers against famine. The Hadza are less integrated into a market (although currently engaged in ethno-touristic business), and the nomadic subsistence lifestyle makes it challenging to store food surpluses. As a result, the Hadza are more vulnerable to food shortages and the unpredictability of food availability, leading to greater food insecurity compared to the Datoga.

Food Insecurity at the Individual Level

We measured food insecurity at the individual level, using various indicators of nutritional condition, categorised as (1) long-term nutritional condition (2) short-term nutritional condition and (3) current nutrient intake. Nutritional condition indicates food insecurity, as food insecurity is one of the leading causes of malnutrition (Meerman et al., 2012).

Long term nutritional condition was measured with the assessment of body fat tissue, which serves as energy storage for an organism (Nettle et al., 2017). A high body fat percentage is a sign that a person's energy balance was positive in the past—more calories were consumed than expended. Maintaining a high level of fat tissue requires a positive or neutral energy balance to be sustained. Similarly, a low body fat percentage is a sign that a person keeps a neutral or negative energy balance.

We assessed body fat percentage (BF%) through Bioelectrical Impedance Analysis (BIA), a safe, non-invasive, and portable method for gauging body composition (Böhm & Heitmann, 2013). We used a medically approved portable body composition monitor–Tanita SC 240 MA, which complies with directives of the European Commission for medical equipment (NAWI Class III, MDD Class II-a). The analyser was placed on a flat wooden board and sanitised with alcohol before each measurement. Participants were instructed to take off their shoes, brush sand off their feet, and shed additional clothing such as shukas, belts, bags, or head ornaments. For accuracy, we considered the impact of bracelets worn by the Datoga and leather skirts worn by some Datoga women, adjusting analyses to account for their potential influence on impedance. If a participant wore a leather dress, we subtracted 2kg (approximate weight of the dress) from their total body mass. Participants were directed to stand upright with their legs apart, avoiding body contact with their hands. The accuracy of the BIA measurement was further enhanced by considering the subjects' dietary intake on the day of the survey (current nutrient intake variable described below).

In addition to BF%, weight, and height (measured with a professional anthropometer) were used to compute the Body Mass Index (BMI), a classical albeit criticised nutritional indicator (Nuttall, 2015). BMI served as a cross-reference for more nuanced measures; a lack of positive correlation between BMI and BF% would suggest potential flaws in our BF% measurement.

Short term nutritional condition was measured through the assessment of muscle strength and muscle mass, as these factors respond early to nutritional deprivation and restoration, serving as reliable indicators of short-term undernourishment (Norman et al., 2011). Muscle mass, similarly to body fat

percentage, was measured with bio-impedance analysis. To measure muscle strength, we used a Harpenden spring dynamometer and followed the procedure described by Misiak and colleagues (2020). We took three measurements for each hand and calculated the mean score. The scores for each hand demonstrated a strong correlation (r = 0.91), leading us to use the mean of all measurements as a general indicator of handgrip strength. Due to hand injuries, we were unable to collect right-hand measurements from one Datoga man and left-hand measurements from two Datoga women and one Hadza man.

To assess current nutrient intake, we conducted interviews wherein each participant was asked to enumerate the foods consumed during that day, before the study. We recorded each food item and then generated several dichotomous variables describing the caloric and macronutrient composition of a meal: *(1) whether a meal contained calories* (as some participants stated they had not eaten anything, while others reported consuming only tea)*? (2) Whether a meal was rich in carbohydrates? (3) Whether a meal was rich in proteins? (4) Whether a meal was rich in fats?* Examining the specific food products consumed by the individual on the day of the study also played a crucial role as a control mechanism, enhancing the accuracy of the BIA measurement. The reliability of this measurement can be compromised if the person has consumed food prior to the test. By factoring in the control for the food eaten on the day of the study, we achieved improved precision in the BIA results.

