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Characteristics of food waste: water and salinity contents

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Abstract

The high intrinsic water content and salinity of food waste prevent a smooth composting process and consequently cause social, economic and environmental problems. In this study, we investigated the distribution of the water content and salinity in food wastes to obtain useful primary data to ensure adequate and quality recycling. A total of 300 food waste (FW) samples were collected from residential apartments (home generated FW), a wide range of restaurants, i.e., restaurant generated FW that included Korean, Chinese, Japanese and western FWs, and several places that included food waste processing facilities (dehydrated FW cakes). The collected food wastes were oven dried for 48 hours at 80°C after which the water and salinity contents were analyzed. The results show that the average water content of the FWs was 72.45 ± 10.51%, and the average salinity content was 2.03 ± 0.57%. Furthermore, the salinity of the collected FWs was characterized by where the FW was generated. By location, the salinity concentration of home generated FW was 2.30% while western food had the lowest salinity concentration of 1.18%. However, dehydrated cakes had the highest salinity concentration of 2.84%. Especially, the distribution of the salinity content in food wastes can form the basis for improving the compost quality in food waste recycling.

Key words: food waste, salinity, water content

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Introduction

In 2004, food waste churned out an average of 11,464 ton·day^{-1}, which consistently increased gradually year after year reaching an average of 15,143 metric tons per day in 2008. The policy to reduce food waste was enacted in 2008 which helped to gradually reduce food waste (FW) and by 2016, FW disposal rate stood at 14,389 metric tons per day accounting for 27.4% of the total amount of domestically generated waste (ME, 2017a). A rough 90.4% of the FW is recycled at recycling facilities while the incinerated and landfilled portions account for 2.5% and 7.1%, respectively of total generated FW. The most extensive proportion of the recycled FW is used for animal feeding (41.6%), 32.0% is composted while the remaining 16.8% is utilized for a wide range of other applications including but not limited to biogas production (ME, 2017b).

Composting FW offers an environmentally sustainable pathway to recycling plant nutrients and managing the increasingly generated putrescible domestic waste (Li et al., 2013). However, FW is inherently heterogeneous in its composition with abnormally high water content and salinity (for wastes arising from meal preparation and consumption) which affect both the composting process and the resultant compost. High water content in FW increases the risk of pore spaces being filled with water resultantly generating anaerobic zones inside in the composting piles with consequential exacerbation of odour emissions and dwindling of microbe populations (Adhikari et al., 2008). Besides, Salinity content may have an effect on the efficiency of the composting process because a study by Lee et al., (2015) found that high salinity content of the FW inhibited the decomposition of cellulose and lignin during pyrolysis. A similar scenario might be deleterious in FW composting since it would result in delayed stabilization and maturation of the compost although there is hardly any available data to that effect at the moment.

Thus, It is vital to create an inventory of the water and salinity contents of the FW originating from different areas in order to work out a proper recycling method or to properly adjust the inadequacies for the surety of successful FW recycling. In this study, we tried to investigate the distribution of water and salinity contents in food wastes to create an inventory that covers the whole country for recycling.

Materials and Methods

The investigation of Salinity and water contents of FW involved collecting FW samples from eleven cities, seven of which were major cities while four of them were coastal ones. The major cities included Seoul, Incheon, Daejeon, Gwangju, Daegu, Busan and Ulsan whereas Sokcho, Gangneung, Boryeong and Changwon represented the coastal ones as shown in Fig. 1. Food waste was sampled from various generating and collecting sites. The FW generating sites included residential apartments (Home meal FW) and a variety of restaurants (Restaurant meal FW) comprising of Korean, Chinese, Japanese and Western food restaurants while the food waste processing facilities (dehydrated FW) constituted the collecting sites. A total of 10 food waste processing facilities, 55 residential apartments, 93 Korean restaurants, 48 Chinese restaurants, 48 Japanese restaurants and 46 Western food restaurants were sampled all of which added up to 300 samples collected per each sampling. The number of FW generating and collecting sites sampled in each of the cities are shown in Table 1. In order to prevent spoilage of the collected FW, samples were hurriedly transported to the laboratory for the analysis of salinity and water content.

