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Seasonal and Cultural Drivers of Household Food Waste in Oman: Evidence from Descriptive and Inferential Analysis

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ABSTRACT

Food waste poses a major environmental, economic, and social challenge globally, and Oman is no exception. This study investigates the scale, composition, and determinants of household food waste in Oman, aiming to generate evidence that supports effective policy and community-based interventions. A structured survey was conducted among 500 households across different places, representing different climatic, socioeconomic, and urban rural contexts. Data was analyzed using descriptive and inferential statistics, including t-tests and ANOVA, to examine relationships between household characteristics and waste generation. The findings reveal that fruits and vegetables constitute the largest portion of daily discarded food, followed by cooked meals and bakery products. Household size, income level, and cultural practices were significant predictors of waste generation. Food waste was found to increase by nearly 30% during religious and social occasions, particularly Ramadan and Eid, where over-preparation is common. Most households dispose of food waste in mixed bins, with limited composting or redistribution practices due to inadequate infrastructure. However, over 80% of respondents expressed willingness to reduce waste through better meal planning and separation if appropriate facilities were provided. The study estimates the national economic loss from household food waste in the tens of millions of Omani Rials annually. It concludes that reducing food waste in Oman requires a comprehensive strategy that integrates public awareness, behavioral change, and improved waste management systems. Embedding cultural and religious values of moderation and gratitude into awareness campaigns can further strengthen sustainable food practices across Omani society.

1. INTRODUCTION

Food waste has emerged as a critical global challenge, intricately linked to environmental degradation, economic loss, and social inequity. According to the Food and Agriculture Organization [1], approximately one-third of all food produced for human consumption is lost or wasted each year. This inefficiency translates into vast resource depletion and environmental stress, contributing significantly to greenhouse-gas emissions, land-use expansion, and freshwater consumption. The associated global economic loss is estimated at around USD 940 billion annually, while the environmental footprint of wasted food is immense equivalent to roughly 8% of global greenhouse-gas emissions and the use of nearly a quarter of the world's agricultural water resources [2].

In the Sultanate of Oman, the management of municipal solid waste remains a persistent concern. With a population approaching four million, Oman generates an estimated 1.7 million tons of solid waste annually, corresponding to a per-capita rate exceeding 1.2 kg per day [3, 4]. Landfilling remains the dominant disposal method, with food waste constituting around 27% of the total municipal waste stream, while more than half of the waste produced is technically recyclable. However, much of it is still sent to authorized and unauthorized dumpsites, often located near residential or catchment areas, creating both environmental and public-health risks [5]. These patterns highlight the limited supervision of waste management systems and the need for public engagement and awareness programs.

Household food waste represents a particularly acute dimension of the problem, contributing to climate change, resource inefficiency, and food insecurity [6]. Across the supply chain from farm to fork inefficiencies occur at every stage, yet the household level is among the most difficult to address because it is driven by social norms, habits, and cultural expectations. In September 2015, the United Nations General Assembly adopted the 17 Sustainable Development Goals (SDGs) to guide global sustainability efforts. SDG 12, which promotes sustainable consumption and production, specifically targets (Target 12.3) a 50% reduction in per-capita global food waste at the retail and consumer levels, alongside

significant reductions in production and supply-chain losses by 2030 [7, 8]. The linkage to Sustainable Development Goal 12.3 is presented as a conceptual and policy-relevant framing of household food waste, rather than as a direct indicator-level assessment, reflecting current data and measurement limitations at the household scale.

The Sultanate of Oman's national strategy, Oman Vision 2040, prioritizes environmental protection, sustainable resource management, and circular-economy practices as key components of its development agenda [9]. Municipal and academic reports consistently indicate that food waste accounts for 25–30% of municipal waste in several governorates. Be'ah, the national environmental services holding company, has estimated the economic loss from food waste at tens of millions of Omani rials annually [10, 11]. Despite these indications, comprehensive household-level assessments remain scarce, underscoring the need for robust empirical research to inform policy and behavioral interventions.

Within the wider Gulf Cooperation Council (GCC) region, the literature on food waste has expanded in recent years but remains relatively under-represented globally. El Bilali and Ben Hassen [12] conducted a systematic review revealing limited research output from GCC countries compared with other regions and emphasized the importance of understanding sociocultural determinants of waste. Studies from Saudi Arabia, the United Arab Emirates, and Qatar demonstrate that bread, fruits, and vegetables are the most frequently wasted household items [13, 14]. Early exploratory studies in Oman similarly report high household waste rates, attributing them to cultural practices, over-purchasing, and insufficient storage or redistribution facilities [11, 15].

