



RFBiocidics™

Next Generation Food Safety Solutions

AN ALLIED MINDS COMPANY

An RF Biocidics White Paper

RF Biocidics: Solution Overview

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Overview

From salmonella outbreaks to E.coli contamination, when something goes wrong within the food industry, the problem often becomes headline news. Protecting food quality has always been a top priority of the food industry.

Yet the need to protect food against contamination and infestation can run into another set of public concerns: healthy eating and the growing consumer demand for pesticide-free and organic products. Consumer concerns have driven organic food sales in the United States from \$11 billion in 2004 to \$27 billion in 2012, according to the USDA. This places the industry in the difficult position of protecting the food chain while keeping products as natural as possible.

The food industry is in need of new technologies to meet these market requirements. RF Biocidics Inc., by utilizing radio frequency technology, offers two chemical-free treatment solutions through its **APEX** and **SENTINEL** food disinfection and disinfestation systems.

Providing a Safer, Chemical-Free Means of Protecting Food

Founded in California in 2008, RF Biocidics designs, develops and operates disinfection and disinfestation systems on behalf of its worldwide customers to create the next generation of food safety solutions. The company provides an environmentally friendly, chemical-free alternative for disinfection, enzyme inactivation, disinfestation, and drying of food and other products. This organic technology has a broad range of potential applications, including food safety, agriculture, import/export compliance, and wood and wastewater treatment.

RF Biocidics manufactures equipment specifically designed for the elimination of food-related pathogens, pests and fungi. The engineered systems offer quick and convenient treatment with no change to sensory, nutritional or functional values. The process uses radio frequency (RF) photons at specific frequencies to activate specific targeted molecules in the host commodity and its pests, thereby inducing well-controlled thermal and electronic effects.

RF Biocidics embraces new applications of RF energy, developed at the University of California, Davis, for the food and agriculture industries. One application of RF allows food products to be heated inside of packaging, unlike conventional thermal processing that must be done before packaging. This reduces the chance of re-contamination that would be present if the products had to be re-packaged after treatment.



Dr. Jareer Abu-Ali, Director of the ASEAN-American Industrial Food Consulting Center at Naresuan University in Thailand, has spoken of the value of RF technology for treating pre-packaged product as it moves along a conveyor.

“As a scientist, microbial contamination is a concern,” Dr. Abu-Ali says. “There is always a chance of contamination when you open a package. Very few technologies process products in a package on a conveyor belt system.”

Another valuable characteristic of RF is that it is a *physical* process, which means that it is chemical-free, non-additive, and leaves no residue. This new process is applicable to conventional and to organic commodities.

For example, the chemical-free nature of RF can help with the need to repeatedly treat bulk rice in storage. “Rice is stored in massive quantities, and you have to treat it and hold it for years, depending on pricing,” Dr. Abu-Ali says. “If you have to use gas every time you treat it, large deposits of chemicals build up.”

Food processors require seamless, integrated, immediate solutions to help bring their products to market. RF Biocidics’ systems achieve consistent reliable pathogen control, high throughput efficiency, and cost-effective performance without the use of chemicals or the limitations of external steam treatment or conductive heating.

Key products include:

