ADAPTATION MEASURES FOR THE FOOD AND BEVERAGE INDUSTRY TO THE IMPACT OF CLIMATE CHANGE ON WATER AVAILABILITY

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Abstract

Water is used as an ingredient, as an essential processing element, as a cooling agent and for the cleaning of equipment and installations in many food and beverage industries. Consequently, the sector is affected by the impact of climate change of reduced water availability. This paper presents current issues related to water demand in the food and beverage industry and addresses adaptation measures in response to reduced water availability. The food and drink industry is a large drinking quality water consumer. Owing to that, the sector has to adopt reduction and minimisation measures in line with Best Available Techniques. In particular, some general measures can be adopted by all industries of the sector while other measures are sector-specific measures including the meat and poultry processing sector, the fish and shellfish sector, the fruit and vegetables division, dairies, the starch manufacturing sector, the sugar sector, the coffee producing sector and the brewing industry. Through widespread adoption of water reducing and minimisation measures, the sector will move towards sustainable development contributing to decoupling of economic growth from resource use as response to reduced water availability.

Keywords

Food and beverage industry; water demand; climate change; water availability; adaptation measures

1. Introduction

Food and beverage industrial sector constitutes a leading pillar of the European economy contributing 1.9% to EU gross value added while comprising the largest manufacturing sector in terms of turnover, value added and employment in European level for 2011 [1]. Water is a key input for the food and drink industry as process water, cooling water and boiler feed-water [2] and as a result the food and drink industry is directly affected by low water availability due to climate change. Water management constitutes a major field for climate change adaptation. In general, climate change can increase water demand e.g. in agriculture while shrinking water supplies resulting in reduced water availability. Although a certain amount of water use is unavoidable for the production of food and drink products, water management practices should be considered for the sector so as to ensure its sustainability. This paper presents information concerning water usage and demand in the food and beverage manufacturing industry as well as adaptation measures in response to reduced water availability as an impact of climate change.

2. Water consumption in the food and beverage industry

The food and beverage industry is one of the most important sectors in the European Union (EU) in terms of financial and social significance owing to its continuous and constant growth. In 2011 the turnover of the food and beverage industry of EU-27 reached €1,017 billion (increase of 6.8% compared to 2010) while the direct employment was stable compared to 2010 (4.25 million employees) [2]. Food and beverage industry includes various sub-sectors aiming at manufacturing different types of products. Based on the "*Nomenclature générale des Activités économiques dans les Communautés Européennes (NACE)*" *(Statistical classification of economic activities in the European Communities) Rev. 2,* food and drink industry is identified by the division C10 for food products and C11 for drinks. The NACE division of food manufacturing is organised by activities dealing with different kinds of products organized in nine groups while the beverage manufacturing NACE division is composed of seven classes organised into one group (*Figure 1*).

