2013

1. Oikonomopoulou, V.P.; Krokida, M.K.. Novel Aspects of Formation of Food Structure during Drying. *Drying Technology*, 2013, 31(9):990-1007.
http://dx.doi.org/10.1080/07373937.2013.771186

Abstract: The acceptance of processed or minimally processed food products by consumers is highly dependent on several quality and nutritional attributes as well as their organoleptic characteristics. Shelf-life is an additional factor that influences consumer behavior. Moreover, consumers now demand high-value food products that are healthier and have high nutritional value. The quality, nutrition level, and perception of processed foods is governed, among other attributes, by the structure of the dried product. Hence, examination of the structure of dried foods is of significant importance. Dehydration methods have a great impact on the structural properties of most food products. The effect of various dehydration methods on shrinkage and porosity of dried foods is discussed in this article following a comprehensive review of the available literature. Novel drying processes and combination of various conventional drying methods are discussed with regard to their expected impact on food structure. Finally, aspects of food formulation during diverse drying processes and recommendations for future research are presented.

Keywords: Food drying, Pore structure, Shrinkage

2. Minea, V. Heat-Pump–Assisted Drying: Recent Technological Advances and R&D Needs. *Drying Technology*, 2013, 31(10):1177-1189.
http://dx.doi.org/10.1080/07373937.2013.781623

Abstract: Drying is one of the most energy-intensive processes in many industries. Among other technologies, drying heat pumps help to reduce primary energy consumption as well as greenhouse gas emissions. First, this paper reviews some of the general R&D requirements and challenges for heat pumps in general. Second, based on a brief review of the drying literature and the author's experience, the paper focuses on technical integration and control-required improvements as well as on future R&D needs for drying heat pumps. It suggests more rigorous studies and increased interaction between drying, heat pump, and process control researchers and specialists at both the academia and industry levels. The main goal is to stimulate the successful application of drying heat pumps in various industrial fields.

Keywords: Food drying, Fruits and vegetable drying, Heat pump, Wood drying

3. Wang, W.; Wu, L.; Li, Z.; et al. An Overview of Adsorbents in the Rotary Desiccant Dehumidifier for Air Dehumidification. *Drying Technology*, 2013, 31(12):1334-1345.
http://dx.doi.org/10.1080/07373937.2013.792094

Abstract: This review discusses the challenges and opportunities for adsorptive dehumidification for rotary desiccant dehumidifiers. As well, it presents an overview of current approaches and

emerging technologies in the development of high-performance adsorbents for air dehumidification, including silica materials, activated carbons (ACs), supported haloid-based salts, zeolites, metal organic frameworks (MOFs), etc. The adsorption–desorption characteristics—that is, adsorption isotherms—and adsorption kinetics of different kinds of adsorbents are reviewed and further discussed. Some important issues to further advance the research and development of adsorptive dehumidification for rotary desiccant dehumidifiers are also summarized in this work.

Keywords: Adsorbent, Adsorption, Air dehumidification, Rotary desiccant dehumidifier

2014

1. Haydar, K.; Adnan, M.; Aydin, K.; Ibrahim, D. A review on thin-layer drying-curve equations. *Drying Technology*, 2014,32(7), 757-773.
http://dx.doi.org/10.1080/07373937.2013.873047

Abstract: This paper presents a comprehensive review of thin-layer drying-curve models available in the literature and their comparisons for single-layer drying applications from 2003 to 2013. In this regard, a total of 67 models are selected and classified under 28 performance assessment criteria for comparison purposes. These models are then evaluated by considering the following parameters: (1) product type; (2) pretreatment type; (3) drying parameters, such as temperature, air velocity, layer thickness, microwave power levels, amount of solar radiation, vacum pressure, frequency of sound wave, excitation amplitude, relative humidity, bed depth, product shape, pH, salt content, absolute pressure, etc.; and (4) drying method employed. Furthermore, the best models obtained are employed for product drying applications and compared for different drying methods, drying parameters, and dried products.