Beyond the regional context, international research underscores the multifaceted nature of food waste. Key drivers include inadequate date-labelling systems, behavioral factors, and inefficiencies along the food supply chain [16, 17]. To facilitate cross-country comparison and policy development, the United Nations Environment Program (UNEP) introduced the Food Waste Index (2024), which standardized methodologies for measuring waste across household, retail, and food-service sectors. Applying such frameworks in national contexts enables consistent benchmarking and supports evidence-based policymaking.

Social and cultural norms play an especially significant role in the GCC, where hospitality and generosity are deeply embedded values. During religious and social occasions most notably Ramadan and the two Eids food preparation and consumption patterns change dramatically, often resulting in substantial over-preparation and waste. Hence, interventions must be culturally sensitive, balancing respect for tradition with sustainability goals [15].

Moreover, the economic implications are considerable. National sustainability reports (Be'ah, OQ Sustainability Reports) highlight the potential for cost savings and emission reductions through prevention and redistribution initiatives. International experience demonstrates the effectiveness of combined regulatory and voluntary approaches, including mandatory waste reporting for large producers, incentive schemes for food donations, and investment in recycling and composting infrastructure [18, 19].

Despite increasing recognition of the food-waste challenge across the GCC region, empirical studies examining its magnitude, behavioral determinants, and socio-cultural drivers remain limited, particularly at the household level in Oman. Most existing assessments rely on aggregated municipal data, with little integration of household behavioral insights, cultural influences, or temporal variations associated with religious and social practices. Consequently, there is insufficient evidence to inform targeted policy interventions or community-based awareness initiatives.

Against this background, the present study provides one of the first comprehensive, household-level empirical investigations of food waste generation in Oman. It quantifies the scale and composition of household food waste, identifies socio-demographic and cultural predictors of waste behavior, and analyses seasonal variations linked to religious and social occasions. By integrating quantitative analysis with contextual interpretation, the study contributes novel evidence to the regional literature and offers policy-relevant insights to support the implementation of Oman Vision 2040 and Sustainable Development Goal 12.3. In doing so, it advances current understanding of how socio-economic, behavioral, and cultural factors interact to shape food-waste dynamics within a rapidly modernizing Arab society.

2. METHODOLOGY

2.1 Study locations and sampling

This research adopted a cross-sectional survey design to assess household food waste generation and management practices across different climatic and socioeconomic zones of the Sultanate of Oman. Four governorates Muscat, Salalah, Sohar, and Nizwa were purposively selected to capture regional diversity in climate, population density, and urbanization level. These areas collectively represent the key urban–rural spectrum of Oman, from the coastal capital to inland and southern settlements, thereby ensuring geographical and cultural representativeness.

A total sample of 500 households was determined as adequate for statistical reliability while maintaining logistical feasibility. The sample size was calculated using standard power-analysis principles for medium-effect detection at a 95% confidence level. Stratified random sampling was employed to ensure balanced representation across household income levels, size categories, and residential settings (urban and rural). Within each stratum, households were selected through systematic random sampling from municipal records and community listings. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection.

2.2 Survey instrument and measurement

The survey instrument was carefully designed to capture a comprehensive picture of household food waste generation and management practices. It was structured into multiple sections covering key aspects such as demographic information (including household size, income levels, and education), weekly food purchasing and consumption patterns, and self-reported daily household food waste across major food categories. Specific categories included bread, fruits, vegetables, meat, dairy products, and other prepared or cooked items, which were selected based on both prior regional studies and preliminary assessments of commonly wasted food in Oman. In addition, the survey explored household food storage practices, levels of awareness and attitudes toward

food waste reduction, and preferences for different waste management strategies, such as composting, redistribution, or recycling initiatives.

To strengthen the validity and contextual relevance of the findings, secondary data sources were also consulted. Municipal waste composition reports published by Be'ah and national environmental authorities were reviewed and cross-referenced with the household-level measurements to provide a broader perspective on food waste trends in Oman. This secondary data not only offered a benchmark for comparison but also helped in identifying discrepancies between reported municipal-level statistics and the more detailed, household-level measurements generated by this study. Together, these methodological approaches aimed to provide a holistic understanding of the drivers, magnitude, and composition of household food waste, thereby contributing to more targeted recommendations for waste reduction and sustainable resource management in Oman.

As with many household-level food-waste studies, the data collected in this research are based on self-reported responses and may therefore be subject to recall and social-desirability bias. However, this approach is widely used in large-scale behavioral assessments where direct measurement is not feasible. The results are accordingly interpreted as indicative of household behaviors and general waste patterns rather than as precise measurements of actual waste quantities.