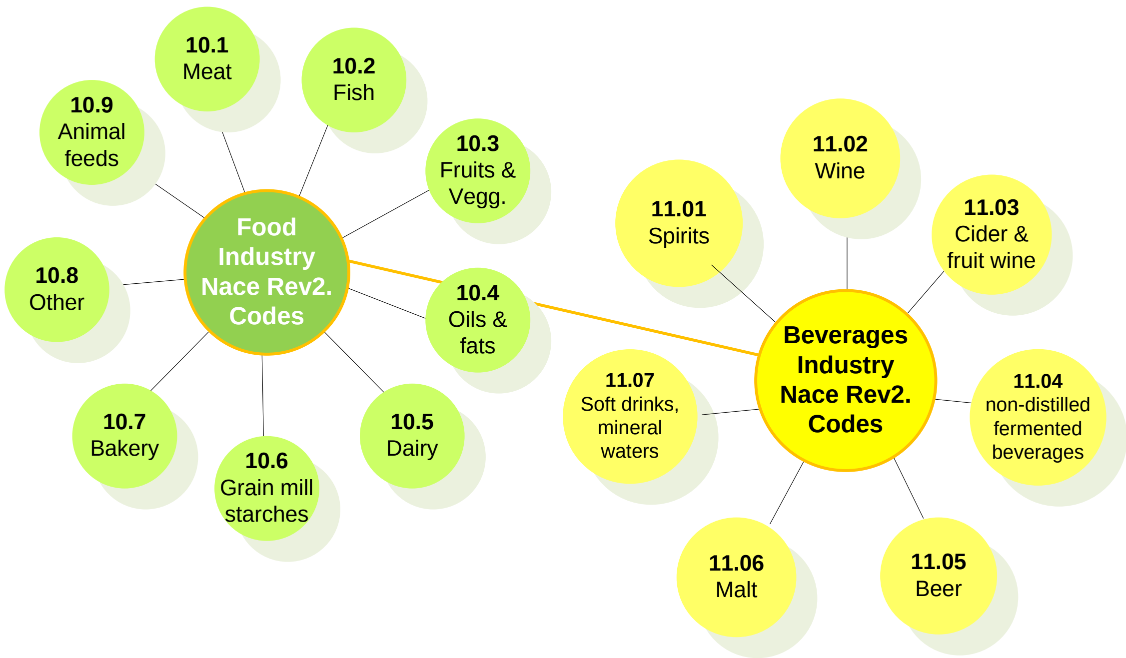

Figure 1: Presentation of the divisions of food and drink industry according to NACE rev.2

As illustrated in *Figure 2*, in 2010 the highest percentage (54%) of companies of the food and beverage sector within the EU-27 manufactured '*bakery and farinaceous products*' while the '*meat processing industry*' occupied the second position. In line with this trend, '*bakery and farinaceous products*' division employed 32% of the total number of employees, followed by the '*meat processing industry*' with 21%. In 2010, the '*meat processing sector*' occupied the first place in terms of turnover and the forth in terms of value added contributing with 20% and 15% to the total turnover and value added of the sector of EU-27, accordingly. Moreover, in 2010, the '*drink sector*' contributed with 15% to the total turnover and 18% to the total value added of the sector of EU-27, ranking in the first place in terms of value added [1].

Overall food and beverage industry is considered as a large water consumer and in particular of drinking-quality water. In general, in the food and beverage industrial sector as a whole, 75% of water used is of drinking-

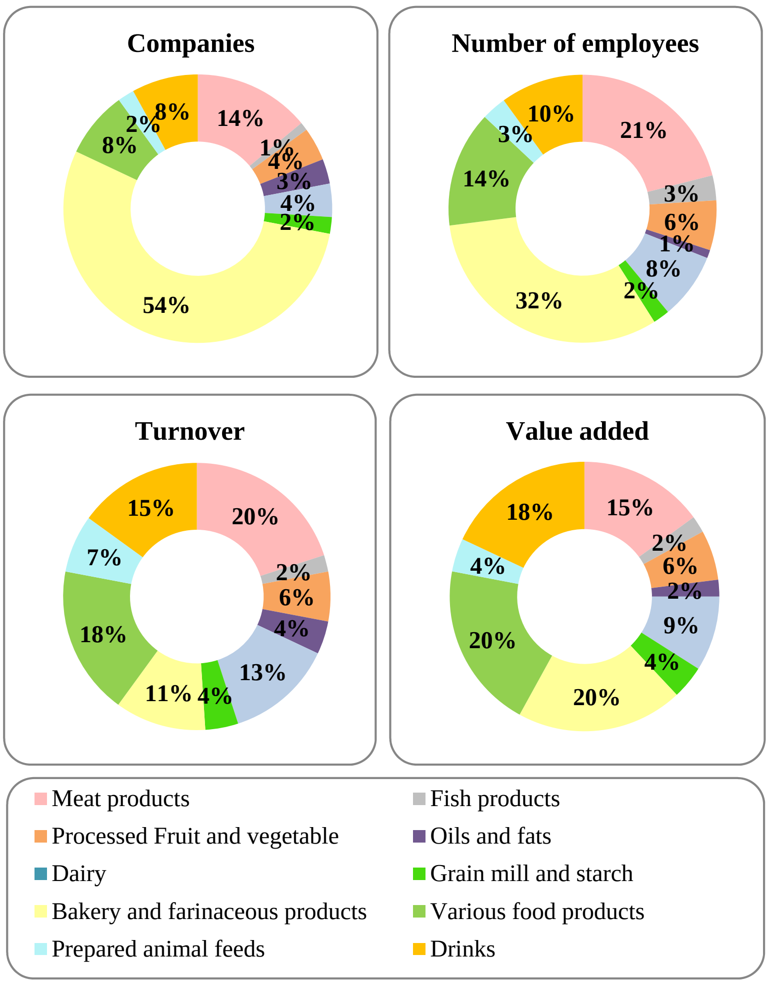

Figure 2: Distribution of turnover, value added, number of employees and companies in food and drink industry sub-sectors, 2010 (%) [1]