Keywords: Drying, Drying models, Food, Performance evaluation, Thin layer

2. Sotudehgharebagh R. Measurement Techniques to Monitor and Control Fluidization Quality in Fluidized Bed Dryers: A Review. *Drying Technology*, 2014, 32(9):1005-1051.
http://dx.doi.org/10.1080/07373937.2014.899250

Abstract :Fluidized bed dryers (FBD) are commonly employed in many industries to dry particulate solids. FBDs provide good solids mixing, high rates of heat and mass transfer, and relative ease of material handling. For efficient operation, it is important to be able to monitor and control the fluidization regime, particle size distribution (PSD), moisture content, and bulk density as well as product chemical properties. This review provides an overview of the trends in the application of different experimental techniques to monitor and control the hydrodynamic conditions of FBDs which influence the particle physiochemical properties. This review covers a wide range of measurement techniques, including infrared moisture sensor (IR), near infrared (NIR) spectroscopy, analysis of pressure fluctuations, optical imaging techniques, acoustic emission (AE), electrical capacitance tomography (ECT), spatial filter velocimetry (SFV), Raman spectroscopy, focused beam reflectance measurement (FBRM), microwave resonance technology (MRT), triboelectric probes, positron emission particle tracking (PEPT), and some novel

techniques for monitoring and control of FBDs. The present review summarizes the use of the diverse techniques and outlines their merits and limitations. Prospects for future research in this area are also identified. The measurement techniques can be used for research, development, and operation of fluidized bed equipment used in non-drying applications as well.

Keywords: Bed hydrodynamics, Control, ECT, IR, Moisture content, NIR, Particle size distribution (PSD), PEPT, Raman spectroscopy

3. Barrozo, M.A.S.; Mujumdar, A.S.; Freire, J.T. Air-drying of seeds: a review. *Drying Technology* 2014, 32(10), 1127-1141.
http://www.tandfonline.com/doi/full/10.1080/07373937.2014.915220

Abstract: Beginning with harvesting, seeds are usually subjected to a series of processes which include drying for immediate or future use. Seed quality can be influenced by several factors during drying. This article presents a review of the seed air-drying process, including mathematical models based on differential equations derived from mass and energy balances for seeds and air in fixed and moving bed dryers. The article concludes with an overview of several potential drying technologies that can be applied to seeds.

Keywords: Fixed bed dryer, Mathematical model, Seed quality, Sliding bed dryer, Spouted bed

4. Freire, F.B.; G.; Vieira, G.N.A.; Freire, J.T.; et al. Trends in Modeling and Sensing Approaches for Drying Control. *Drying Technology*, 2014, 32(13):1524-1532.
http://dx.doi.org/10.1080/07373937.2014.925471

Abstract:A number of contributions have been made in the field of chemical process monitoring and control with applications ranging from simple flow and temperature control to highly complex inferential adaptive control systems in biochemical and polymer production. These technologies face difficulties when applied to drying equipment, due to the inherent complexity of the operation. This article shows some recent trends in monitoring and control of drying processes. This review is organized in sections according to the transport phenomena involved in the operation of a dryer. In each section, examples of recent trends in monitoring and control strategies of key variables directly related to these transport phenomena are discussed.

Keywords: Drying equipment control, Inferential control, Transport phenomena

5. Tolga, T.; Orhan, U. A Review of Dehydration of Various Industrial Sludges. *Drying Technology*, 2014, 32(14):1642-1654.
http://dx.doi.org/10.1080/07373937.2014.909846

Abstract: Wastewater characteristics and sludge generation potential of point source categories are

reviewed critically. Novel industry-specific sludge dewatering/drying solutions necessary to establish a sustainable model are examined through a detailed literature survey. Knowledge of sludge properties is one of the most critical issues needed to design dewatering/drying equipment. This study focuses on industrial wastewater/sludge characterization. In addition, a comprehensive review of current drying models and technologies is also presented. A summary of the results derived from a novel thin-film-based photonic sludge dewatering/drying study is outlined as an alternative approach for industrial sludge control. Sludge was dried in a tubular quartz reactor (TQR), the inner surface of which was coated with a TiO2 thin film. The TQR was irradiated with UV A, UV B, and UV C lamps. The consumed and generated energy fluxes through endergonic and exergonic reactions driven by photolysis and photocatalysis were investigated. In addition, the variations in sludge dewatering/drying characteristics were also examined and compared with conventional methods to evaluate the energy requirements.