2.3 Data analysis

Collected data was processed and analyzed using standard statistical techniques. Both descriptive and inferential analyses were employed to derive meaningful insights to ensure both a clear understanding of household food waste patterns and a robust examination of underlying relationships. Descriptive statistics, including measures of central tendency (mean, median) and variability (standard deviation, range), were first applied to summarize the quantity and distribution of food waste across households and categories. These descriptive outputs provided an initial profile of waste generation levels, allowing the identification of dominant food groups contributing to overall household waste. Cross-tabulations were then employed to explore relationships between demographic variables (such as household size, income level, and education) and food waste quantities, thereby highlighting potential socioeconomic drivers of waste generation.

To test the significance of these differences, inferential statistical methods were applied. Independent sample t-tests were used to compare mean waste levels between two groups (e.g., male, female-headed households, or rural, urban households), while one-way Analysis of Variance (ANOVA) was conducted to assess differences across multiple categories, such as household income brackets or educational attainment levels. These inferential techniques enabled the identification of statistically significant variations, supporting more nuanced interpretations beyond descriptive trends. In addition, the data were aggregated into time-series formats to capture temporal variations in food waste, with particular attention to seasonal effects and culturally significant periods. Special emphasis was placed on religious and national holidays, such as Ramadan and Eid, where food preparation and consumption behaviors differ markedly from routine patterns. This seasonal analysis provided insights into how cultural and social practices influence waste dynamics, offering critical evidence for designing targeted interventions during peak consumption periods. By integrating descriptive summaries, comparative statistical tests, and temporal analyses, the study generated a multi-dimensional understanding of food waste at the household level in Oman, thereby enhancing the reliability and policy relevance of its findings. In addition to descriptive and comparative analyses, exploratory regression analysis was employed to examine associations between selected household characteristics and reported food-waste generation. Given the cross-sectional and survey-based design of the study, regression results are interpreted in an associative and indicative manner, without implying causality.

3. RESULTS AND DISCUSSIONS

3.1 Respondents characteristics

A total of 500 households were surveyed across Muscat, Salalah, Sohar, and Nizwa, representing Oman's major geographic, climatic, and socio-economic zones. Of these, 63.6% resided in urban areas and 36.4% in rural or peri-urban settings, providing a balanced perspective on diverse consumption and waste-management behaviors. Household size varied between single-person dwellings and large extended families exceeding eight members, with the modal group comprising four to six people (50%). Smaller households (one to three members) represented 24%, while larger families (> six members) accounted for 26%.

Income distribution reflected the growing Omani middle class: 22% of households reported monthly incomes below 500 OMR, 40% earned between 500 and 1000 OMR, and 38% exceeded 1000 OMR. Educational attainment was generally high, with 70% of respondents holding at least a bachelor's degree and 18% possessing postgraduate qualifications. The full demographic profile is presented in Table 1.

Regression analysis found that household size, income, and presence of elderly members were significant predictors of waste. Larger households (4-6 members) generated more total waste but lower per-capita waste relative to single-person households. Higher-income households (> 1000 OMR/month) had higher per-capita waste, likely reflecting bulk purchasing and consumption patterns.

Table 1. Household demographics of survey respondents (n=500)

Parameter	Category	Frequency	Percentage (%)
Area	Urban	318	63.6
	Rural	182	36.4
Household Size	1–3 members	120	24
	4–6 members	250	50
	> 6 members	130	26
Monthly Income (OMR)	< 500	110	22
	500–1000	200	40
	> 1000	190	38
Education Level	Secondary	150	30
	Bachelor	260	52
	Postgraduate	90	18

3.2 Reasons for food waste

Figure 1 presents the self-evaluated performance of surveyed households across four key behavioral dimensions that directly influence food-waste generation: food reuse, food

preparation, shopping planning, and meal planning. Each behavior was rated on a five-point scale ranging from Extremely Low to Excellent.

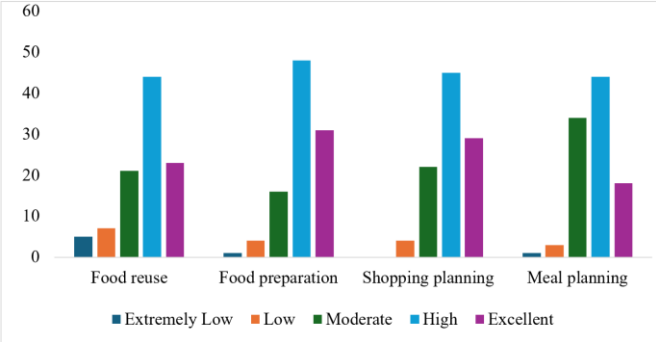

Figure 1. Self-rated household food waste behaviors

Overall, the results reveal that most households perceive their performance as either high or moderate, suggesting a growing awareness of the importance of responsible food management among Omani families. Nevertheless, the distribution also indicates that many households still fall short of optimal practice, reflecting a gap between awareness and consistent implementation.