quality [2]. According to *Environment Agency*, the food and drink sector is the third largest industrial user of water [3] and is responsible for approximately 1.8% of Europe's total water use [4, 5]. In the UK, water use in food and drink manufacture represents 56% of total water used in industry [6].

The "*Draft Reference Document on Best Available Techniques in the Food, Drink and Milk Industry*" distinguishes three basic water categories: process water, cooling water and boiler feed-water. Process water is defined as water which can come into contact with the food product either directly or indirectly, or water used for technical purposes and which in some way or another can affect the quality of the food products [2]. It includes water used for: (a) direct preparation of products or other items which come into direct contact with the products, (b) cleaning and disinfection, (c) regeneration of water treatment equipment and (d) various technical purposes. Examples of process water for each case are detailed in *Figure 2*. Process water is mostly of drinking quality. In principle, in every case where water is in direct contact with food, the properties of water must be of drinking water quality. Water used for cleaning the external part of equipment, walls and floors is rather unlikely to contact food products, so strictly speaking drinking water quality is not required. However, drinking water quality is often used, to avoid any hazard. Also, water used for various technical purposes meet drinking water quality in order to avoid any risk in case of contact with the food product due to equipment failure [2].

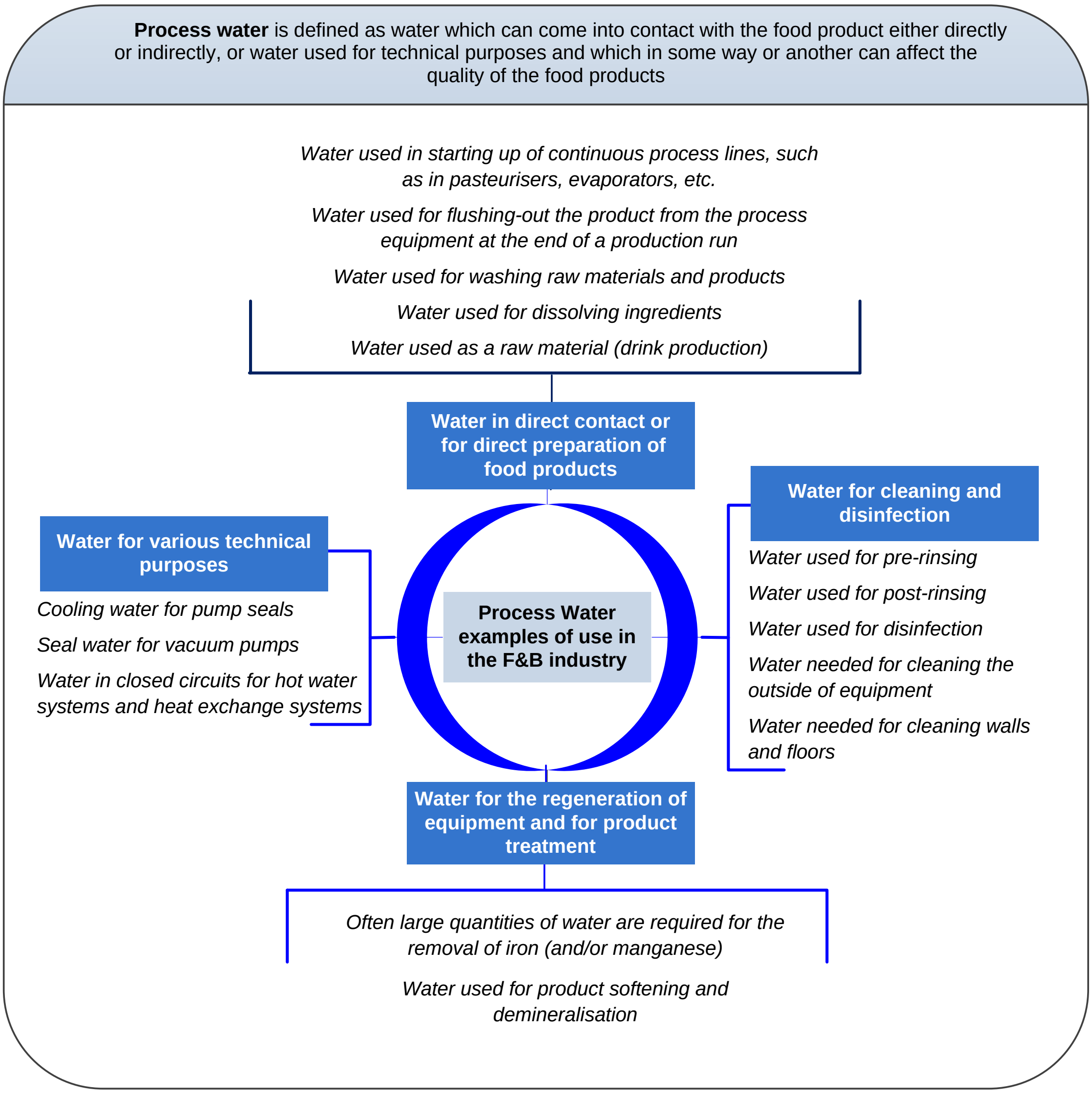

Figure 2: Uses of process water in the food and beverage (F&B) industry

Cooling water is the water used for the removal of heat from process streams and products. Common applied cooling systems in the food industry include: (a) once-through cooling systems, with no recirculation of cooling water, (b) closed circulation cooling systems (chilled water, brine), (c) open circulation cooling systems (cooling towers) and (e) cooling by direct contact with cooling water. In general, once through cooling systems are characterized by the highest levels of water demand compared to closed circulation cooling systems, cooling towers or air-cooling [2].