Water content was measured by dry weight method. After oven drying for 24 hours at 80℃, the water content of the food waste was determined by the differences in weight before and after drying. Salinity content was determined following homogenization of the dried FW by diluting it 5 - 10 times (10 - 20 mL) with distilled water. 2 g of ground FW sample was weighed and after water addition, the mixture was shaken for 30 minutes on a reciprocal shaker (Fine pcr, sh30, Gunpo, Korea). Then Salinity content was measured with a Salty meter (Atago PAL-ES2, Atago Co., Tokyo, Japan) after standing the mixture for 1 hour.

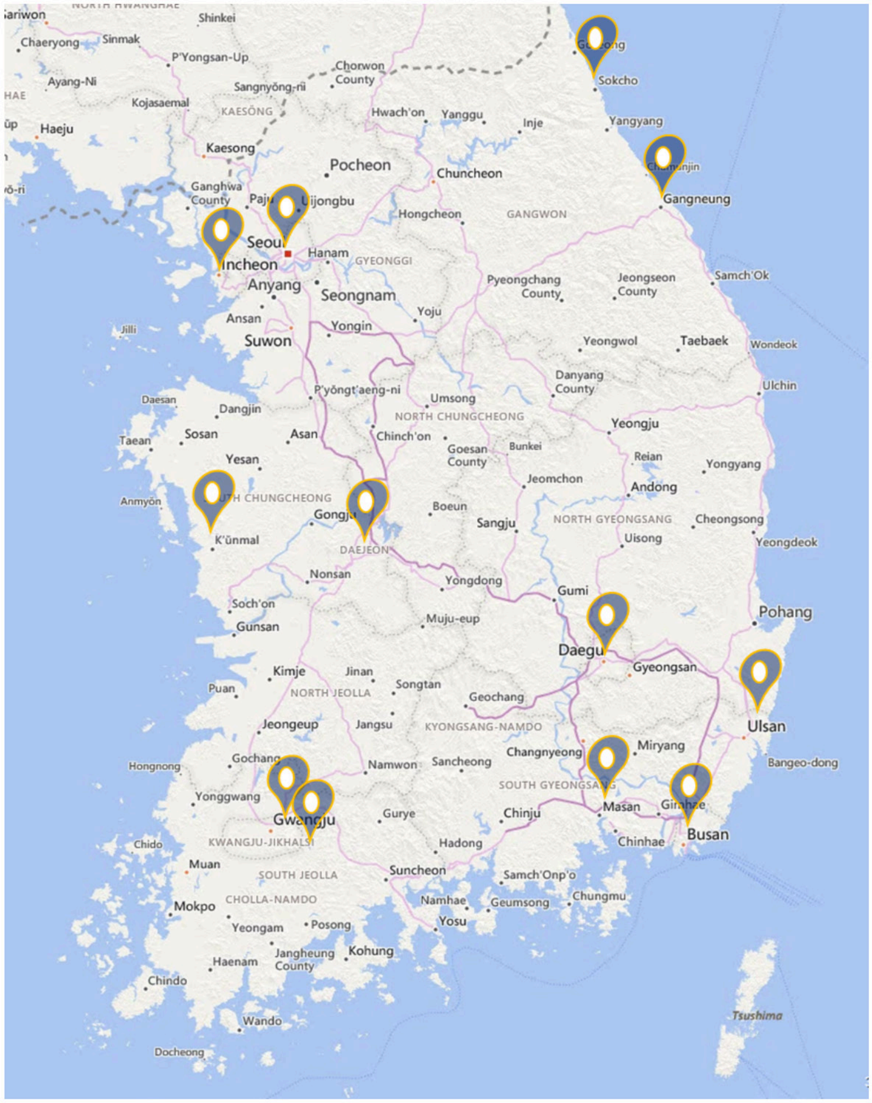

Fig. 1. Regional location for sampling food waste (n = 300).

Table 1. Samples numbers of food waste collected form whole country in Korea.