With respect to food reuse, approximately 45% of respondents rated their engagement as high, while only about 23% described it as excellent. This finding suggests that although many households attempt to repurpose leftovers or share surplus food with neighbors and relatives, such practices are not yet routine. Qualitative comments from respondents revealed that social conventions sometimes discourage the reuse of food, particularly during family gatherings and social events where serving reheated or previously prepared dishes may be perceived as inconsistent with traditional notions of generosity and hospitality. Comparable findings have been reported in other GCC countries, where social prestige and cultural expectations of abundance contribute to the reluctance to reuse food [12, 14].

Performance in food preparation was similarly encouraging, with nearly 48% of households rating their performance as high and about 31% as excellent. This pattern suggests a growing consciousness of portion control and cooking efficiency. However, over-preparation remains prevalent during festive periods such as Ramadan and the two Eids, when cultural and religious traditions of generosity lead to the preparation of large and diverse meals. As discussed in Section 3.4, these occasions correspond with substantial increases in household food waste, underscoring the need for context-sensitive awareness campaigns that address the social and cultural dynamics of food preparation.

For shopping planning and meal planning, the trends were comparable. Approximately 44% of respondents reported high levels of shopping planning, and 30% assessed themselves as excellent. Similarly, 40% of households rated their meal planning as high and 18% as excellent, whereas about one-third (34%) remained at a moderate level. These findings imply that while many households acknowledge the value of planning, behavioral consistency is still limited. Impulse buying, promotional offers, and the aesthetic appeal of food displays in modern retail environments continue to drive over-purchasing particularly of perishable goods such as fruits, vegetables, and bakery products. Similar consumer patterns have been observed in the UAE and Saudi Arabia, where affluence and convenience-oriented consumption led to increased waste [13, 20].

The combined results of Figure 1 highlight a behavioral paradox: awareness and intention are relatively high, yet tangible actions remain inconsistent. This indicates that behavioral change alone is insufficient without supportive infrastructure and policy frameworks. Providing structural enablers such as affordable cold-storage solutions, smaller packaging options, and community composting facilities can help households translate awareness into practice. In addition, framing food reuse and planning within the ethical and religious context of Islam, which strongly discourages waste (isrāf) and encourages moderation (al-iqtiṣād), can enhance social acceptance and long-term behavioral adoption.

The composition of household food waste was examined across eight main categories: fruits and vegetables; cooked or prepared foods; bakery and grain products; dairy products; meat, fish, and poultry; eggs and shells; beverages and liquids; and packaged or expired processed foods. The distribution of these categories is presented in Figure 2.

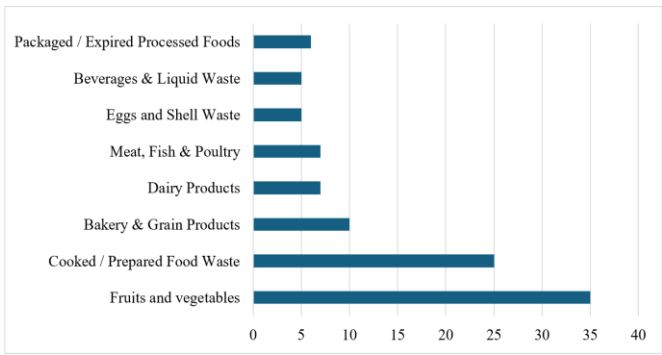

Figure 2. Major types of food waste

As illustrated in Figure 2, fruits and vegetables represented the highest proportion of household food waste, accounting for approximately 35–36% of total discarded food. Cooked and prepared meals followed closely at 25%, while bakery and grain products contributed around 10%. These three categories together comprised more than two-thirds of total household waste, confirming that most discarded food in Oman consists of readily perishable or freshly prepared items. The relatively low shares of dairy products (6%), meat, fish, and poultry (7%), and packaged or processed foods (6%) indicate that waste primarily arises from daily meal preparation rather than from long-life or preserved items.

The results visually reinforce the conclusion that avoidable food waste dominates household disposal streams in Oman. The heavy concentration of perishable waste categories underscores the need for interventions focusing on storage efficiency, portion control, and food redistribution mechanisms. Furthermore, the lower percentages of packaged and processed foods imply that consumer-level strategies rather than industrial or retail reforms will have the greatest impact in reducing food waste on the national scale.