Finally, boiler feed-water is the water used for steam generation through boilers with working pressures up to about 30 bars. Steam is used for the sterilization of tanks and pipelines, in ultra high temperature (UHT) treatment with direct steam injection e.g. for heating the product or for adjusting the water content of the raw material. Since, in all these cases more or less, direct contact between steam and the food product is possible, the boiler feed-water also needs to meet drinking water quality requirements [2].

Water consumption in the food and drink industry varies depending on different factors such as: diversity of each manufacturing sub-sector, number of end-products, capacity of the plant, type of applied processes, equipment employed, level of automation, system used for cleaning etc. [4]. Current quantitative data on water usage within the food and drink industry is very little in literature and is often expressed in different ways, e.g. as the volume of water consumed either per finished product or per raw material processed, which makes it hard to compare data from different studies or sources [4, 7]. In 2013, *Waste & Resources Action Programme* (WRAP), aiming at obtaining a better understanding on how much water is used within the UK food and drink industry in response to the *Federation House Commitment (FHC)*[1], considered two *key performance indicators* (*KPIs*) relative to water use: (a) *the absolute KPI*: water use (excluding that in product)[2], and *relative KPI or water intensity*: water use (excluding that in product) per tonne of product. Total water use[3] or water use (excluding that in product) depends on the size of each sub-sector within food and beverage industry while water intensity is a more comparable indicator and usually utilised for benchmarking as, for instance, water consumption may increase on a site, but this may be a direct result of increased production [7, 8].

The *International Water Association* defines benchmarking as: *a tool for performance improvement through systematic search and adaptation of leading practices*. Benchmarking consists of two consecutive steps: performance assessment and performance improvement [9]. It is important to distinguish between different metrics often used in the literature to express water consumption. For instance, the specific water consumption for the manufacture of a product in a given time can be characterised as a performance indicator. Such indicators for the beverage industry are illustrated in *Figure 3*.