Moral Judgement of Food Wasting Behaviour

Moral judgment regarding food wasting behaviour was evaluated using the pictorial scale developed by Misiak and colleagues to discern differences in the severity of moral judgments among illiterate populations (2018). Participants were instructed to rank a list of six immoral behaviours, including wasting food, from the worst to the least bad. We then assigned a score (1-6) to the food wasting behaviour—if it was rated as more immoral, it received a higher score (i.e. a score of 5 was assigned to the judgment of a person who believed food wasting was the second most immoral behaviour from the set).

Statistical Analyses

We started our analyses by looking at descriptive statistics and comparing the variables between the populations. We used Welch's t-test—as it is less biased than the classical Student's t-test (Delacre et al., 2017), and a Chi-square test of independence to compare the frequency of pre-study nutrient intake between the Hadza and the Datoga.

To verify whether nutritional characteristics predict moral judgment of

food wasting behaviour we performed a multiple linear regression model. The predictors encompassed body fat percentage, muscle mass, hand grip strength, pre-study carbohydrate intake, population, gender, and age. Based on exploratory analyses, we opted to include pre-study carbohydrate intake as a measure of current nutrient intake. Both carbohydrate intake and calorie intake significantly predicted moral judgments of food wastage behaviour, with carbohydrate intake explaining more variance and being more specific. Notably, we excluded BMI due to its high Variance Inflation Factor (VIF > 5). Although BF% presented a higher VIF, we omitted BMI for technical reasons—BMI is a derivative of body fat and muscle mass, and we assessed these more detailed indicators.

Body composition was measured with bioimpedance analysis — because of this, we tested an identical model that included the number of metal bracelets and whether a person was wearing a leather skirt. The results of this model did not differ substantially from the original, indicating that the ornaments did not interfere with the BIA measurement. The results of this model are presented in the Supplementary material (Table S1).

We used an alpha level of 0.05 with the Benjamini-Hochberg procedure for multiple comparisons (Supplementary material, Table S2). To minimise the risk of overlooking important findings (Type II error), we chose to adhere to the conventional alpha level for hypotheses testing. This decision was motivated by two factors: the relatively small size of our sample and the exploration of novel hypotheses. To conduct the analyses, we used the Jamovi software (The Jamovi Project, 2023).

Results

The descriptive statistics and the comparisons between the Hadza and the Datoga samples are presented in Table 1. We found no group difference regarding the frequency of consumed carbohydrates (χ^2 (1) = 3.94, p = .047; not significant after B-H correction). The correlation matrix of the variables used in the study is presented in Supplementary material (Table S3). The results of the regression analysis are presented in Table 2.

Table 1

Descriptive statistics and differences between the Hadza and the Datoga

Measures	Hadza	Datoga	Welch's t	*p*	Effect size
	Mean (*SD*)	Mean (*SD*)			Cohen's d
Age	34.1 (13.8)	35.8 (14.3)	-0.73	.468	-0.12
BMI	21.3 (2.34)	20.8 (4.02)	1.03	.302	0.18
Body Fat %	17.2 (7.43)	21.2 (10.2)	-2.68	.008*	-0.45
Muscle Mass	41.6 (5.75)	40.5 (7.33)	0.92	.361	0.15
HGS	34.1 (10.1)	29.2 (9.20)	2.97	.004*	0.50
Food items count	1.29 (0.96)	2.07 (1.07)	-4.58	<.001*	-0.77
FW judgment[a]	2.56 (1.29)	2.64 (1.04)	-0.43	.666	-0.07

Note. BMI = Body Mass Index, HGS = handgrip strength, FW judgment = severity of food wasting moral judgment, SD = standard deviation, p = p-value

[a] A higher score indicates harsher judgment of food wasting behaviour.

* A significant difference according to the Benjamini-Hochberg procedure.