Regions	Home meal	Korean restaurants	Chinese restaurants	Japanese restaurants	Western restaurants	Food waste processing facilities
Seoul	5	11	10	11	5	2
Incheon	5	5	4	3	5	1
Daejeon	5	26	5	5	3	1
Gwangju	5	5	3	3	4	1
Daegu	5	6	4	6	3	1
Pusan	5	7	5	4	4	1
Ulsan	5	9	3	3	5	1
Changwon	5	6	4	3	6	1
Sokcho	5	8	4	4	3	1
Kangneung	5	5	3	3	5	0
Boryong	5	5	3	3	3	0
Subtotal	55	93	48	48	46	10
Grand total			300			

Results and Discussion

The analyzed was the water and salinity content of a total of 290 food wastes collected from all over Korea. The results of the experiment showed that the average of the water content was 72.45% and the average of Salinity content of the FW in the country was 2.03% (Fig. 2.). The wateriest FW came from Korean restaurants with water content amounting to 74.80%. It was followed by food waste collected from apartments whose water content stood at 73.88% while the restaurant produced Chinese FW contained 73.10% water and Japanese one had 69.65% water. The western FW collected from restaurants had the lowest water content of 67.81% (Fig. 3.). The Salinity and water content of the FW are broadly categorized according to their sources of generation (SG) as shown in Fig 4. The SG categorization basically includes specific places where the FW is generated from including residences and restaurants. This was closely followed by FW produced at home with a salinity content of 2.30% while Korean, Chinese and Japanese foods collected from respective restaurants contained 2.19, 2.17, and 1.95%, respectively. FW collected from western restaurants contained the lowest Salinity content of 1.18%. FW from the food waste processing facilities contained the highest quantities of salinity amongst all the SGs with a concentration of 2.84%. As the moisture of food waste is regulated at the food waste facility, the salinity in the dehydrated cake is more concentrated than the pristine food waste.

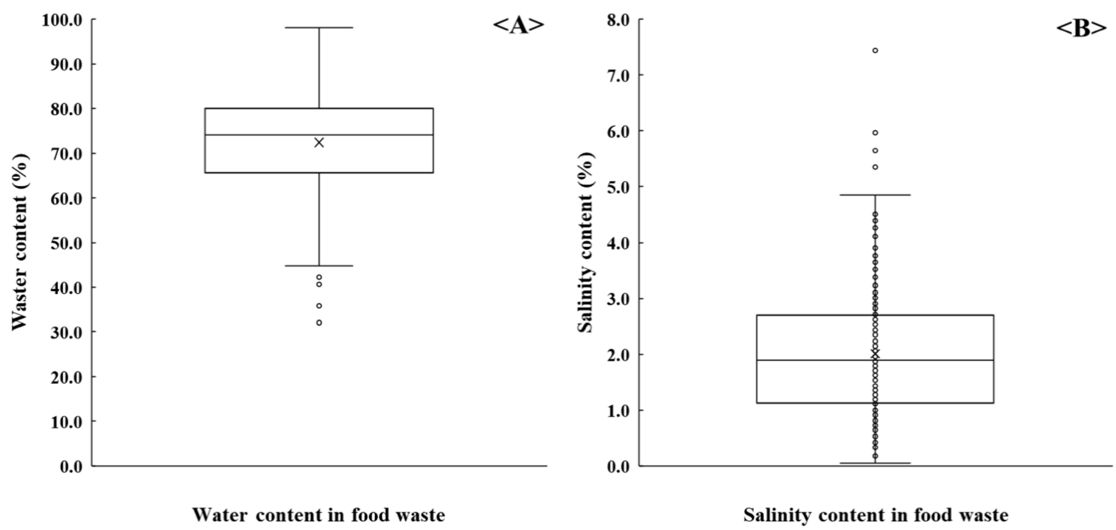

Fig. 2. Distribution of water (A) and salinity (B) content in food waste collected from whole country in Korea (n = 290).

