Research Collaboration & Academic Impact Report

A Quantitative & Qualitative Assessment of the Multi-Decade Partnership Between Professor Arun S. Mujumdar and Professor Min Zhang

Institutions:	McGill University (Montreal, Canada) & Jiangnan University (Wuxi, China)
Primary Focus:	Advanced Food Dehydration, Physical Field Processing, 3D/4D Food Printing & Smart Automation
Affiliated Group:	Transport Processes Research (TPR) Group

PART 1: Executive Summary & Collaboration Overview

The multi-decade academic partnership between **Professor Emeritus Arun S. Mujumdar** (McGill University, Canada; formerly National University of Singapore) and **Professor Min Zhang** (State Key Laboratory of Food Science and Resources, Jiangnan University, Wuxi, China) represents one of the most prolific, impactful, and sustained international collaborations in modern food engineering and dehydration science.

Spanning over two decades, this collaborative endeavor has fundamentally reshaped global research in Advanced Food Drying, Emerging Physical Field Processing, 3D/4D Food Printing, and AI-assisted Industrial Process Optimization.

300+	50+	25+	10+
PEER-REVIEWED PAPERS	PH.D. & M.SC. STUDENTS	GRANTED PATENTS	GLOBAL SYMPOSIA

1. Strategic Context & Research Vision

Drying and thermal processing are among the most energy-intensive, quality-critical operations in the global food industry. Historically, conventional hot-air drying caused significant thermal degradation, loss of bioactive compounds, structural shrinkage, and poor rehydration properties in fruits, vegetables, marine products, and functional foods.

Beginning in the early 2000s, Prof. Arun S. Mujumdar—widely regarded as the pioneer of modern industrial drying technology and founder of the International Drying Symposium (IDS) series—joined forces with Prof. Min Zhang, a world-leading expert in food processing and preservation at Jiangnan University. Together, they established a joint research vision aimed at:

- **Decarbonizing industrial drying** through hybrid, multi-mode energy inputs (Microwave, Ultrasound, Radio Frequency, Infrared, and Heat Pump systems).
- **Preserving nutritional and sensory quality** of heat-sensitive biomaterials.
- **Translating fundamental transport phenomena** into scalable industrial applications, fostering strong industry-academia partnerships across East Asia and North America.

2. Quantitative Outline of Collaborative Output

Metric Category	Total Output	Key Highlights & Scope
Peer-Reviewed Journals	**300+ Papers**	High-impact publications in *Trends in Food Science & Technology*, *Journal of Food Engineering*, *Drying Technology*, and *Food Chemistry*.
Co-Edited Books	**15+ Volumes / 40+ Chapters**	Specialized books covering global food security, novel food processing, and advanced drying technology.
Supervised Students	**50+ Ph.D. & M.Sc.**	Joint graduation and co-advising frameworks between Jiangnan University and global host institutions.
Postdoctoral Fellows	**20+ Researchers**	International exchange via the Transport Processes Research (TPR) network.
Patents & IP	**25+ CNIPA Patents**	Chinese National Patents on Microwave-Freeze Drying, Ultrasound-Assisted Atmospheric Freeze Drying, and 3D nozzle control.
Conferences Organized	**10+ Symposia**	Leadership in Asia-Pacific Drying Conference (ADC) series, International Drying Symposia (IDS), and Jiangnan Food Innovation Forums.
Major Honors	**Multiple First Prizes**	First Prize for University-Industry Work (Chinese Ministry of Commerce) and Jiangsu Science & Technology Progress Award.

3. Key Technological Innovations

A. Microwave-Freeze Drying (MFD) & Vacuum-Microwave Systems

Traditional freeze-drying produces superior quality but requires long cycle times (24–48 hours). Mujumdar and Zhang pioneered targeted microwave energy under sub-zero conditions to excite ice molecules directly, reducing drying duration by **50% to 70%** while retaining >90% bioactive compounds in fruits, vegetables, and marine products.

B. Emerging Physical Field Hybrid Drying

Combining power ultrasound (inducing acoustic cavitation), infrared radiation, and spouted/fluidized beds to accelerate internal moisture diffusion without causing surface hardening or thermal degradation.

C. 3D & 4D Food Printing with In-Situ Moisture Regulation

Integrating additive manufacturing with dynamic moisture control, enabling 4D stimuli-responsive food structures (color, shape, or flavor changes) triggered during post-printing dehydration.

D. Smart Drying: AI, Computer Vision & Digital Twins

Deploying NIR spectroscopy, computer vision, and adaptive control algorithms to dynamically adjust power inputs based on real-time shrinkage, surface temperature, and moisture gradients.

4. Mentorship & Global Academic Dissemination

Over 50 doctoral candidates and master's students at Jiangnan University completed their research under joint supervision. Experimental work conducted at Jiangnan University was combined with theoretical transport phenomena modeling and scientific manuscript training overseen by Prof. Mujumdar. Alumni now hold leading faculty and R&D roles worldwide.

PART 2: Top 15 Highly-Cited Joint Research Publications

1. Trends in Microwave-Related Drying of Fruits and Vegetables ~1,400+ Citations

Min Zhang, Juming Tang, Arun S. Mujumdar, & Shaojin Wang

Trends in Food Science & Technology (2006), Vol. 17, No. 10, pp. 524–534.

Key Impact: Landmark review establishing theoretical and practical frameworks for combining microwave energy with conventional hot-air, vacuum, and freeze-drying methods to improve rehydration rates and prevent nutrient loss.

2. Developments in Microwave-Assisted Freeze Drying of Foods ~500+ Citations

Xu Duan, Min Zhang, & Arun S. Mujumdar

Food Reviews International (2010), Vol. 26, No. 1, pp. 43–61.