3.3 Quantified household food waste

Quantifying household food waste provides critical insight into the scale of inefficiency within daily consumption practices in Oman. Based on average per-capita household food-waste values reported in the survey and national population statistics, household food waste in Oman was

estimated to be in the range of approximately 300,000–320,000 tons per year. This estimate is intended to provide an order-of-magnitude indication rather than a precise accounting figure and is subject to uncertainty arising from household-size variation and seasonal effects.

The survey analysis revealed that average household food waste generation fluctuates significantly throughout the year, with distinct peaks during religious and social events. Under normal conditions, an average Omani household was estimated to discard approximately 0.45–0.50 kg of food per person per day, equivalent to 1.8–2.2 kg per household per day based on the mean household size of 4–5 persons. Extrapolating these findings to the national scale suggests that Omani households collectively generate an estimated 300,000–320,000 tons of food waste annually, representing a substantial portion of the municipal solid waste stream.

The composition and temporal patterns of this waste reveal important behavioral insights. As discussed earlier, food waste levels increased markedly by about 30% during festive seasons such as Ramadan, Eid al-Fitr, and Eid al-Adha, as well as during weddings and family gatherings (see Figure 3). These fluctuations demonstrate that the volume of food waste in Oman is not constant but rather socially and seasonally contingent, reflecting changes in food preparation, guest numbers, and consumption habits. The reported increase of approximately 30% during Ramadan, Eid, and major social occasions is based on aggregated self-reported comparisons provided by respondents and reflects a consistent behavioral trend rather than a statistically controlled effect size.

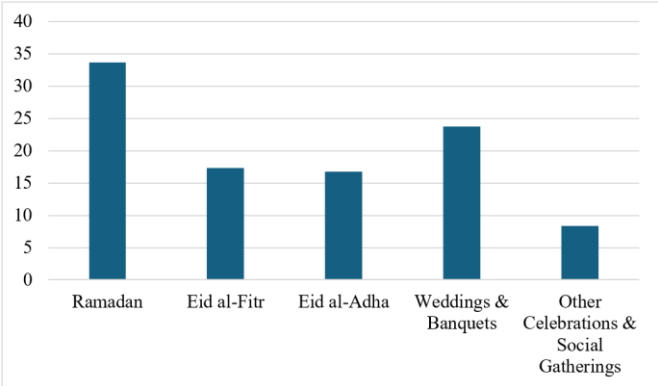

Figure 3. Food waste is an increasing percentage in holidays and occasions

From a demographic perspective, larger households (4–6 members) generated greater total food waste, whereas smaller or single-person households exhibited higher waste per capita. This pattern suggests that food is utilized more efficiently in extended families, where leftovers are more likely to be shared or reused. By contrast, small families and individuals are more prone to purchasing and cooking excess food relative to their needs, a finding consistent with European and Asian studies where single-person households were identified as disproportionately high per-capita wasters [6, 8].

Income and education also played significant roles in shaping waste behavior. High-income households (> 1000 OMR month^{-1}) generated noticeably more food waste than lower-income groups, mainly due to bulk purchasing and a greater variety of perishable items. Yet despite higher education levels and awareness of sustainability issues, many respondents reported difficulties in translating awareness into concrete action. This "knowledge practice gap" underscores the need for structural and behavioral support mechanisms such as improved storage facilities, household composting schemes, and social incentives for redistribution to convert environmental concern into measurable reductions.

Further analysis revealed that food waste in Oman primarily consists of avoidable waste, meaning items that were originally edible but discarded due to over-preparation, spoilage, or perceived lack of freshness. Avoidable waste accounted for roughly 80% of total discarded food, while only 20% was classified as unavoidable (such as bones, peels, or shells). The predominance of avoidable waste indicates that household behavior change could yield significant reductions without major technological intervention. In this study, avoidable food waste refers to edible food items discarded due to over-preparation, spoilage, or behavioral factors, while unavoidable waste includes inedible components such as peels, bones, and shells. This classification follows commonly used international definitions, including those adopted by UNEP, and is based on respondents' self-reported assessments.

When translated into economic terms, the magnitude of waste becomes more striking. Using conservative retail price averages for common food items (1.5–2 OMR kg^{-1}), the typical Omani household loses approximately 300–350 OMR annually due to wasted food. At the national level, this equates to 40–60 million OMR per year, a figure consistent with prior estimates reported by Be'ah and national environmental authorities [10, 11]. Beyond economic loss, the environmental consequences are considerable. Decomposing organic matter contributes to methane emissions from landfills, a potent greenhouse gas, thereby intensifying Oman's carbon footprint within the waste-management sector.

These findings demonstrate that food waste in Oman is not merely a logistical or infrastructural problem, but a multidimensional socio-environmental issue shaped by cultural norms, affluence, and behavioral patterns. The quantitative evidence highlights the potential for substantial impact through targeted interventions. Reducing household food waste by 25% could prevent nearly 75,000 tons of waste annually, saving millions of rials and significantly lowering emissions from the solid waste sector.