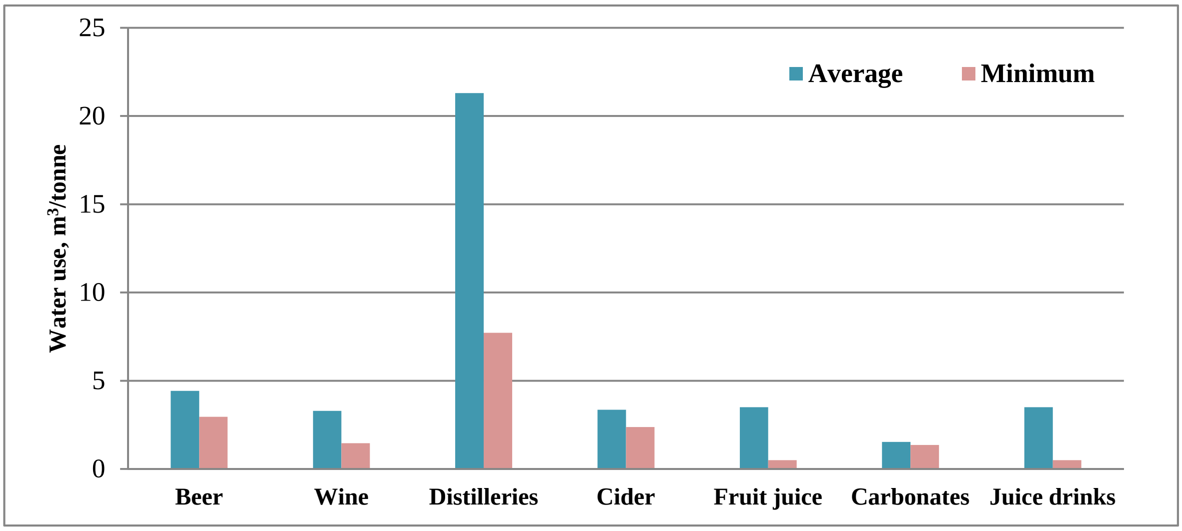

Figure 3: Specific water consumption indicators for the drink industry [7]

[1] *FHC is a voluntary commitment which was launched in 2008 by the Britain's food and drink producers in order to reduce water use and contribute to an industry-wide reduction target of 20% by 2020 against a 2007 baseline.*

[2] *Water use (excluding that in product) is calculated by total water use minus water in product (WIP). WIP is the amount of water that is used as a raw material in product also referred to as "ingredient water" and is determined by the water requirements of the product and the manufacturing process.*

[3] *Total water use, which includes all water used at a manufacturing site including water in product (WIP).*

Target benchmarks or *benchmarks* usually represent a theoretical optimum range of values of specific water consumption for a product. In *Table 1* target benchmarks for some sectors published by the *Environmental Agency* are illustrated. The achievement of these benchmarks is considered as Best Available Technique (BAT).

Table 1: EPR specific water consumption target benchmarks for some products [7, 10-13]

Product	Specific water consumption benchmark
Cattle	700-1000 (L/animal)
Pigs	160-230 (L/animal)
Sheeps	100-250 (L/animal)
Chicken	8 – 15 (L/bird)
Turkey	40 -60 (L/Bird)
Milk	0.6 – 1.8 (L/L)
Milk powder	0.6 – 1.7 (L/L)
Ice-cream	4 – 5(L/kg)

3. Adaptation measures for the food and beverage industry

Minimising water consumption and contamination has been addressed by EC in the *Reference Document on Best Available Techniques in the Food, Drink and Milk Industries* in the framework of Integrated Pollution and Prevention Control. In this regard adaptation measures for the sector can be identified between BATs in the concept of preventing and minimising water consumption as presented in the following table.

Table 2: Adaptation measures for the food and beverage industry in response to the impact of climate change on reduced water availability [2, 7, 10-14]

A. General adaptation measures for the whole sector
A1. General (1) Application and maintenance of a methodology for preventing and minimising the consumption of water incorporating: ✓ management commitment, organisation and planning ✓ analysis of production processes, including individual process steps to identify areas of high water consumption to identify opportunities to minimise these, taking into account the water quality requirements for each application, hygiene and food safety ✓ assessment of objectives, targets and system borders ✓ identification of options for minimising water consumption, using a systematic approach, such as water pinch technology ✓ an evaluation and feasibility study ✓ a programme for minimising the consumption of water and ✓ ongoing monitoring of water consumption levels and the effectiveness of control measures. This can involve both measurement and visual inspection (2) Implementation of a system for monitoring and reviewing consumption and emission levels for both individual production processes and at site level, to enable actual performance levels to be optimised (3) Transportation of solid raw materials, products, co-products, by-products and waste dry, including avoiding fluming except where washing involving the re-use of water is carried out during fluming and where fluming is necessary to avoid damage to the material being transported (4) Segregation of outputs, to optimise use, re-use, recovery, recycling and disposal (5) Optimisation of the segregation of water streams to optimise re-use and treatment

