

THE EFFECTIVENESS OF WATER FOOTPRINT REDUCTION AND TRADE-OFF AMONG ENVIRONMENTAL CATEGORIES IN THE INTRODUCTION OF INNOVATIVE PACKAGING SYSTEM FOR READY MEAL

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ABSTRACT

Food loss may result in significant water availability loss. A new innovative packaging system (MicVac) for ready meals can make it possible to preserve ready meal at maximum 45 days in chilled storage by applying vacuum-sealed package. Water footprint and other whole impacts relevant to ready meals made in conventional way and MicVac were assessed and compared. The results showed predominance of ready meal by MicVac system in both water footprint and full impact assessment mainly due to saving food ingredient input related to unsold meal loss. It could be quantitatively verified that the effects of the increase in power consumption for microwave cooking and chilled storage in MicVac system were relatively smaller compared to the advantage of saving food loss in the perspectives of both water and other relevant environmental issues.

INTRODUCTION

Agriculture is a large user of freshwater. Thus, water footprint of food is generally significant factor in the perspective of water resource management. In Japan, 5-8 million ton of food is wasted annually. In other words, large amount water is lost accompanying with food loss. Reducing food loss is of highly importance in the context of water footprint.

An innovative technology of cooking and pasteurization system for ready meals (MicVac) has firstly developed by the Swedish company, Micvac. In the system, food ingredients and seasoning liquid are filled and sealed in a container and then cooked and pasteurized simultaneously using microwaves whereby MicVac can be preserved for long-term (at the maximum 45 days in chilled storage). Thus, the extension of expiration date can be expected to contribute water footprint reduction of ready meals by reducing food loss at retail stores and households. This technology also practically implemented in Japan by the collaboration of a packaging company (Dai Nippon Printing Co., Ltd.) and a food processing company (Fujicco Co., Ltd.).

The main scope of this study was to verify the effectiveness of the innovative packaging technology on reducing water footprint based on the actually collected foreground data.

Additionally, the effectiveness was also assessed from the viewpoint of comprehensive impacts on relevant categories.

METHODS

Scope and system boundary

Both conventional ready meal and MicVac were selected as targets of the assessment. Functional unit was set as 1 package of ready meal, Japanese meat and stew (main content: 250g). Whole life cycle from food ingredient/package/seasoning liquid production to waste disposal (only packages excluding leftover foods) by households including retail and cooking at households was defined as the system boundary for the assessment (Fig.1).

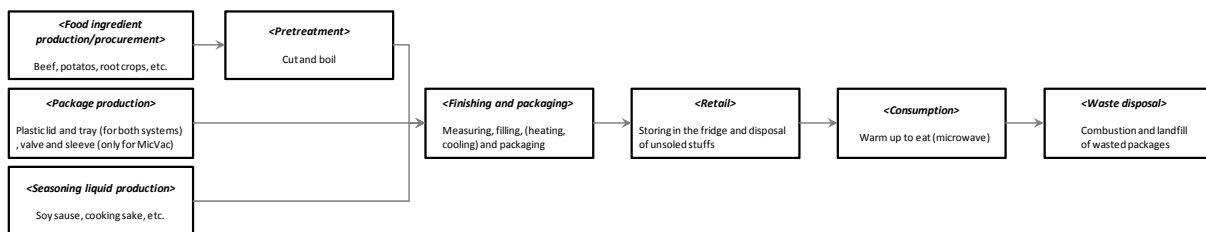


Fig.1 System boundary for the assessment of a conventional ready meal

Data collection

Foreground data on ready meal production was collected by surveying actual input/output amounts of energy and materials on-site. Energy consumption at retail stores was estimated by average power consumption rate of refrigerators and the investigated average term for storing ready meals at retail stores. Unsold loss rates of both ready meals were also surveyed on-site, respectively. At the consumption stage, the conventional ready meal should be consumed within a day cooked, while MicVac was assumed to be stored during three days on average. Based on this assumption, energy consumption of a microwave for warming up and refrigerator at households was calculated.

Inventory analysis and impact assessment

Japanese LCI database (IDEA: Tahara et al., 2012) was adopted for the inventory analysis and relevant impact categories to the items of elementary flow of IDEA were selected as targets of the impact assessment. For water availability footprint, only water consumption (excluding return flow) was accounted as inventory data and characterization factor of water consumption on human health (Motoshita et al., 2010; Motoshita et al., 2011) was applied. Concerning on water footprint profile (including quality degradation effects on water availability), aquatic acidification, eutrophication, human toxicity (aquatic) and eco-toxicity (aquatic) were evaluated by applying characterization factors of LIME2 method (Itsubo & Inaba, 2012). Applied characterization factors on four endpoints (human health, social asset, biodiversity, primary production) were aggregated into a single metric (economic value: willingness to pay for protecting endpoints) by using the weighting factors in LIME2. All relevant other categories were also assessed in the same way by applying the weighted characterization factors of LIME2 (Global warming, ozone layer depletion, photochemical oxidant, urban air pollution (respiratory diseases), resource consumption, waste disposal).