Keywords: Dewatering, Drying kinetics, Drying methods, Industrial sludge, Nanotechnology, Photocatalysis

2015

1. Levy, A. Multi-Scale Multiphase Modeling of Transport Phenomena in Spray Drying Processes. *Drying Technology*, 2015, 33(1):2-23.
http://dx.doi.org/10.1080/07373937.2014.941110

Abstract: Spray drying is an extensively used technology in process engineering for receiving small particles by rapid moisture evaporation from a spray of droplets. This contribution summarizes achievements and results of the comprehensive scientific research on multi-scale multiphase modeling of transport phenomena in spray-drying processes undertaken by our research group: (1) study of particle formation on the scale of an individual droplet; (2) modeling and simulation of droplet–droplet and particle–particle collisions in a spray; (3) study of gas-spray mixing; (4) 2D and 3D study of spray drying by an innovative multi-scale simulation tool coupled to a commercial CFD software. The proposed multi-scale multiphase model of transport phenomena in a spray-drying process has been developed based on a thorough analysis of previously published experimental and theoretical works. The content of this paper will be useful for both academia and industry; e.g., pharmaceutical, biotechnology, chemical, ceramics, materials, nutrition, and other applications of spray drying.

Keywords: CFD, Drying kinetics, Particle engineering, Spray drying, Transport phenomena

2. Su, Y.; Zhang, M.; Mujumdar, A.S. Recent Developments in Smart Drying Technology. *Drying Technology*, 2015, 33(3):260-276.
http://dx.doi.org/10.1080/07373937.2014.985382

Abstract: With advances in computer, control, and sensing technologies, it is now possible to design smart dryers for certain products. In this article, a generalized definition of smart (or

intelligent) drying technology is proposed and discussed. Recent developments in smart drying technology for fresh foods are reviewed. Such technology can be cost-effective in detecting and monitoring various food quality parameters which vary with time of the drying process, thus controlling the conditions of drying and producing high-quality products. Some important categories of smart drying technology are listed and discussed; these include biomimetic systems, computer vision technology, microwave dielectric spectroscopy, near infrared reflectance (NIR) spectroscopy, magnetic resonance imaging (MRI), ultrasonic techniques, electrostatic sensor technology, and control systems for the drying environment. Several applications of these smart drying technologies are analyzed. Key factors leading to the success of smart drying technologies are discussed. Developments, challenges, and applications that represent a major step toward the development of drying technology are presented.

Keywords: Control, Detection, Drying technology, Monitor, Sensor, Smart

3. Si, C.; Wu, J.; Wang, Y.; et al. Drying of Low-Rank Coals: A Review of Fluidized Bed Technologies. *Drying Technology*, 2015, 33(3):277-287.
http://dx.doi.org/10.1080/07373937.2014.952382

Abstract: The high moisture content of low-rank coals is a matter of concern in many areas, creating high transportation costs, potential safety hazards in transportation and storage, and the low thermal efficiency obtained in conversion processes. It is important to reduce this moisture content to acceptable limits in order to decrease energy losses, transportation costs, and to increase product quality. Drying characteristics, chemical structure change, and energy consumption of low-rank coals as well as the affecting factors are discussed. This article represents a review of conventional fluidized bed drying technologies and additional field-assisted fluidized bed drying technologies, such as microwave, vibration, agitation, and acoustic field. Relative merits and limitations of the various additional fluidized bed drying technologies and the current state of their development are presented. Some of the unresolved problems are identified and directions for further research are suggested.

Keywords: Additional field assistance, Drying, Fluidized bed, Low-rank coals

4. Minea, V. Overview of Heat Pump-Assisted Drying Systems - Part I: Integration, Control Complexity and Applicability of New Innovative Concepts. *Drying Technology*, 2015, 33(5):515-526.
http://dx.doi.org/10.1080/07373937.2014.952377

Abstract: Over the last two decades, many academic R&D studies on drying used heat pumps to improve the overall energy efficiency of the process as well as the quality of dried materials. Part I of this overview focuses on a number of proposed new and innovative heat-pump-assisted drying concepts. It investigates the accuracy of integration configurations and associated control methods, and tries to evaluate their industrial application potential. This article aims to help identify as well

as promote the most promising technological advancements and the application of industrial heat-pump-assisted drying systems.