Table 2

Results of regression model predicting harshness of moral judgments of food wasting behaviour among Hadza and Datoga

					95% CI	
Predictor	B	SE	*p*	*β*	Lower	Upper
R^2 = 0.16						
Intercept	1.567	0.773	0.045			
Body Fat %	0.029	0.017	0.086	0.225	-0.032	0.482
Muscle Mass	0.060	0.026	0.021	0.347	0.054	0.641
HGS	-0.060	0.018	< .001	-0.514	-0.816	-0.213
Carbohydrates[a]	-0.528	0.205	0.011	-0.455	-0.804	-0.106
Population[b]	-0.190	0.203	0.351	-0.164	-0.510	0.182
Gender[c]	0.478	0.419	0.257	0.412	-0.304	1.128
Age	0.002	0.008	0.835	0.020	-0.168	0.207

Notes. HGS = handgrip strength, R^2 = proportion of the variation in the dependent variable that is predictable from the independent variables, B = unstandardised coefficient, SE = standard error, p = p-value, β = standardised coefficient, CI = Confidence Interval

[a] 0 – meal deficient in carbohydrates, 1 – meal rich in carbohydrates

[b] 0 – Hadza; 1 – Datoga

[c] 0 – Women; 1 – Men

We found a significant regression equation for the multiple regression model ($F(7,128) = 3.37$, $p = .002$, $R^2 = .0.16$) in which mean HGS, Muscle Mass, and pre-study carbohydrate intake predicted judgment of food wasting. The estimated marginal means plots are presented in Figure 1 and Figure 2.

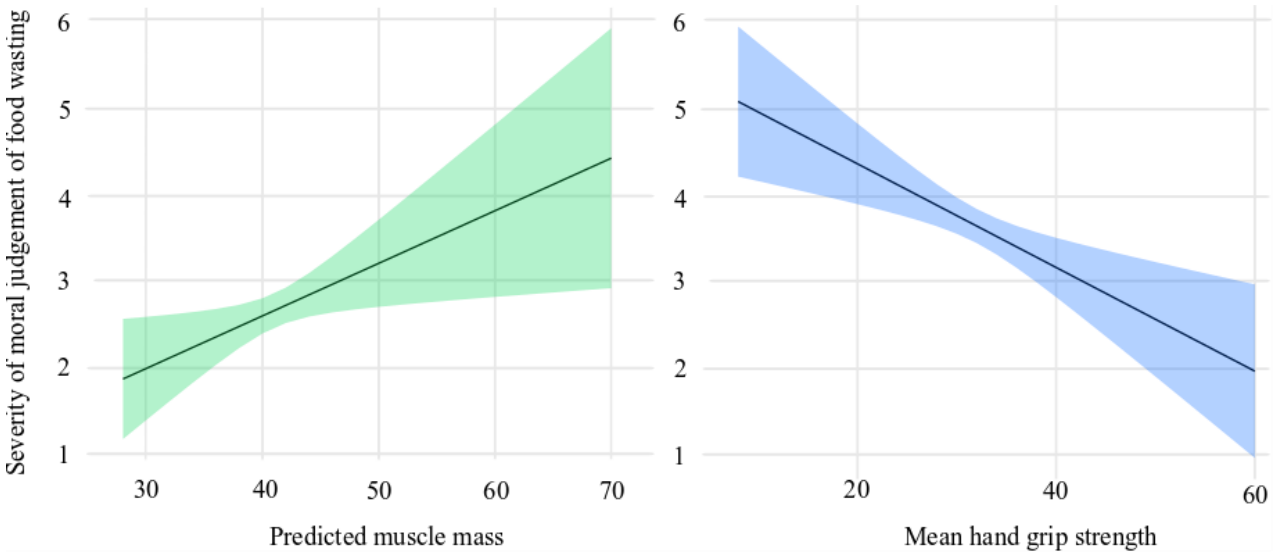

Figure 1

Estimated marginal means plots for the model predicting the severity of moral judgment by the mean hand grip strength and predicted muscle mass (kg) when controlled for the indicators of nutritional condition