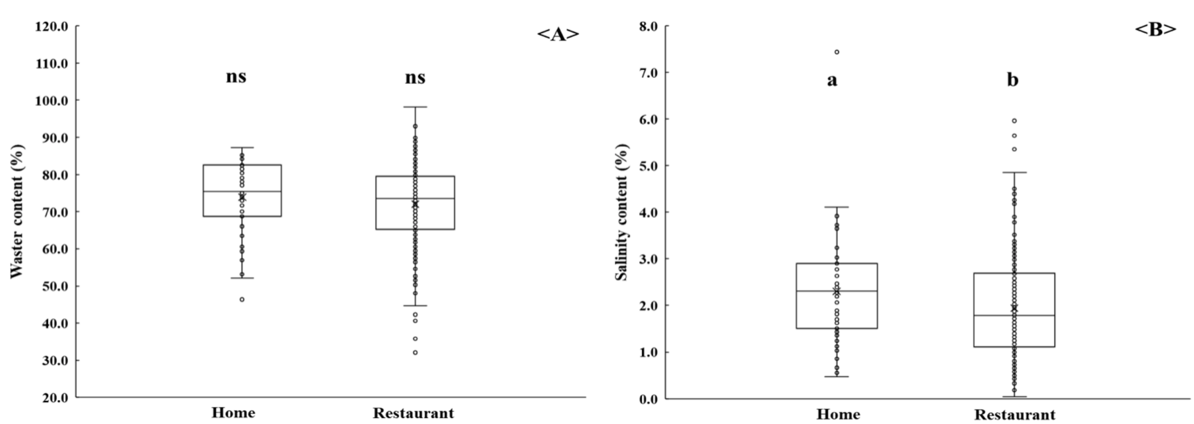

Fig. 3. Distribution of water (A) and salinity (B) content in food waste collected from home generated food waste (FW) (n = 55), and a wide range of restaurants (n = 235).

FW is inherently heterogeneous in its composition with abnormally high water content and NaCl (for wastes arising from meal preparation and consumption) which affect both the composting process and the resultant compost. Since porosity is pivotal to the successful composting regime of FW and is proportionately influenced by the water content of the FW, excessive water therefore impairs FW composting (Cerda et al., 2018). High water content in FW increases the risk of pore spaces being filled with water resultantly generating anaerobic zones inside in the composting piles with consequential exacerbation of odour emissions and dwindling of microbe populations. In the pursuit of optimising the composting process, several studies have attempted to improve the porosity of FW by mixing with highly porous and adsorptive bulking materials (Adhikari et al., 2008).

Although sodium is needed by animals in large quantities, it is an inessential nutrient for plant growth and development despite its close relationship to potassium (Troeth and Thompson, 1993). Chlorine on the hand has been reported to be beneficial to plants through aiding in stomatal openings alongside potassium, improving plant resistance to diseases, etc. (Goos, 1987). However, Troeth and Thompson (1993) reported that the concentration of chlorine in the soil is abundantly sufficient that its excesses are more frequent than deficiencies. That therefore implies that adding FW compost to the soil heightens the chlorine burden through ionization of chloride ions contained in NaCl. Overabundance of chlorine is detrimental to a certain category of crops causing watery potatoes and poor burning of tobacco (Troeth and Thompson, 1993). Its thus evident that both Na^+ and Cl^- should be supplied to the soil in infinitesimal quantities.

Besides, NaCl content may have an effect on the efficiency of the composting process, Lee et al. (2015) found that high NaCl content of the FW inhibited the decomposition of labile compounds like cellulose. Since it would result in delayed stabilization and maturation of the compost although there is hardly any available data to that effect at the moment. Distribution of water and salinity in dehydrated food waste sampled from total of 10 food waste processing facilities was average 71.0 ± 6.76 and 2.84 ± 0.99%, respectively (Table 2). These results indicate that composting process for recycling of food waste need to treat with adjusting water and salinity to improve compost quality such as complete maturity and safety for crop cultivation in soil. Therefore, water and salinity control in dehydrated cake of food waste is might be key work to food waste recycling as compost for soil amendment and nutrient supply to sustainable agricultural productivity.

Table 2. Distribution of water and salinity content in food waste generated from different restaurant types.

Sources of food waste	Water content (%)	Salinity (%)
Korean food	74.8 ± 10.7a	2.19 ± 1.24a
Chines food	73.1 ± 9.0ab	2.17 ± 1.08a
Japanese food	69.7 ± 11.9bc	1.95 ± 0.94b
Western food	67.8 ± 7.4d	1.18 ± 0.48c
Food waste facility	70.1 ± 6.76abc	2.84 ± 0.99a

a - d: The same letter means not significant at 0.5% levels.

Conclusion

The present study investigated water and salinity contents of the food waste (FW) categorized according to their sources of generation including domestically produced FW in the apartments, restaurant industry (Korean, Chinese, Japanese, and Western food restaurants), and FW processing facilities with the aim of securing practical basic data for equalizing the quality of FW in Korea. The results showed that the average the water content was 72.45 ± 10.51% and salinity content of the FW in the country was 2.03 ± 0.57%. It might be alternative to establish as a standard for composting process and manage compost quality on the crop production and soil amendments for recycling of food waste.

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