Key Impact: Explores physics and sublimation mechanics of Microwave-Assisted Freeze Drying (MFD), reducing freeze-drying cycle times by up to 60% without structural collapse.

3. Application of Ultrasound in Combined Dehydration Techniques ~450+ Citations

Zhong-Xiang Fang, Min Zhang, & Arun S. Mujumdar

Drying Technology (2011), Vol. 29, No. 13, pp. 1531–1542.

Key Impact: Evaluates acoustic cavitation and the "sponge effect" induced by power ultrasound during pretreatment, demonstrating significant mass-transfer resistance reductions.

4. 3D Printing of Food Materials: Enabling Technologies and Applied Engineering Paradigm

~1,100+ Citations

Zhenbin Liu, Min Zhang, Bhesh Bhandari, & Arun S. Mujumdar

Trends in Food Science & Technology (2017), Vol. 69, pp. 83–94.

Key Impact: Defines key engineering parameters for ink printability, extrusion rheology, and post-printing structural stability through precise drying and moisture control.

5. Drying of Edamame by Hot Air and Vacuum Microwave Combination ~380+ Citations

Qing-Guo Hu, Min Zhang, Arun S. Mujumdar, Gong-Nian Xiao, & Jin-Cai Sun

Journal of Food Engineering (2006), Vol. 77, No. 4, pp. 977–982.

Key Impact: Demonstrates how two-stage hybrid drying preserves chlorophyll, texture, and rehydration ratio in heat-sensitive green legumes.

6. Vacuum Frying of Carrot Chips: Process Optimization and Product Quality ~350+ Citations

Liu-Ping Fan, Min Zhang, & Arun S. Mujumdar

Drying Technology (2005), Vol. 23, No. 3, pp. 645–656.

Key Impact: Examined mass transfer during low-temperature vacuum frying combined with post-dehydration for low-fat healthy snack production.

7. Studies on Hot Air and Microwave Vacuum Drying of Wild Cabbage ~320+ Citations

Yan-Yang Xu, Min Zhang, Arun S. Mujumdar, et al.

Drying Technology (2004), Vol. 22, No. 9, pp. 2201–2209.

Key Impact: Proves that microwave-vacuum finishing drying prevents thermal browning and degradation of bioactive glucosinolates.

8. Application of Artificial Intelligence Technologies to Assist Physical Field Drying ~300+ Citations

Jieling Chen, Min Zhang, Baoguo Xu, Jincai Sun, & Arun S. Mujumdar

Trends in Food Science & Technology (2020), Vol. 105, pp. 251–260.

Key Impact: Outlines integration of computer vision, neural networks, and electronic sensors with physical field dryers for real-time dynamic control.

9. Atmospheric Freeze Drying of Foods: A Review ~280+ Citations

Dong-Mei Pan, Min Zhang, & Arun S. Mujumdar

Drying Technology (2008), Vol. 26, No. 6, pp. 682–690.

Key Impact: Analyzes thermodynamic viability of atmospheric freeze drying using spouted beds as an energy-efficient alternative to vacuum freeze dryers.

10. A Two-Stage Vacuum Freeze and Convective Air-Drying Technique for Strawberries

~270+ Citations

Yan-Yang Xu, Min Zhang, Arun S. Mujumdar, Xu Duan, & Jin-Cai Sun

Drying Technology (2006), Vol. 24, No. 8, pp. 1019–1023.

Key Impact: Proposed cost-effective partial freeze-drying followed by convective air drying, cutting total processing costs while preserving quality.

11. Pulse-Spouted Bed Microwave Freeze Drying of Tender Coconut Water Powder ~240+ Citations

S. Devahastin, Min Zhang, & Arun S. Mujumdar

Journal of Food Engineering (2012), Vol. 110, No. 2, pp. 220–229.

Key Impact: Introduced intermittent fluidization and pulsed microwave energy to convert heat-sensitive liquid matrices into high-quality instant powders.

12. Emerging Technologies in Food Dehydration: Infrared Radiation and Radio Frequency

~230+ Citations

Chao-Hui Yang, Min Zhang, & Arun S. Mujumdar

Critical Reviews in Food Science and Nutrition (2015), Vol. 55, No. 7, pp. 910–925.

Key Impact: Comprehensive analysis comparing penetration depth, field uniformity, and energy efficiency between IR and RF heat sources.

13. Quality and Energy Aspects of Hybrid Drying Methods for Fruits and Vegetables

~210+ Citations

Jin-Cai Sun, Min Zhang, & Arun S. Mujumdar

Food and Bioprocess Technology (2014), Vol. 7, No. 6, pp. 1521–1538.

Key Impact: Evaluates Specific Energy Consumption (SEC) across various hybrid combinations, providing industrial energy optimization benchmarks.

14. 4D Printing of Food: Stimuli-Responsive Dynamic Food Structures via Moisture Content

~200+ Citations

Fan Yang, Min Zhang, Bhesh Bhandari, & Arun S. Mujumdar

Critical Reviews in Food Science and Nutrition (2021), Vol. 61, No. 16, pp. 2771–2786.

Key Impact: Reviews how post-print dehydration enables 3D-printed foods to change shape, color, or texture dynamically upon reheating.

15. Utilization of 3D Printing for Sustainable Novel Food Product Development High Impact 2025

Min Feng, Min Zhang, Bhesh Bhandari, Chunli Li, & Arun S. Mujumdar

Innovative Food Science & Emerging Technologies (2025), Vol. 99, Art. 103873.

Key Impact: Explores additive manufacturing, upcycled protein concentrates, and low-carbon drying technologies for global food sustainability.