Keywords: Agro-food product drying, Drying heat pumps, Fruit drying, Heat balance control, Wood drying

5. Minea, V. Overview of Heat-Pump–Assisted Drying Systems, Part II: Data Provided vs. Results Reported. *Drying Technology*, 2015, 33(5):527-540.
http://dx.doi.org/10.1080/07373937.2014.952378

Abstract: art II of this overview investigates the general relevance of several published experimental and theoretical R&D studies on drying using electrically driven, vapor compression heat pumps coupled with air convective dryers. It also tries to evaluate the relevance of the data provided versus the results reported with various dryer-heat pump integrations aimed at improving drying performance for agro-food, timber, and unconventional products. The scope is to encourage future R&D work to provide the information required to help promote technological advancement and accelerate the industrial implementation of heat-pump-assisted drying systems.

Keywords: Food drying, Fruits and vegetables, Heat pump drying, Wood drying

6. Weigler, F. Advances in the Application of a Rotary Dryer for Drying of Agricultural Products: A Review. *Drying Technology*, 2015, 33(5):541-558.
http://dx.doi.org/10.1080/07373937.2014.958498

Abstract: Agricultural roducts are highly perishable and drying of the product after harvest has been proved as one of the methods to minimize postharvest losses. Different studies have been conducted to evaluate the performance of a rotary dryer for drying of agricultural products. The advantages and the challenges of rotary dryers in drying of agricultural products are discussed. This study discusses the effects of product and drying air properties, and dryer design and operation parameters, on dryer performance and product quality. Rotary dryers are capable of processing a variety of agricultural products with a wide range of thermo-physical and flow properties. Rotary dryers have been used for drying of grains, beans, nuts, vegetables, herbs, woody biomass, animal feeds, agricultural wastes, and by-products. This review paper summarizes the advances in the application of rotary dryers in drying of different agricultural products and recommends future research into the use of rotary dryers to improve the efficiency of the drying process.

Keywords: Agricultural products, Drying, Postharvest, Rotary dryer

7. Ramaswamy, D.W.H.S. Novel Concepts in Microwave Drying of Foods. *Drying Technology*, 2015, 33(7):769-783.

http://dx.doi.org/10.1080/07373937.2014.985793

Abstract: Drying is a widespread concept in the food industry, typically employed to convert a surplus crop into a shelf-stable commodity. With advancement of technology, however, there is interest in moving forward from the traditional convective air drying that is most widely used today for grains, both to improve product quality as well as to modernize processes in order to increase throughput and decrease energy costs. In this context, novel techniques for drying and, more recently, microwave-based dehydration techniques have been poised to make an impact commercially. Until now, however, many of these techniques have largely remained in the experimental realm. This article will review recent progress made in microwave-based drying, both benefits and drawbacks, and highlight several technologies with high industrial applicability.

Keywords: Food drying, Freeze drying, Microwave drying, Osmotic dehydration, Spouted bed drying, Vacuum drying

8. Liu, X.; Lee, D.J. Some Recent Research and Development Advances in Drying Technologies: Product Perspective. *Drying Technology,* 2015, 33(11):1339-1349.
http://dx.doi.org/10.1080/07373937.2015.1026986

Abstract: Thermal drying is a major industrial energy consumer in developed economies. Efficient, energy-saving, low environmental impact drying processes to produce dried products of uniform quality that meet specific specifications are desired. This mini-review provides a nonexhaustive view of recent advances in drying technologies, particularly on product perspectives. Based on the listed studies, the challenges and ways forward are discussed.

Keywords: Biomass, Food drying, Wood

9. Aghbashlo, M.; Hosseinpour, S.; Mujumdar, A.S. Application of Artificial Neural Networks (ANNs) in Drying Technology: A Comprehensive Review. *Drying Technology*, 2015, 33(12): 1397-1462.
http://dx.doi.org/10.1080/07373937.2015.1036288

Abstract: Inspired by the functional behavior of the biological nervous system of the human brain, the artificial neural network (ANN) has found many applications as a superior tool to model complex, dynamic, highly nonlinear, and ill-defined scientific and engineering problems. For this reason, ANNs are employed extensively in drying applications because of their favorable characteristics, such as efficiency, generalization, and simplicity. This article presents a comprehensive review of numerous significant applications of the ANN technique to solve problems of nonlinear function approximation, pattern detection, data interpretation, optimization, simulation, diagnosis, control, data sorting, clustering, and noise reduction in drying technology. We summarize the use of the ANN approach in modeling various dehydration methods; e.g., batch convective thin-layer drying, fluidized bed drying, osmotic dehydration, osmotic-convective drying, infrared, microwave, infrared- and microwave-assisted drying processes, spray drying,

