March/2024

Benefits of processing in dairy

Scientific excellence
Industry applicability
Strategic networking
Global influence

Dairy processing is pivotal in converting raw milk into a diverse range of high-quality and safe dairy products. This factsheet is intended to provide key information on the broader relevance of what processing milk means, from safety to diversity.

Introduction

Humans have been processing food since prehistoric times. Archaeological evidence suggests that fire has been used to cook food as far back as 780 000 years (Zohar et al., 2022). Processing consists of various processes or technologies that transform agricultural raw materials or ingredients into a new form with improved properties (Knorr & Augustin, 2021). Processing includes traditional methods such as cooking, drying, smoking, fermentation, and modern methods such as pasteurization, ultra-high heat-short-time treatment, filtration or pressure processing. Processing enables the transformation of perishable agricultural raw materials into edible, safe and nutritious food (Pandey et al., 2023). Therefore, food processing technology has accelerated transforming our food systems, making food safer, more available and more convenient.

The extent to which products are processed does not determine their role in a healthy and balanced diet. These processes do not cause deleterious changes to the nutritional value of dairy products or ingredients (Albuquerque et al., 2022). In fact, processing contributes to safer and healthier diets and provides other benefits important to sustainable food systems (Fanzo et al., 2022). Despite this, significant concerns regarding processing, particularly the concept of ultra-processed food (UPF), and its impact on consumer health, have surfaced in recent years.

The dairy sector plays an essential role in nourishing the world with global milk production in 2022 forecast at around 930 million tonnes, up by 0.6% from 2021 (Food and Agriculture of the United Nations [FAO], 2022) and estimated to increase to 1 020 million tonnes by 2030 per FAO data (OECD & FAO, 2021). This expanding milk supply contributes to more dairy availability beyond just the region where it is produced. More than 80% of the world's population, or about 6 billion people, regularly consume liquid milk or other dairy products, which would not be possible without processing advances and distribution. The dairy sector is the third largest provider of protein and fat in human diets and an important source of affordable, sustainable and essential nutrients for all (FAO & Global Dairy Platform, 2018).

Why is dairy processing necessary?

Milk is a valuable, nutritious food, and the foundational ingredient for all other dairy foods. In its raw or fresh form, it has a short shelf-life and can quickly spoil without quick refrigeration, heat treatment and/or use of other processing technology (the reader is referred to FAO website *Gateway to dairy production and products; Milk processing*). Milk is highly perishable because it is an excellent medium for the growth of microorganisms – particularly bacterial pathogens and spoilage microorganisms. If raw milk is not further processed, it could cause serious illness and disease in consumers such as listeriosis, brucellosis and tuberculosis (Dash et al., 2022). Milk processing can reduce or eliminate pathogens in raw milk, extract important milk components such as proteins, fats, lactose, and micronutrients that can be used in other products. It can also increase the shelf-life and nutritional value of milk and dairy products, for instance through fermentation (Bourdichon et al., 2012).

The usable life of milk and its component ingredients can be extended from days to months and, in the case of dairy powders, years, through the use of various processing technologies resulting in different dairy products. Pasteurization is an internationally accepted heat treatment process that extends the usable shelf-life of liquid drinking milk to a duration of as long as approximately 20 days (Codex Alimentarius, 2011; International Dairy Federation [IDF], 2022a) under optimal storage conditions with minimal impact on its nutritional value (IDF, 2019a). Drying milk either in whole milk powder or after fat separation into butter (or butter oil) and skim milk powder is a very efficient way to extend shelf-life and reach markets where fresh milk and dairy are in short supply. Cheese is also a product that concentrates milk fat, proteins and minerals into a nutrient-dense food form that also has a longer shelf-life than milk.

Find more information on dairy processing technologies in Annex 1 and Annex 2.

What are the benefits of dairy processing?

1. **Food quality and safety**. Quality and safety of food is enhanced by reducing or eliminating spoilage and pathogenic bacteria to prevent foodborne diseases (Bourdichon et al., 2021; Claeys et al., 2013; Lucey, 2015) related to dairy food consumption as well as to prevent unnecessary food waste. The shelf-life is prolonged through processing and packaging to make dairy products widely available and improve the nutritional intake of consumers while maintaining nutritional value throughout the shelf-life of the dairy product or ingredient (Rysstad & Kolstad, 2006).