Therefore, accurate quantification of household food waste serves as both a diagnostic and a strategic tool: it defines the scale of the challenge and illuminates where efforts should be concentrated. Combining measurement with public education, improved infrastructure, and culturally resonant awareness campaigns can help Oman move decisively toward achieving Oman Vision 2040 and Sustainable Development Goal 12.3, which calls for halving per-capita food waste by 2030.

3.4 Waste destination and current practices

Understanding how households dispose of food waste is essential for identifying practical entry points for intervention. The survey results revealed that most households in Oman still rely on conventional disposal methods, with limited participation in recycling, composting, or redistribution schemes. Approximately 70% of respondents reported that their household food waste is routinely placed in mixed municipal bins, ultimately destined for landfill sites. Only about 15% of households stated that they practiced home composting or fed organic scraps to animals, while a mere 5% engaged in food donation or redistribution activities. These findings illustrate that, despite increasing public awareness,

the infrastructure and institutional support for source separation and reuse remain limited across most governorates.

This situation mirrors broader regional trends. In many GCC countries, landfill disposal remains the dominant method of solid-waste management, accounting for more than 90% of municipal waste streams [5, 12]. The reasons are both structural and behavioral: the absence of curb-side collection systems for segregated organics, insufficient composting facilities, and a prevailing perception that waste disposal is solely the responsibility of municipal authorities. As a result, households have few incentives or opportunities to handle food waste separately.

Nevertheless, the survey findings provide encouraging signs of latent willingness to change. More than 80% of respondents indicated they would be ready to plan meals more carefully or separate organic waste if supportive facilities or incentives were provided. Similarly, about 75% expressed interest in participating in community composting programs or curb-side collection initiatives for segregated organic waste. This enthusiasm reflects a broader societal shift towards environmental awareness, particularly among younger and educated citizens who increasingly engage with sustainability discourses through schools, universities, and social media.

When asked about potential strategies for reducing food waste, the most frequently cited measures were awareness campaigns and community-based activities (35.7%), followed by restaurant take-away or leftover reuse initiatives (27.4%), and financial penalties or waste-generation fees (18.6%). These preferences suggest that Omani households favor participatory and educational approaches rather than purely punitive mechanisms. While the idea of financial penalties resonates with the principle that "wasting food is wasting money," many respondents felt that such measures would be more practical for the hospitality and catering sectors than for individual households, where monitoring and enforcement would be more complex.

The lack of food-redistribution mechanisms was another important finding. Very few respondents reported donating excess cooked food, largely due to logistical constraints, concerns about food safety, and the absence of formal channels linking donors to charities. Yet, several successful international examples such as Food Bank Singapore and Too Good To Go in Europe demonstrate that digital platforms can effectively connect households, restaurants, and community organizations for real-time redistribution of surplus food. Adapting such models within Oman, supported by local authorities and civil-society organizations, could substantially reduce edible waste and strengthen community solidarity.

The predominance of landfill disposal also carries environmental consequences. Food waste decomposes rapidly under anaerobic conditions, generating methane a greenhouse gas with a global warming potential approximately 28 times higher than carbon dioxide. In addition, the high moisture content of organic waste increases leachate production, posing risks to groundwater quality. Introducing source-separation systems for organics, coupled with investment in aerobic composting or anaerobic-digestion facilities, would not only reduce the volume of waste reaching landfills but also create valuable by-products such as compost and biogas, contributing to Oman's circular-economy aspirations under Vision 2040.

Rural practices provide a glimpse of viable low-cost solutions. In many rural households, leftover rice, vegetables, and bread are repurposed as animal feed for goats, chickens, and sheep as a practice grounded in both economic necessity and cultural tradition. Scaling such informal practices through community-level composting hubs or household training programs could formalize and expand organic-waste recovery without imposing excessive infrastructure demands.

3.5 Awareness of food waste management

Public awareness and social engagement play a pivotal role in shaping household food-waste behavior. The survey explored respondents' perceptions of effective strategies for reducing food waste, focusing on educational, behavioral, and policy-based measures. The results are presented in Figure 4.