freeze drying, rotary drying, renewable drying, deep bed drying, spout bed drying, industrial drying, and several miscellaneous applications. Generally, ANNs have been used in drying technology for modeling, predicting, and optimization of heat and mass transfer, thermodynamic performance parameters, and quality indicators as well as physiochemical properties of dried products. Moreover, a limited number of researchers have focused on control of drying systems to achieve desired product quality by online manipulating of the drying conditions using previously trained ANNs. Opportunities and limitations of the ANN technique for drying process simulation, optimization, and control are outlined to guide future R&D in this area.

Keywords: Artificial neural network (ANN), Controlling, Drying processes, Modeling, Optimization, Prediction

10. Qiu, J.; Khalloufi, S.; Martynenko, A.; et al. Porosity, Bulk Density, and Volume Reduction During Drying: Review of Measurement Methods and Coefficient Determinations. *Drying Technology*, 2015, 33(14):1681-1699.
http://dx.doi.org/10.1080/07373937.2015.1036289

Abstract: Several experimental methods for measuring porosity, bulk density, and volume reduction during drying of foodstuffs are available. These methods include, among others, geometric dimension, volume displacement, mercury porosimeter, micro-CT, and NMR. However, data on their accuracy, sensitivity, and appropriateness are scarce. This article reviews these experimental methods, areas of applications, and limits. In addition, the concept of porosity, bulk density, and volume reduction and their evolution as a function of moisture content during drying are presented. In this study, values of initial porosity ($\epsilon 0$) and density ratio (β) of some food products are summarized. It has been found that $\epsilon 0$ is highly dependent on the type of food products, while β ranges from 1.1 to 1.6. The possibility of calculating solid density based on food compositions has also been validated. The inter-predictions between porosity, bulk density, and volume density have been made mathematically evident.

Keywords: Collapse, Density, Modeling, Porosity, Shrinkage, Volume reduction

11. Chiewchan, N.; Mujumdar, A.S.; Devahastin, S. Application of Drying Technology to Control Aflatoxins in Foods and Feeds: A Review. *Drying Technology*, 2015, 33(14):1700-1707.
http://dx.doi.org/10.1080/07373937.2015.1068795

Abstract: Aflatoxins are secondary metabolites produced by certain species of Aspergillus, i.e., A. flavus, A. parasiticus, and the rare A. nomius, during their growth under favorable conditions of temperature and humidity. Aflatoxins are highly toxic compounds, which can cause acute and chronic toxicity in humans and animals. The incidence of aflatoxins in foods and feeds is relatively high in tropical and subtropical regions, where the warm and humid weather provides optimal condition for the growth of molds. As aflatoxins are very heat stable and cannot be easily eliminated by domestic cooking, rapid drying of agricultural products to reduce their moisture

content is important, as this can avoid the favorable conditions for the growth of fungi. This article reviews general information on aflatoxins, products prone to be contaminated with aflatoxins, and the use of different drying techniques to control mold growth and aflatoxins production, as well as to reduce the contamination level of aflatoxins in food products.

Keywords: Aflatoxins, Decontamination, Drying, Fungi, Postharvest management

2016

1. Rattanadecho, P., Makul, N. Microwave-Assisted Drying: A Review of the State-of-the-Art. *Drying Technology*, 2016, 34(1):1-38.
http://dx.doi.org/10.1080/07373937.2014.957764

Abstract:Offering advantages of energy-saving rapid drying rates, short processing times, deep penetration of the microwave energy, instantaneous and precise electronic control, and clean heating processes, microwave-assisted drying (MWD) has become a popular method that is currently used for many materials and processes. This article presents a systematic and comprehensive review of experimental and theoretical studies regarding the kinetic mechanisms of MWD. Factors affecting, methods for measuring, and applications of the dielectric property are discussed. From the experimental perspective, laboratory- and commercial-scale MWD systems are elaborated, including the equipment used and the stability, safety, and regulation of MWD systems. Theoretical investigations of thermal and nonthermal equilibrium models and moving-load computational models are discussed. Finally, some future trends in the research and development of MWD systems are suggested.