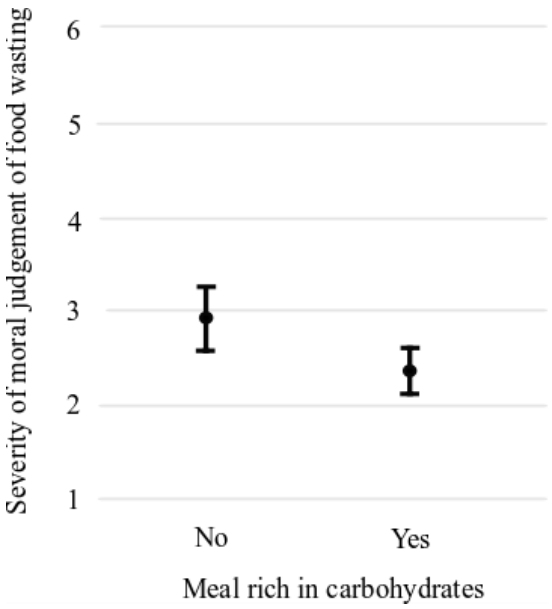

Figure 2

Estimated marginal means plot for the model predicting the severity of moral judgment by whether a participant consumed a meal rich in carbohydrates before the study

Discussion

People condemn food wasting behaviour. However, it is not clear why. In our study, we verified whether food insecurity—both on population and individual levels—shapes judgments of food wasting behaviour among two subsistence-economy populations: Hadza and Datoga. We found that people with poorer short-term nutritional condition and those with a lower current intake of energy-dense foods judged food wasting behaviour as more immoral. Contrary to our initial expectations, our findings did not support the existence of any differences between the populations or establish a connection between long-term nutritional condition and judgments regarding food wasting behaviour.

The relationship between short-term nutritional condition and food wasting moral judgments may appear counterintuitive. Our model revealed that greater muscle strength is associated with harsher moral judgments of food wasting behaviour, while greater muscle mass is linked to less severe moral judgments. These variables are thematically related - how is it possible that they show contrary relationships with moral judgments? We break down the logic of our findings in the subsequent paragraphs.

In our model, we included muscle strength (measured by HGS) and muscle mass (measured by bioimpedance). These variables appear thematically similar but refer to different aspects of muscle physiology. Muscle mass pertains to the weight of one's muscles, while strength is more about muscle performance. Muscle strength is the result of the interplay between muscle mass and available energy deposit (Jaric, 2003; Ørtenblad et al., 2013). When the energy reserves are depleted, muscle strength is compromised, but it does not necessarily mean that muscle mass will immediately decrease. (Jacobs et al., 1981). To illustrate this, consider a bodybuilder undergoing a temporary fast. Despite their impressive muscle mass, their bench press performance will decline because their muscles will not have the 'fuel' to complete the exercise. The inclusion of both strength and muscle mass in the regression model meant that muscle mass was controlled for by a separate variable, so the measure of muscle strength effectively became a measure of the level of energy deposit. A weaker strength

marked an individual's lower level of available energy. This, in turn, was linked to harsher judgments of food wasting behaviour. This result supports our hypothesis that short-term food insecurity, reflected in lower energy deposits, predicts harsher judgments of food wasting behaviour.

The results related to muscle mass did not align with our hypothesis. Individuals with higher muscle mass judged food wasting behaviour as more immoral than those with lower muscle mass. This outcome might be explained when considering the social context of food provisioning in subsistence populations. Muscle tissue is relatively expensive to maintain at a healthy level, requiring a continuous intake of proteins and engagement in resistance exercises (Witard et al., 2016). In the context of pre-industrialised subsistence-economy populations, those who engage in provisioning activities are more likely to develop greater muscle mass. Provisioning in non-industrialised populations places additional physical demands, from hunting and gathering among the Hadza to herding or churning butter among the Datoga. What is more, those engaged in food provisioning may have better access to nutritious and protein-rich foods. For example, Hadza men who participate in hunting have a better opportunity to access meat, as they consume some of it before bringing it back to camp (Berbesque et al., 2016).