RESULTS

The results of water availability footprint (assessed in the perspective of water consumption) for both conventional ready meal and MicVac are shown in Fig.2. In both systems, significant processes in the context of water consumption were food ingredient production and seasoning liquid production. However, MicVac system can save unsold goods at retail stores and subsequently reduce the net amount of food ingredient input for 1 package production. Water footprint profile in Fig.3 shows integrated impacts on water consumption, acidification, eutrophication, human toxicity (aquatic) and eco-toxicity (aquatic). Physical availability loss by water consumption was dominant compared to other impacts on water availability loss relevant to quality degradation for both conventional ready meal and MicVac. The effectiveness on water footprint reduction by introducing MicVac system could be estimated as around 7.7 % (water availability footprint) and 8.2 % (water footprint profile).

In addition to impacts on water issues, the result of aggregated impacts on relevant categories is shown in Fig.4. Most dominant impact was water consumption in both systems and accompanied with global warming, urban air pollution, and resource consumption. Reduction of whole environmental impacts by introducing MicVac system could be accounted for 13.8 % compared to conventional ready meal.

DISCUSSION

Basically, major differences between both ready meals in their life cycle can be determined as follows.

- Unsold meal loss (advantage in MicVac; disadvantage in conventional ready meal)
- Pretreatment boiling (advantage in MicVac; disadvantage in conventional ready meal)
- Power consumption of microwave cooking and pasteurization at production stage (advantage in conventional ready meal; disadvantage in MicVac)
- Power consumption at retail and household (advantage in conventional ready meal; disadvantage in MicVac)

Above advantages in MicVac could contribute to the reduction of water footprint as shown in Fig.2 and 3. Even though energy consumption for microwave cooking at production stage and storage at consumption stage would increase in MicVac system, saving unsold meal loss seemed to be more critical in the context of water footprint. In other categories like global warming, urban air pollution and resource consumption, additional energy consumption in MicVac system may result in the increase of impacts. However, net impacts on these categories could be reduced in MicVac system compared to conventional system (Fig.4). It indicates that the decrease of unsold meal loss and energy consumption for pretreatment can overcome the impacts of energy consumption increase for microwave cooking and storage term in refrigerators.

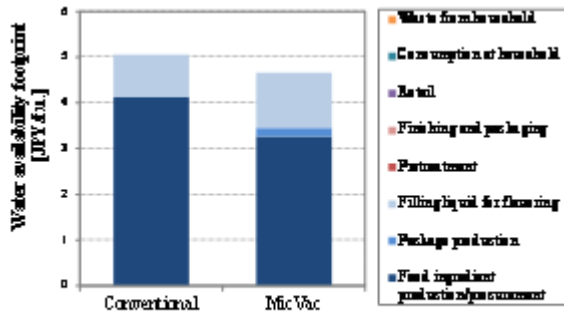


Fig. 2 The result of water availability footprint of ready meals

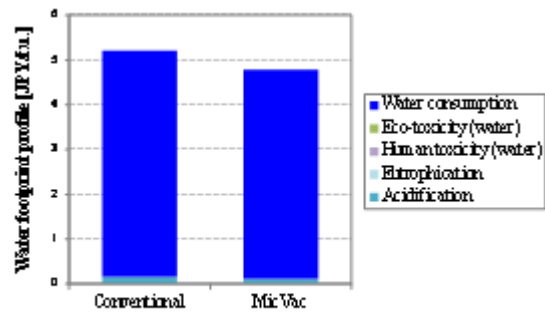


Fig. 3 The result of water footprint profile of ready meals

On the other hand, the effect on water footprint was mainly caused by beef and potato production. Thus, the results may be different in case of other ready meal menu.

CONCLUSIONS

It could be verified that the innovative technology for cooking and pasteurization of ready meals can contribute to reduce water footprint of meals by reducing unsold meal loss. The increase of energy demand for microwave cooking and chilled storage in the new system can be fully offset by saving input food ingredient in the perspective of not only water footprint but also full impacts relevant to the system.

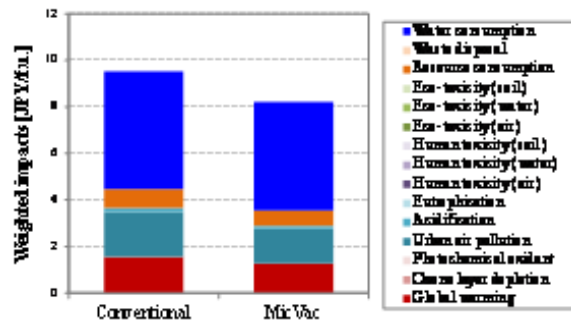


Fig. 4 The full impact assessment profile of ready meals

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