2. **Nutrition and health.** Increased dairy product variety allows consumers to have more choices and a richer selection of dairy products, which are more likely to provide the nutrients necessary for healthy diets (Pereira, 2014). Dairy product processing can result in foods that address nutritional deficiencies and thereby reduce the risk of nutrition-related health problems (Akram et al., 2020), or enhance the nutritional value of foods that utilize processed dairy ingredients (i.e., protein enhancement), increased digestibility via fermented dairy products, and nutritional enhancement through micro-nutrients found naturally in milk (e.g., calcium and vitamin B12). Dairy proteins, fats, lactose and micronutrients are used in a vast list of non-dairy foods, such as infant formula, toddler and children's foods, dry cereals, flavourings, sports drinks, other beverages, bakery products, etc.

3. **Accessibility and diverse product range**. The nutritional benefits of milk and dairy foods would not be available in most cities without processing. Dairy farms and plants are often at a distance from the end consumers. Extending the shelf-life through processing and packaging makes dairy products widely available and improves the nutritional intake of consumers. By further processing, milk can be converted into a variety of products that are transported across the globe to consumers in other countries where dairy demand exceeds domestic production. Processing enables the creation of a diverse range of dairy products, catering to different tastes and preferences. This includes improved/diverse palatability, taste, smell, appearance (e.g., prevent creaming through homogenization), flavour, and texture (e.g., yogurt and cheese making).

4. **Environmental sustainability.** By the use of various processing technologies, milk that might spoil can be salvaged and converted into nutritionally valuable dairy foods with extended shelf-life to enhance the diets of consumers around the world. Therefore, dairy processing reduces food waste. Moreover, by valorisation of by-products, other food waste is prevented. One clear example of this is the valorisation of whey, a by-product generated during the manufacturing of cheese and casein-based dairy products, into valuable and highly nutritious products through different processing techniques (Buchanan et al., 2023). The dairy processing industry is also continually increasing operational efficiency while reducing energy and water use – capturing, treating and reusing processing water, resulting in lower volumes of wastewater release.

5. **Increased value.** Processing of dairy products gives dairy producers additional markets for their milk and often additional cash income vs. selling fresh milk directly to local consumers, providing opportunities to reach regional and urban markets. Milk processing can also address the reality of seasonal fluctuations in milk supply. This variation is influenced by factors such as changes in daylight hours, temperature, and feed availability and can impact the availability and price for consumers. The transformation of raw milk into a range of dairy products can benefit entire communities by generating off-farm jobs in milk collection, transportation, processing and retail sales while improving the nutritional value of a consumer's diet (FAO, 2017). Therefore, dairy processing generates employment, supports rural livelihoods, and facilitates international trade, making it a crucial component of sustainable economic development.

Conclusions

Dairy is a staple food with traditions deeply woven into societies all around the world. The versatility and affordability of milk and dairy products allow for varied uses and incorporation into various dietary patterns across different cultures. Dairy processing contributes to nutrition and health, reduces food waste and reduces poverty. Without safe, accessible, affordable, and nutritious food there is no food security and certainly no nutrition security.

Acknowledgements

This factsheet was prepared under the leadership of the IDF Task Force on Processing.

References

Akram, M., Sami, M., Ahmed, O., Onyekere, P. F., & Egbuna, C. (2020). Health Benefits of Milk and Milk Products. In C. Egbuna & G. Dable Tupas (Eds.), *Functional Foods and Nutraceuticals: Bioactive Components, Formulations and Innovations* (pp. 211-217). Springer International Publishing. https://doi.org/10.1007/978-3-030-42319-3_12

Albuquerque, T. G., Bragotto, A. P. A., & Costa, H. S. (2022). Processed Food: Nutrition, Safety, and Public Health. *Int J Environ Res Public Health*, *19*(24). https://doi.org/10.3390/ijerph192416410

Bourdichon, F., Arias, E., Babuchowski, A., Bückle, A., Bello, F. D., Dubois, A., Fontana, A., Fritz, D., Kemperman, R., Laulund, S., McAuliffe, O., Miks, M. H., Papademas, P., Patrone, V., Sharma, D. K., Sliwinski, E., Stanton, C., Von Ah, U., Yao, S., & Morelli, L. (2021). The forgotten role of food cultures. *FEMS Microbiol Lett*, *368*(14). https://doi.org/10.1093/femsle/fnab085

Bourdichon, F., Casaregola, S., Farrokh, C., Frisvad, J. C., Gerds, M. L., Hammes, W. P., Harnett, J., Huys, G., Laulund, S., Ouwehand, A., Powell, I. B., Prajapati, J. B., Seto, Y., Ter Schure, E., Van Boven, A., Vankerckhoven, V., Zgoda, A., Tuijtelaars, S., & Hansen, E. B. (2012). Food fermentations: Microorganisms with technological beneficial use. *International Journal of Food Microbiology*, *154*(3), 87-97. https://doi.org/10.1016/j.ijfoodmicro.2011.12.030