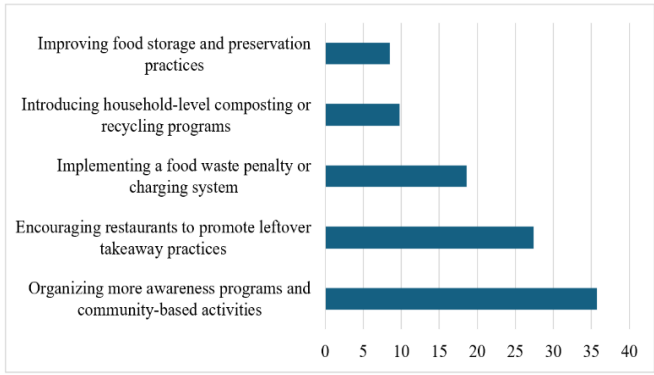

Figure 4. Suggestions from respondents towards reducing food waste

As illustrated in Figure 4, organizing awareness programs and community-based activities emerged as the most strongly supported measure, selected by approximately 36% of respondents. This finding reflects the growing recognition among Omani households that sustainable change begins with education, community dialogue, and collective engagement. Awareness campaigns, conducted through schools, religious institutions, or local councils were seen as essential for reshaping everyday consumption habits and reinforcing social responsibility. Such initiatives could be particularly effective when linked to cultural and religious values that promote moderation (al-iqtisād) and discourage extravagance (isrāf).

The second most supported strategy, endorsed by 29% of respondents, involved encouraging restaurants to promote leftover takeaway practices. Many participants noted that a large share of avoidable waste occurs outside the home, particularly in restaurants and event catering where portion sizes are often excessive. Promoting a social norm that normalizes taking leftovers home could significantly reduce post-consumption waste. In similar campaigns across the United Arab Emirates and Malaysia, the introduction of "love your leftovers" or "smart portion" initiatives has successfully encouraged diners to accept takeaway packaging without social stigma [20]. Applying this approach in Oman could foster more mindful dining practices while maintaining cultural values of hospitality.

The third most popular recommendation, supported by around 19% of respondents, was the implementation of a food-waste penalty or charging system. Respondents viewed this measure as a potentially effective deterrent, particularly for commercial food establishments that generate large volumes of waste. However, there was less enthusiasm for applying such financial penalties at the household level. Many participants expressed concern about enforcement challenges, fairness, and the risk of penalizing families without access to

recycling infrastructure. This nuanced view suggests that while economic instruments can play a role, they must be complemented by awareness, incentives, and infrastructure to ensure equitable outcomes.

Other suggested interventions included introducing household-level composting or recycling programs (10%) and improving food-storage and preservation practices (9%). Though less frequently mentioned, these measures address the practical dimensions of food-waste reduction providing households with tools and systems to translate awareness into action. Simple, low-cost technologies such as compost bins, airtight storage containers, and refrigerator organization guides could empower households to reduce spoilage and manage organic waste more effectively.

The combination of preferences revealed in Figure 4 highlights a crucial insight: Omani households are highly aware of the food-waste problem and willing to participate in solutions, but they prioritize collaborative and educational approaches over punitive or regulatory ones. This indicates a collective readiness for behavior change one that can be strengthened through institutional support, public infrastructure, and consistent messaging.

From a policy perspective, the results suggest several actionable priorities:

•Education and awareness as the foundation – Integrate food-waste education into school curricula, community workshops, and mosque-based programs, linking sustainable behavior with religious and cultural principles.

•Partnership with the hospitality sector – Encourage restaurants, hotels, and catering services to adopt "leftover-friendly" policies and collaborate with charities for surplus food redistribution.

•Pilot incentive-based schemes – Instead of penalties, introduce positive incentives such as discounts on compost bins, recognition programs for low-waste households, or reduced waste-collection fees for households participating in organic waste separation.

•Infrastructure for household composting – Develop decentralized composting hubs and curb-side collection systems for organics to make participation convenient and visible.

4. ECONOMIC IMPLICATIONS AND COST-BENEFIT CONSIDERATIONS

Food waste is not merely an ethical or environmental concern it also represents a significant economic inefficiency within households and at the national level. Every kilogram of food discarded embodies wasted resources: the money spent on purchasing it, the energy used in production and transportation, and the environmental costs of its disposal. The findings of this study reveal that the economic burden of food waste in Oman is considerable, reflecting both avoidable household losses and wider implications for national sustainability targets.

Based on the survey results, the average Omani household was estimated to waste approximately 0.45–0.50 kg of food per person per day, equating to around 1.8–2.2 kg per household per day. Considering the average retail price of commonly wasted food items mainly fruits, vegetables, bread, and cooked meals at 1.5 to 2.0 OMR per kilogram, the annual cost of wasted food per household is projected to range between 300 and 350 OMR. When extrapolated to the national scale of approximately 1 million households, this translates to an estimated 40–60 million OMR in direct annual economic losses.