(6) Collection of water streams, such as condensate and cooling water separately to optimise reuse consumption of water and in particular:

- ✓ where heat processes are applied and/or materials are stored or transferred at critical temperatures, or within critical temperature ranges, to control the temperature by dedicated measurement and correction
- ✓ where materials are pumped or flow, to control flow and/or level, by dedicated measurement of pressure and/or dedicated measurement of flow and/or dedicated measurement of level and using control devices, such as valves
- ✓ where liquids are stored or reacted in tanks or vessels, either during manufacturing or cleaning processes, to use level-detecting sensors and level measurement sensors
- ✓ to use analytical measurement and control techniques to reduce waste of water and reduce wastewater generation in processing and cleaning

(7) Use of automated water start/stop controls to supply process water only when it is required

(8) Control of water supply pressure to normal levels

(9) Checking for leakage on the distribution system

(10) Repair leaks within the process equipment e.g. flanges or valve seals

(11) Restrict flow through taps in hygiene (hand washing) stations of the factories

(12) Control of overflows

A2. Environmental management

Implementation and systematic monitoring of an Environmental Management System (EMS) that incorporates between others water consumption benchmarking

A3. Equipment and installation cleaning

(1) Management and minimisation of the use of water, energy and detergents used

(2) Supply pressure-controlled water via nozzles

(3) Optimisation of the application of the re-use of warm open-circuit cooling water, e.g. for cleaning

B. Additional adaptation measures for some processes and unit operations occurring in a number of food and beverage sectors

B1. Cooling

(1) Re-use of cooling water

(2) Optimisation of the operation of cooling water systems to avoid excessive blowdown of the cooling tower

(3) Elimination of once-through cooling systems

B2. Water use

(1) If groundwater is used, only pumping of water that is actually required

(2) When the quality of the wastewater is suitable for re-use, re-use water after it has been sterilised and disinfected, avoiding the use of active chlorine and which meets the standard of Council Directive 98/83/EC

C. Additional adaptation measures for some sectors

C1. Additional adaptation measures for the meat and poultry sector

Meat

(1) Use of recirculation systems to recycle water. Once-through cooling systems should not be used.

(2) Interlocking of chemical dosing pumps with cleaning operations, so that dosing does not continue after cleaning is complete.

(3) Achievement of the following water consumption benchmarks:

- Cattle: 700-1000 L/animal
- Pigs:160-230 L/animal
- Sheeps:100-250 L/animal

Poultry

(1) Use of recirculating systems to recycle water e.g. use of scald tank water for wet feather flume. Once through cooling systems should not be used

(2) Use of nozzles instead of irrigation pipes during defeathering stage.

(3) Use of water efficient shower heads to wash poultry during evisceration

(4) Interlocking of chemical dosing pumps with cleaning operations so that dosing does not continue after cleaning is complete

(5) Achievement of the following water consumption benchmarks:

- Chicken: 8-15 L/bird
- Turkey: 40-60 L/bird

C2. Additional adaptation measures for the fish and shellfish sector

(1) Thawing of mackerel, by immersing them in containers filled with water which is mixed by bubbling air through it. The level of the water is maintained by recirculation and using level-actuated switches, achieving a water consumption of <2 m^3/tonne of raw fish

(2) Thawing of whitefish, by immersing them in containers filled with water which is mixed by bubbling air through it. The level of the water is maintained by using level-actuated switches, achieving a water consumption of 1.8 - 2.2 m^3/tonne of raw fish

(3) Thawing of shrimps and prawns by immersing them in containers filled with filtered peeling water, if available. The water is mixed by bubbling air through it. The level of the water is maintained by recirculation and using level-actuated switches, or by using level-actuated switches

(4) When filleting a 60 - 75 % reduction in water consumption can be obtained by: removing unnecessary nozzles so that water is only added where required, replacing those nozzles that take the fish from the tail cut with a mechanical device, replacing the nozzles for cleaning the driving wheels on the filleting part with mechanical devices, replacing existing nozzles by nozzles with a lower water consumption, using pulsating water nozzles

(5) Reduction of both the number and size of spray nozzles (water saving of about 75%).