The possibility that individuals involved in food provisioning may hold harsher moral judgments of food wasting behaviour highlights a fundamental role of morality: fostering cooperation (Curry et al., 2019). We propose that individuals providing food for their kin or campmates may be more sensitive to food wasting behaviour due to its disruptive impact on the reciprocal cooperative process. (Fehr et al., 2002). The time and energy spent by the provider in obtaining food become squandered when others waste the food, making their efforts ineffective. A parallel can be drawn in industrialised societies, where certain individuals deem food wasting behaviour immoral, perceiving it as a lack of respect for those who contributed to the food's production (Misiak et al., 2020).

Not only the short-term indicators of nutritional condition predicted harsher moral judgement of food wasting behaviour. The current nutrient intake predicted it as well. We found that individuals who did not

consume foods rich in carbohydrates before the study held harsher moral judgments toward food wasting behaviour. We looked at the different macronutrient compositions, and we found no association between fat-rich foods and protein-rich foods consumed before the study. We are wary of arguing that carbohydrates have some specific effect on moral judgments. There are some premises to believe that the macronutrient composition of a meal may influence psychological functioning (Colzato et al., 2013; Strang et al., 2017), yet we think that our findings could be explained simply through the homeostatic function of the hunger sensation (Atasoy et al., 2012). The sensation of hunger may appear when an individual is energy-deprived, and it reorders motivational priorities in order to get food (Al-Shawaf, 2016). Carbohydrates, compared to fats and proteins, are the best sources of energy for the body's metabolism and have the property to raise blood glucose levels quickly, therefore providing energy to the brain and muscles (Webster-Gandy et al., 2020). The moral judgments of individuals who were energy-deprived could be influenced by the sensation of hunger, reordering their motivational priorities (Williams et al., 2016; Yam et al., 2014). Food wasting behaviour could be seen as especially harmful for such individuals, as they currently experience hunger and the food that could relieve this unpleasant sensation is being lost.

The results did not support the hypothesis that poorer long-term nutritional condition, as indicated by the lower body fat percentage, predicts harsher moral judgments of food wasting behaviour. It could be that this association is too subtle to be identified with the pictorial scale. It could also be that this association is not linear and only the individuals with the lowest level of body fat percentage are more likely to morally condemn food wasting behaviour, as they are the most vulnerable to malnutrition. Our method of assessing body fat percentage was inadequate to verify whether everyone presented a healthy or unhealthy level of body fat, and we could not explore this hypothesis further.

Limitations and Future Directions

The recognition of the WEIRD problem has been a prominent aspect of discourse within the social sciences for over a decade (Henrich et al., 2010). A substantial portion of research in these

fields has historically focused on populations that are Western, Educated, Industrialised, Rich, and Democratic (WEIRD). Although there is a growing awareness of the limitations associated with this narrow focus, with many acknowledging the challenges of generalizing findings beyond WEIRD populations (Muthukrishna et al., 2020), the importance of studying underrepresented populations is crucial for advancing social sciences. Nevertheless, research involving these populations comes with its own set of challenges and complexities that may not be present in studies conducted within the more commonly investigated WEIRD contexts.

A typical trade-off relates to the difficulty of recruiting and maintaining the attention of the participants, as well as the length of the research procedure. Ensuring that the testing procedure is attractive is particularly important because samples in industrialised populations, compared to samples from industrialised countries, are small and difficult to access. The longer and more complicated the procedure, the fewer people may be willing to participate, increasing the likelihood that research participants will lose interest. To mitigate the risk of participant attrition, we chose to minimize the number of potential methods employed in the study. Although future studies in similar populations will involve a similar trade-off, we believe researchers should use conventional methods as well, to better understand the phenomenon of how food insecurity affects moral judgments. One such method could be the FIES (Saint Ville et al., 2019), which is a standard measure of food insecurity and using it could allow broad comparisons with populations where the FIES has already been used. Although FIES is a short and intuitive tool that could be very well used to study illiterate populations, we did not include it in our study only because we did not want to extend an already complicated procedure.