Keywords: Experimental, microwave- assisted drying (MWD), modeling, thermal applications

2. Freire, F.B. Thermal Treatment of Solid Wastes Using Drying Technologies: A Review. *Drying Technology*, 2016, 34(1):39-52.
http://dx.doi.org/10.1080/07373937.2014.995803

Abstract:The proper treatment of organic or inorganic solid wastes is necessary for economic and environmental interests. Added-value by-products of market interest can be obtained through the recovery, reuse, and treatment of solid wastes, which are otherwise discarded inappropriately in large quantities into the environment. In this review, the drying process is presented as an alternative environmental technology for the thermal treatment of residues of different natures from different origins. The main techniques applied to solid waste drying are described and, in parallel, the most relevant studies found in the literature for this theme are analyzed. Moreover, the main dryers currently used are presented, as well as their most important characteristics. Some general aspects of the thermal and energetic performance of these dryers fundamental for process feasibility analysis are also discussed in this review. Essential aspects of the solid waste drying process are primarily presented with the purpose of showing the particularities that this approach offers when it comes to putting the theory into practice.

Keywords: Biodrying, dewatering, dryer, energetic analysis, fry-drying, heat and mass transfer

3. Duan, X.; Yang, X.; Ren, G.; et al. Technical Aspects in Freeze Drying of Foods. *Drying Technology,* 2016, 34(11): 1271-1285.
http://dx.doi.org/10.1080/07373937.2015.1099545

Abstract: Drying is a widespread concept in the food industry, typically used to convert a surplus crop into a shelf-stable commodity. With advancement of technology, however, there is interest in moving forward from the traditional convective air drying that is most widely used today for foods, to maintain at a very high level the nutritional and organoleptical properties of the initial fresh product. Freeze-drying (FD) produces the highest quality food product obtainable by any drying method, but it is considered the most expensive operation for manufacturing a dehydrated product owing to high energy consumption and high costs of both operation and maintenance. Microwave freeze-drying (MFD) and atmospheric freeze-drying (AFD) have been developed to reduce the FD energy consumption. The product quality of these two drying methods is similar to FD, due to removal of water content in materials by sublimation in both MFD and AFD. Although a significant amount of scientific research has been carried out in the field of sublimation drying, there are only a few comprehensive summarizations about the various sublimation drying methods. As a result, this review aims to highlight some of the latest and most notable advancements in sublimation-drying of foods, with main emphasis given to recent developments of reducing energy consumption of FD process and suggests future research areas on sublimation-related drying.

Keywords: Atmospheric freeze-drying, foods, freeze-drying, microwave freeze-drying, sublimation

4. Deshmukh, R.; Wagh, P.; Naik, J. Solvent evaporation and spray drying technique for micro- and nanospheres/particles preparation: A review. *Drying Technology*, 2016, 34(15), 1758-1772.
http://dx.doi.org/10.1080/07373937.2016.1232271

Abstract:This article presents a comprehensive review of research relating to the preparation of biodegradable and biocompatible controlled/sustained release of micro and nanoparticles. It covers recent developments in the area of technology through solvent evaporation followed by lyophilization and spray drying. The last decade seen a shift from empirical formulation efforts to a technological approach based on better understanding of micro and nanoparticle formation in the solvent evaporation and spray drying technique. This review provides concepts and a theoretical framework for the preparation of micro and nanoparticle formation. Encapsulation of pharmaceutical materials has received much attention due to enhanced effectiveness, bioavailability, and the dissolution rates that can be achieved. Polymeric micro and nanoparticles can be used to transport drug in a rate-controlled and sometimes targeted manner. Initially, laboratory-scale experiments are performed, but for industrial scale-up, experiments are required using sophisticated technologies. The objective of this review article is to summarize the solvent

evaporation and spray drying techniques for the preparation of biodegradable and biocompatible controlled/sustained release of micro and nanospheres/particles with focus on the steps involved in its preparation, materials used, and the technique of microencapsulation. The review also summarizes recent research on solvent evaporation and spray drying.