Buchanan, D., Martindale, W., Romeih, E., & Hebishy, E. (2023). Recent advances in whey processing and valorisation: Technological and environmental perspectives. *International Journal of Dairy Technology*, *76*(2), 291-312. https://doi.org/10.1111/1471-0307.12935

Claeys, W. L., Cardoen, S., Daube, G., De Block, J., Dewettinck, K., Dierick, K., De Zutter, L., Huyghebaert, A., Imberechts, H., Thiange, P., Vandenplas, Y., & Herman, L. (2013). Raw or heated cow milk consumption: Review of risks and benefits. *Food Control*, *31*(1), 251-262. https://doi.org/10.1016/j.foodcont.2012.09.035

Codex Alimentarius. (2011). *Milk and milk products*. https://www.fao.org/3/i2085e/i2085e00.pdf

Dash, K. K., Fayaz, U., Dar, A. H., Shams, R., Manzoor, S., Sundarsingh, A., Deka, P., & Khan, S. A. (2022). A comprehensive review on heat treatments and related impact on the quality and microbial safety of milk and milk-based products. *Food Chemistry Advances*, *1*, 100041. https://doi.org/10.1016/j.focha.2022.100041

Fanzo, J., Rudie, C., Sigman, I., Grinspoon, S., Benton, T. G., Brown, M. E., Covic, N., Fitch, K., Golden, C. D., Grace, D., Hivert, M. F., Huybers, P., Jaacks, L. M., Masters, W. A., Nisbett, N., Richardson, R. A., Singleton, C. R., Webb, P., & Willett, W. C. (2022). Sustainable food systems and nutrition in the 21st century: a report from the 22nd annual Harvard Nutrition Obesity Symposium. *Am J Clin Nutr*, *115*(1), 18-33. https://doi.org/10.1093/ajcn/nqab315

Food and Agriculture Organisation of the United Nations. (2017). *The future of food and agriculture: Trends and challenges*. https://www.fao.org/3/i6583e/i6583e.pdf

Food and Agriculture Organisation of the United Nations & Global Dairy Platform. (2018). *Climate change and the global dairy cattle sector – The role of the dairy sector in a low-carbon future*. https://www.fao.org/3/CA2929EN/ca2929en.pdf

Food and Agriculture Organization of the United Nations. (2022). *Dairy Market Review: Emerging trends and outlook 2022*. https://www.fao.org/3/cc3418en/cc3418en.pdf

International Dairy Federation. (2002). *Health benefits and safety evaluation of certain food components* (Bulletin of the IDF N° 377/2002). https://www.fil-idf.org/wp-content/uploads/woocommerce_uploads/2002/03/B377_2002_Health-Benefits-and-Safety-Evaluation-of-Certain-Food-Components-Secured-7ajr9v.pdf

International Dairy Federation. (2012). *Safety Demonstration of Microbial Food Cultures (MFC) in Fermented Food Products* (Bulletin of the IDF N° 455/ 2012). https://www.fil-idf.org/wp-content/uploads/woocommerce_uploads/2012/03/455-2012-Safety-demonstrations-of-MFC-in-fermented-food-products.pdf

International Dairy Federation. (2018). *Inventory of microbial food cultures with safety demonstration in fermented food products* (Bulletin of the IDF N° 495/ 2018). https://www.fil-idf.org/wp-content/uploads/woocommerce_uploads/2018/12/Bulletin-of-the-IDF-N%C2%B0-495_2018_Inventory-of-microbial-food-cultures-with-safety_Cat.pdf

International Dairy Federation. (2019a). *The technology of pasteurisation and its effect on the microbiological and nutritional aspects of milk* (Bulletin of the IDF N° 496/2019). https://www.fil-idf.org/wp-content/uploads/woocommerce_uploads/2019/02/B496-2019-The-technology-of-pasteurisation-and-its-effect-on-the-microbio-and-nutri-aspects-of-milk-.CAT_-1.pdf

International Dairy Federation. (2019b). *Manufacture of milk protein concentrates and isolates by membrane filtration* (Factsheet of the IDF N° 009/2019-12). https://www.fil-idf.org/wp-content/uploads/2019/12/Factsheet-009_2019.pdf

International Dairy Federation. (2022a). *Heat Treatment of Milk* (Bulletin of the IDF N° 516/2022). https://cdn.shopify.com/s/files/1/0603/5167/6609/files/Bulletin_of_IDF_B516_Heat_Treatment_of_Milk_CAT_accb3a86-53e2-4df4-84bc-022781e4e259.pdf?v=1651217069