It is important to note that the variance in body composition is determined not only by the environment, but also by the genes, and the interaction of both (Luke et al., 2001; Silventoinen et al., 2008). Any potential relationships between food wasting moral judgments and body composition could mean that there is a common genetic factor that is responsible for both traits. In our study, we were unable to untangle these components. In harsh

environments, such as those in which Hadza and Datoga live, compared to those of rich and industrialised populations, gene expression is more restricted by the environmental condition – it is much harder to develop muscle mass if a source of protein is unpredictable. Although the body composition we measured was the indicator of food insecurity (as it is a result of energy and macronutrient balance), we cannot be sure that this food insecurity was solely determined by the environment.

We did not find enough evidence to confirm the hypothesis that hunter-gatherers hold harsher moral judgments towards food wasting than pastoralists. However, a lower body fat percentage among the Hadza, and their lower count of food items consumed on the day of the study, support our assumption that the level of food insecurity is higher among this population. It could be that differences in moral judgments are too subtle and cannot be easily assessed with the pictorial scale used in this study. Future cross-cultural studies should also employ different methods to assess moral judgments of food wasting behaviour—the pictorial scale used in the study allows for the possibility that food wasting moral judgment scores were distorted by judgments of other behaviours. For instance, if one population deems food wasting as more morally wrong than the other population, but simultaneously holds stronger moral judgments towards behaviours such as lying or stealing, it is possible that the score attributed to food wasting could be lower. This lower score might suggest that food wasting is perceived as less severe in comparison. However, we are not aware of any differences in moral judgments between Hadza and Datoga that could distort the scores regarding the behaviours used in the pictorial scale.

The lack of observed differences could also be attributed to the vertical and horizontal cultural transmission between the Hadza and the Datoga (also known as Galton's problem; Mace et al., 1994). Suppose the Datoga and the Hadza cultures descended from a common ancestor culture. In that case, we could hypothesise that they inherited their moral judgments of food wasting behaviour. Nevertheless, this is not the case—the Datoga originated from the Nilotic population, to which the Hadza are not closely related (Mulder, 1992;

Shriner et al., 2018). There is, however, a possibility of horizontal cultural transfer—the Hadza and the Datoga are neighbouring populations, and they could share their attitude towards food wasting behaviour through observing and copying. Future research could use a more nuanced method for assessing moral judgments and should control for horizontal and vertical cultural transmission.

Food waste poses a threat to global food systems (European Commission, 2015; United Nations General Assembly, 2015; WEF, 2019), and it can decrease the availability of nutritional diets around the world (Willett et al., 2019). To minimise this impact, we should target the populations who are leading producers of food waste. These are the rich countries with industrialised food production—certainly not the subsistence-economy populations (Parfitt et al., 2010). However, studying such populations, like hunter-gatherers and pastoralists, allows us to test hypotheses which could be impossible to test in industrialised populations. The findings, in turn, could inspire future research on more diverse samples. Our study demonstrated that nutritional condition influences moral judgments of food wasting behaviour—conducting a similar study in an industrialised population could be troublesome, as people are rather well-nourished due to their access to highly nutritious and calorie-dense foods (Nestle, 2013). It allowed us to establish, that harsher moral judgments of food wasting behaviour could be influenced by the shortage of energy, and lower carbohydrate intake. It highlights the adaptive role of moral judgments, which could help an individual to adapt to their environment. In future studies, we could expect that individuals from the environments where the access to energy dense foods is restricted, like the populations affected by natural disasters, war, or extreme poverty, would exhibit moral judgments that facilitate their adaptation.

Furthermore, our study suggested that people who are responsible for provisioning (as indicated by greater muscle mass) hold harsher moral judgments of food wasting behaviour. It means that moral judgments of food wasting could be motivated by the reciprocal domain of cooperation (Curry et al., 2019). We could expect that a similar pattern could be observed in industrialised

populations. People who engage in food production, preparation, and provisioning—like farmers, cooks and those responsible for household food preparation—could morally condemn food wasting behaviour as it undermines their work. Future studies should also explore whether food wasting behaviour could distort cooperation in other domains. For example, it could be perceived as a behaviour that goes against tradition, hinders group coordination or shows disrespect.