C3. Additional adaptation measures for the fruit and vegetables sector

(1) Peeling of fruit and vegetables using a batch steam process or a continuous steam process not using cold water to condense the steam and, if for technological reasons steam peeling cannot be applied, use of dry caustic peeling, unless the recipe requirements cannot be met if either of these techniques is used

(2) Optimisation of the re-use of water with or without treatment, depending on the unit operations which require water and the quality of water these require, ensuring that adequate hygiene and food quality standards are maintained

C4. Additional adaptation measures for dairies

(1) Use of just-in-time "component filling" to avoid losses and minimise water pollution, reduce the required frequency of cleaning of centrifugal separators by improving the preliminary milk filtration and clarification

(2) Re-use of cooling water, used cleaning water, condensates from drying and evaporation, permeates generated in membrane separation processes and final rinse-water after the treatment, if any required, to ensure the level of hygiene necessary for the re-use application

(3) Achievement of the following water consumption benchmarks:

- Milk: 0.6 – 1.8 L/L
- Milk powder: 0.6 – 1.7 L/L
- Ice-cream: 4 – 5 L/kg.

C5. Additional adaptation measures for starch manufacturing

Use of gluten process water (in the protein separation step) for germ and fibre washing and steeping processes in maize starch processing.

C6. Additional adaptation measures for sugar sector

Recycling of transport water

C7. Additional adaptation measures for coffee sector

In instant coffee manufacturing, use of the waste heat from the hot liquid coffee extract to heat the process water prior to extraction and use of counter current heat-exchange to use the heat from spray drying within the roasting sector

C8. Additional adaptation measures for drinks sector

(1) Optimisation of water consumption of the rinsing zone in the bottle cleaning machine, by controlling the rinsing water flow, installing an automatic valve to interrupt the water supply in case the line stops and using fresh water for the two last rows of rinsing nozzles

(2) Re-use of bottle cleaning overflows after sedimentation and filtration.

C9. Additional adaptation measures for brewing

(1) Optimisation of the re-use of hot water from wort cooling and recover heat from wort boiling

(2) Re-use of bottle pasteurising overflow water

(3) Achievement of a water consumption level of 0.35 – 1 m^3/hl (1hl=0.1m^3) of beer produced.

In the framework of a study on water management for the food and beverage industry conducted by WRAP, based on site visits to food and industry factories in the UK, water saving opportunities have been identified. From the potential savings identified, the top five frequently encountered opportunities were: elimination of once-through cooling systems, checking water balance and fixing supply leaks, automatic shut-off, control of overflows and optimising water supply pressure [14].

4. Conclusions

The food and drink industry is a large drinking quality water consumer. Current quantitative data on water usage within the food and drink industry are scarse in literature and are often expressed in different ways which makes comparison between them difficult. In general, key performance indicators of water consumption include either total water consumption or specific water consumption i.e. normalized water consumption per tonne of product typically used during benchmarking processes. Since water is an important resource for the food and beverage industry, reduced water availability due to climate change is expected to affect the sector if no adaptation measures are undertaken. Minimising water consumption has been addressed by the EC in the Reference Document on Best Available Techniques in the Food, Drink and Milk Industries. In this regard, adaptation measures can be addressed in the framework of Best Available Techniques. To this end, general measures, such as the application and maintenance of a methodology for preventing and minimising water consumption, the implementation and systematic monitoring of an EMS including water consumption benchmarking, checking for leakage on the distribution system, repairing of leaks within the process equipment, controling overflows, reusing water after achieving appropriate water quality, eliminating of once-through cooling systems, optimising water supply pressure etc. may be adopted by all food and beverage industries. Moreover, additional adaptation measures can be adopted by some specific sectors. Most of these measures can be easily implemented by the food and beverage industry, contributing to a strategic and long-term approach for managing climate change.

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