This figure is broadly consistent with national estimates reported by Be'ah and media analyses [10, 11], confirming that household food waste alone constitutes one of the most substantial components of Oman's economic inefficiency in the waste-management sector. Beyond monetary losses, food waste also imposes indirect costs including the energy and water consumed in food production, the fuel used for transportation, and the resources required for landfill management.

From a life-cycle perspective, food waste represents a loss at every stage of the supply chain. The production of food that ultimately goes uneaten requires arable land, water for irrigation, fertilizers, and labor, all of which contribute to embedded costs. Globally, food waste is estimated to cause an annual economic loss of nearly USD 940 billion, a significant portion of which stems from household consumption patterns [1]. Oman's situation fits within this global trend, underscoring the interconnectedness of economic and environmental inefficiencies.

The environmental cost of wasted food compounds its economic dimension. As discarded food decomposes in landfills, it generates methane, a greenhouse gas with a global-warming potential more than 25 times greater than that of carbon dioxide. Given that organic matter forms a substantial proportion of Omani household waste, this directly contributes to greenhouse-gas emissions and landfill leachate production, posing further economic challenges for waste treatment and environmental protection. Addressing these emissions through composting, biogas recovery, or waste-to-energy technologies could reduce municipal waste volumes and simultaneously produce value-added outputs such as renewable energy and soil conditioners.

From a cost–benefit standpoint, even modest reductions in household food waste would yield notable economic and environmental benefits. A 25% reduction in household waste could save the national economy approximately 10–15 million OMR annually, while also decreasing landfill methane emissions by an estimated 15–20%. Additionally, redirecting edible surplus food through donation and redistribution networks could enhance food security for low-income families, contributing to Oman's broader social sustainability goals.

Economically, preventive measures are more cost-effective than remedial ones. Investing in public awareness campaigns, community composting hubs, and digital food-sharing platforms involves relatively low expenditure compared with the long-term financial and environmental costs of landfill expansion and waste treatment. International experiences demonstrate that every 1 OMR spent on food-waste prevention can generate up to 6 OMR in savings through reduced disposal costs and improved resource efficiency [21]. Applying this principle in Oman suggests that prevention-based strategies would be a high-return investment within the framework of national circular-economy policies.

Behavioral economics also plays a critical role in the financial dimension of food waste. Households often underestimate the cumulative cost of their waste because it occurs in small, routine amounts. When aggregated over time, however, the value of discarded food represents a tangible loss of purchasing power. Promoting cost-awareness through household budgeting apps, smart kitchen tools, and price-

sensitive communication campaigns can help families visualize the real economic impact of waste, thereby reinforcing motivation to reduce it.

5. CONCLUSION

Food waste represents a growing environmental, economic, and social concern worldwide, and Oman is no exception. This study investigates the magnitude, composition, and determinants of household food waste across major Omani cities, providing empirical evidence to support the country's transition towards sustainable consumption and production. A structured survey of 500 households in Muscat, Salalah, Sohar, and Nizwa was conducted to collect data on demographic characteristics, consumption patterns, and waste-management practices. Descriptive and inferential statistical analyses were applied to examine variations in waste generation across household size, income, and education level, as well as temporal fluctuations linked to religious and social events.

The results indicate that household food waste in Oman is dominated by perishable and prepared items, with fruits and vegetables accounting for nearly half of total discarded food, followed by cooked meals and bakery products. Average waste generation was estimated at approximately 0.45–0.50 kg per person per day, equating to about 300,000 tons of food wasted annually and a financial loss of 40–60 million OMR. Waste levels increased by around 30% during Ramadan, Eid celebrations, and large social gatherings, primarily due to over-preparation and cultural norms associating generosity with food abundance. Despite moderate awareness of the issue, practical engagement in waste prevention remains limited, largely due to insufficient infrastructure and institutional support. Encouragingly, over 80% of respondents expressed willingness to adopt preventive practices if facilities and incentives were available.

The study concludes that reducing household food waste in Oman requires a holistic approach integrating behavioral change, infrastructural improvement, and policy intervention. Aligning public awareness with the ethical principles of moderation and stewardship embedded in Omani culture can substantially advance progress towards Oman Vision 2040 and Sustainable Development Goal 12.3. While the findings provide valuable insights into household food-waste behaviors in Oman, they should be interpreted in light of the study's survey-based design and are best viewed as indicative patterns intended to inform policy and awareness initiatives rather than exact quantitative benchmarks.

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NOMENCLATURE

ANOVA	Analysis of Variance
Be'ah	Oman Environmental Services Holding Company
FAO	Food and Agriculture Organization of the United Nations
GCC	Gulf Cooperation Council
GHG	Greenhouse Gas
OMR	Omani Rial
SDG	Sustainable Development Goal
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
WRAP	Waste and Resources Action Programme