Conclusion

Our study demonstrated that people condemned food wasting behaviour more when their short-term nutritional condition was poorer; and when they consumed less energy-dense foods, as indicated by the carbohydrate intake preceding the study. These results suggest that food wasting moral judgments may be adaptive for an individual as in the face of food insecurity they drive their priorities towards food acquisition. Another finding suggested that individuals from subsistence-economy populations, who engaged in food provisioning, held harsher moral judgments of food wasting behaviour. We base our conjecture about that on the assessment of greater muscle mass, which maintaining requires more physical activity and access to protein-rich foods. This finding links moral judgments of food wasting behaviour to the reciprocal domain of cooperation. It means that people could perceive food wasting as immoral because this behaviour undermines their effort to acquire food. Our findings prove that people could judge food wasting behaviour as immoral not only through the appreciation of global environmental threats that food wasting contributes to but also to improve their food security and as a way to regulate reciprocal social interactions. We believe that through studying diverse human populations, we could be able to grasp the factors that contribute to food wasting behaviours and design methods that prevent these behaviours from flourishing.

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Supplement

Table S1

Results of regression model predicting harshness of moral judgments of food wasting behaviour among Hadza and Datoga with bracelets and skirts as co-variates

					95% CI	
Predictor	B	SE	*p*	β	Lower	Upper
R^2 = 0.16						
Intercept	1.705	0.793	0.033			
Body Fat %	0.023	0.018	0.200	0.180	-0.097	0.456
Muscle Mass	0.060	0.026	0.023	0.344	0.049	0.639
HGS	-0.060	0.018	0.001	-0.514	-0.819	-0.210
Carbohydrates[a]	-0.519	0.207	0.013	-0.448	-0.801	-0.095
Population[b]	-0.101	0.229	0.662	-0.087	-0.478	0.305
Gender[c]	0.333	0.451	0.462	0.287	-0.483	1.057
Age	0.003	0.008	0.681	0.041	-0.156	0.238
Number of bracelets	-0.000	0.023	0.988	-0.002	-0.198	0.195
Leather skirt[d]	-0.331	0.382	0.388	-0.285	-0.937	0.366

Notes. HGS = handgrip strength, R^2 = proportion of the variation in the dependent variable that is predictable from the independent variables, B = unstandarised coefficient, SE = standard error, p = p-value, β = standardised coefficient, CI = Confidence Interval

[a] 0 – meal deficient in carbohydrates, 1 – meal rich in carbohydrates

[b] 0 – Hadza; 1 – Datoga

[c] 0 – Women; 1 – Men

[d] 0 – Not worn; 1 – worn

Table S2

Significant effects of group comparisons between Hadza and Datoga according to the Benjamini-Hochberg preocedure

Rank	Original *p*	Critical Value	Benjamini-Hochberg Adjusted *p*	Significant using FDR of 0.05?
1	0.004	0.007	0.028	Yes
2	0.008	0.014	0.028	Yes
3	0.047	0.021	0.110	No
4	0.302	0.029	0.529	No
5	0.361	0.036	0.505	No
6	0.468	0.043	0.546	No
7	0.666	0.050	0.666	No

Note. Calculated with https://tools.carbocation.com/; FDR = false discovery rate, p = p=value

Table S3

Correlation matrix for the variables used in the study

Variables	Age	BMI	BF%	PMM	Mean HGS
BMI	0.09	-	-	-	-
Body Fat %	0.13	0.74**	-	-	-
Muscle Mass	0.08	0.35**	-0.15	-	-
Mean HGS	-0.07	0.18*	-0.29**	0.77**	-
FW judgment	0.16	0.14	0.15	0.05	-0.13

Note. BMI = Body Mas Index, HGS = hand grip strength, BF% = body fat percentage, PMM = predicted muscle mass; FW judgment = severity of food wasting moral judgment

** p*<.05; ***p<.001*