International Dairy Federation. (2022b). *Inventory of microbial food cultures with safety demonstration in fermented food products* (Bulletin of the IDF N° 514/2022). https://fil-idf.org/wp-content/uploads/woocommerce_uploads/2022/01/Bulletin-of-IDF-B514_Update-of-Inventory_of_microbial_food_cultures_CAT-faksy6.pdf

Knorr, D., & Augustin, M. A. (2021). Food processing needs, advantages and misconceptions. *Trends in Food Science & Technology*, *108*, 103-110. https://doi.org/10.1016/j.tifs.2020.11.026

Lucey, J. A. (2015). Raw Milk Consumption: Risks and Benefits. *Nutr Today*, *50*(4), 189-193. https://doi.org/10.1097/nt.0000000000000108

Pandey, V. K., Dar, A. H., Rohilla, S., Mahanta, C. L., Shams, R., Khan, S. A., & Singh, R. (2023). Recent Insights on the Role of Various Food Processing Operations Towards the Development of Sustainable Food Systems. *Circ Econ Sustain*, 1-24. https://doi.org/10.1007/s43615-022-00248-9

Pereira, P. C. (2014). Milk nutritional composition and its role in human health. *Nutrition*, *30*(6), 619-627. https://doi.org/10.1016/j.nut.2013.10.011

Rysstad, G., & Kolstad, J. (2006). Extended shelf life milk—advances in technology. *International Journal of Dairy Technology*, *59*(2), 85-96. https://doi.org/10.1111/j.1471-0307.2006.00247.x

Walstra, P., Walstra, P., Wouters, J. T., & Geurts, T. J. (2005). *Dairy science and technology*. CRC press. https://doi.org/10.1201/9781420028010

Zohar, I., Alperson-Afil, N., Goren-Inbar, N., Prévost, M., Tütken, T., Sisma-Ventura, G., Hershkovitz, I., & Najorka, J. (2022). Evidence for the cooking of fish 780,000 years ago at Gesher Benot Ya'aqov, Israel. *Nat Ecol Evol*, *6*(12), 2016-2028. https://doi.org/10.1038/s41559-022-01910-z

Annex 1: Specific Information on Dairy Processing Technologies (For more information the reader is referred to Walstra et al. (2005))

Commonly used dairy processing technologies include:

- A wide range of heat treatments such as pasteurization, extended shelf-life processing, ultra-high heat treatment and in container sterilizations (International Dairy Federation, 2022a). In addition, thermization is used to treat raw milk allowing it to be stored for longer time for further processing or for cheese making. The purpose of these heat treatments is to destroy microorganisms both pathogenic and spoilage to ensure milk is safe and has reasonable shelf life.
- Fermentation utilizing lactic-acid and similar bacteria to change milk components in a manner that extends their shelf-life and improves palatability and digestibility. Examples include cheese, yogurt, kefir, cultured buttermilk and cultured butter (International Dairy Federation, 2002, 2012, 2018, 2022b).
- Concentration utilizes heat and vacuum separately or with membrane filtration to capture milk or whey ingredients and removing water (milk is approximately 85% water) to provide functionality, develop milk-derived ingredients for further processing or to reduce transportation costs of the concentrated milk, whey or lactose products.
- Drying technology is almost always used in conjunction with concentration technology to remove any remaining water in the concentrated milk, whey or lactose liquid to produce a powder with a moisture content of less than 5% m/m. Many of the various powders have a shelf-life of 12 months or more, if stored properly. The combined use of concentration and drying technology produces dairy-based powders used widely as ingredients in the food and pharmaceutical industries.
- Filtration is a widespread processing technology which is used in the dairy industry to physically separate and selectively concentrate milk components (namely, fat globules, caseins, whey proteins, lactose and milk minerals) (International Dairy Federation, 2019b). Membrane filtration processing encompasses a range of separation technologies that are widely applied within dairy processing for removal of bacteria and bacterial spores, de-fatting of milk and whey, protein enrichment and isolation, partial demineralisation, concentration of dry matter and recovery of water.
- Ion-exchange technology is used to extract various, nutritionally valuable milk and whey components such as lactoferrin, galacto-oligosaccharides (GOS), docosahexaenoic acid (lipid DHA), etc. Some of these are commonly used in infant formula and nutritionally enhanced powders for athletes because of their beneficial nutritional properties.

Annex 2: IDF Infographic – Milk tree