Keywords: Controlled release, microencapsulation, microspheres/microparticles, nanospheres/nanoparticles, solvent evaporation, spray drying

5. Schuck, P., Jeantet, R., Bhandari, B.; et al. Recent advances in spray drying relevant to the dairy industry: A comprehensive critical review. *Drying Technology*, 2016, 34(15), 1773-1790. http://dx.doi.org/10.1080/07373937.2016.1233114

Abstract:Milk is extremely perishable, and yet it has to be preserved for later consumption. In this view, membrane filtration, vacuum concentration lactose crystallization, homogenization, and spray-drying dehydration are valuable techniques to stabilize most dairy ingredients. Considering the increasing development of dairy trade, there is a need for the dairy industry to improve its understanding of how these concentration and spray-drying processes affect the quality of the resulting dairy powders, so to control it. However, the residence time of the droplet and the powder in the spray dryer is so short that it is very difficult to implement studies on the mechanisms of the structural changes in the protein without fundamental research into the process/product interactions. Moreover, several authors have reported the crucial and specific role of dairy components in the mechanisms of water transfer during drying and rehydration. The aim of this paper is to review the present and recent advances in knowledge and innovations, on the properties of spray-dried dairy products, on the modeling and simulation of water transfer processes (drying and rehydration), and on spray-drying equipment and energy consumption.

Keywords: Dairy powder, innovation, spray drying

6. Defraeye, T., Radu, A., Derome, D. Recent Advances in Drying at Interfaces of Biomaterials. *Drying Technology*, 2016, 34(16), 1904-1925. http://dx.doi.org/10.1080/07373937.2016.1144062

Abstract:A better insight in heat and mass transport across interfaces of biomaterials with their environment, particularly at the microscale, is a key element in improving dehydration processes. Recent advances in interfacial drying are targeted, including evaporation from microscopic pores, droplets or microperforated membranes, and drying of soft cellular tissue such as fruit. Manufacturing of thin biopolymer layers, such as (edible) films and coatings, is discussed as well as their performance as barriers at product–environment interfaces. The physical processes at play are illustrated, recent insights are highlighted and a future outlook is given. These interfacial processes are critical for controlling the processing conditions during drying and for tailoring the structure and quality of biomaterials.

Keywords: Drying, food, hydrogel, interface, tailored properties

2017

1. Drosou, C.G.; Krokida, M.K.; Biliaderis, C.G. Encapsulation of bioactive compounds through electrospinning/electrospraying and spray drying: A comparative assessment of food-related applications. *Drying Technology*, 2017,35(2),139-162.
http://dx.doi.org/10.1080/07373937.2016.1162797

Abstract:Spray drying and electrohydrodynamic processes, namely, electrospinning and electrospraying, are the most promising encapsulation technologies for entrapping and effectively delivering bioactive compounds. Encapsulation is used by the food industry to incorporate such compounds into different food matrices, protect them from adverse environmental conditions, and thereby increase the product shelf life and maintain the health-promoting properties of the composite formulation. This review provides a succinct discussion on the potential of food ingredient-based applications of spray drying and electrohydrodynamic processes on encapsulation as well as the principles and the parameters that affect the structure–morphology of the carrier matrix and the encapsulation efficiency of the process.

Keywords: Bioactives, electrospinning, electrospraying, encapsulation, food application, spray drying

2. Stenström, S. Drying of Biofuels From the Forest—A Review. *Drying Technology*, 2017,35(10), 1167-1181.
http://dx.doi.org/10.1080/07373937.2016.1258571

Abstract: The literature during 2000–2016 about drying of biofuels from the forest has been reviewed. Biofuels constitute a low-cost energy resource that is likely to continue to increase and the dryers for such products should be simple, robust, and easy to operate. In 1970s and 1980s, rotary dryers and flash dryers were the most common types, and in 1990s, superheated steam (SHS) dryers became common. Maintenance costs and use of medium pressure steam for the SHS dryers are important topics to consider and one drawback for the rotary dryers is that high-temperature heat sources are used. The development during the last 15 years has moved toward moving bed dryers because of the possibility to use cheap low-temperature energy sources, robust design, and direct capacity control that is achieved by controlling the air temperature in the dryer. A price for the dry biofuel of 15–20 Euro/MWh has been indicated to make a dryer installation profitable based on no cost for the thermal energy and 40 Euro/MWh as the cost for the electrical energy. Shrinkage and the internal transport of moisture and heat in large particles of biofuels will need more considerations in the future. Fractionation of the biofuels, codrying with other products, the total cost for the drying process, environmental issues, and development of drying processes operating at high dew points are the other things to consider.

Keywords: Bed dryer, biofuels, costs, drying, modeling, review, superheated steam