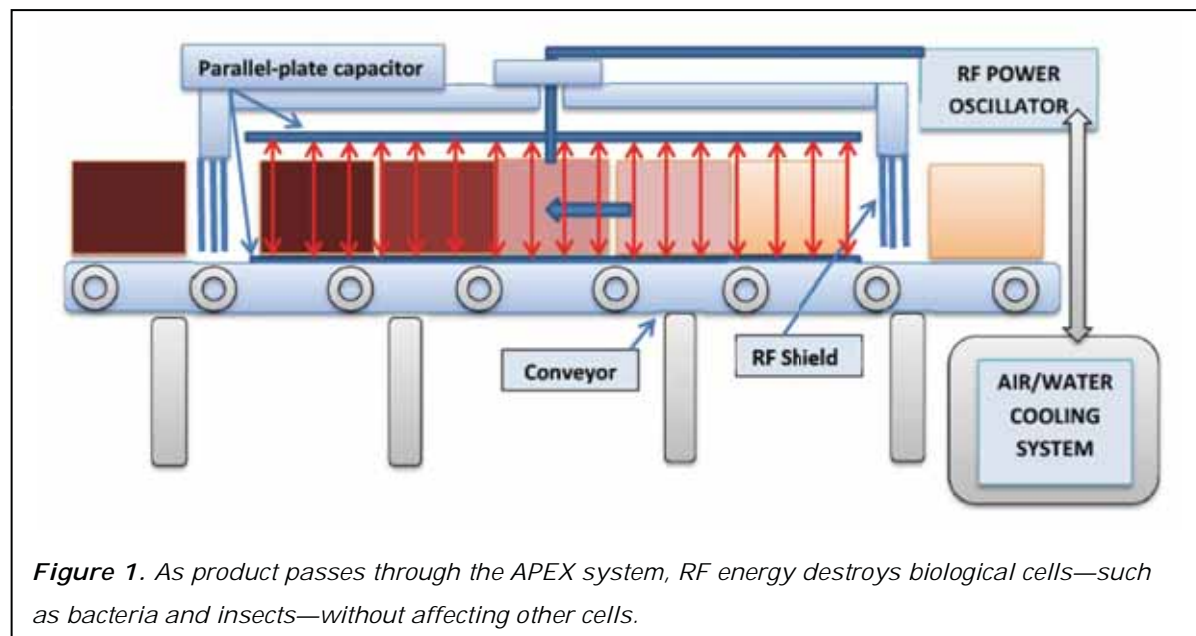
- **APEX System.** The APEX system is a versatile, standalone disinfestation and pasteurization system for loose bulk as well as packaged food commodities, providing a flexible and economical approach to the commodity treatment process. It is designed for the treatment of dry commodities such as walnuts and almonds. The robust construction of the APEX System makes it a workhorse, with few moving parts, robust construction, quality components, and state-of-the-art PLC systems.
- **SENTINEL System.** The SENTINEL System is specifically designed for disinfection and disinfestation of high-moisture and high-salinity commodities, such as raisins, prunes, dried cherries or dried apricots.

RF Biocidics systems are in service today treating tree nuts, edible seeds, spices, dried herbs, tobacco, grains, flour, dried fruit, pickles and pet food, with applications under development for other commodities including soils, irrigation and waste water, and fresh produce.

RF Technology

The RF photons used in RF Biocidics' systems provide a means of disinfecting and disinfestation because the type of energy created by them disrupts biologic cells while leaving the molecular structure of the commodities themselves unharmed.

RF thermal effects are more energy efficient compared to surface heating techniques. The penetrating nature of RF photons means that commodities can be heated internally (or volumetrically) as compared to conventional thermal processes, which only heat surfaces.



RF technology provides value across a spectrum of applications, including:

- **Disinfestation.** RF energy can rapidly increase insect body temperature to lethal levels, destroying them by causing cellular damage and body dehydration. All species and biological stages (eggs, larvae, pupae and adults) are equally affected by absorption of RF energy, since chemical composition and functionality is similar to all arthropods (insects and mites). Insects can't adapt to the destructive powers of RF over time and develop resistance as they can to pesticides and other chemical agents.
- **Pasteurization.** Thermal energy is lethal to microorganisms, with each species presenting specific heat tolerance. Most conventional (surface

heating) and RF thermal disinfection processes are designed principally for pasteurization – killing the pathogenic organisms related to human safety. In addition to pasteurization, RF can reduce spoilage by destroying molds, yeasts, aerobic flora and other spoilage agents.

- **Germination Control.** Germination can lead to significant losses of many foods, including grains and seeds where losses can reach 25-50% during storage. Germination is caused by cell reproduction activity, which can be triggered by warm, moist storage conditions as well as by the action of mites. RF energy reduces germination by destroying the enzymes and the mites that can trigger the process.
- **Food Drying.** Food drying is an important industry process in which moisture levels in natural foods are lowered to levels that provide stabilization and prevent spoilage. While most food dryers today use conventional (surface) heating ovens with various fuels, RF energy provides an efficient and effective alternative.
- **Enhanced Quality for Storage.** RF processing prevents or minimizes oxidation reactions typically affecting the fatty acid composition of many fat-rich foods, including tree nuts. This results in a more stable food and preserves quality because the natural profile of important nutritional components – such as fatty acids – remains unchanged.
- **No Changes to Taste or Nutrition.** RF energy leaves behind absolutely no change to sensory, nutritional or functional values.
- **Chemical-Free, Residue-Free.** RF supports a consumer-driven industry move away from the use of chemical pesticides to chemical-free, effective, and competitive alternatives.

The APEX and SENTINEL systems benefit the food industry by providing an efficient, chemical-free, non-polluting means of destroying insects and bacteria without impacting the flavor or nutritional value of the product.

Campden BRI, in a report on the commercial use of RF for pasteurization, noted that RF could actually enhance the quality of treated product.

“Radio-frequency heating positively affected the nutritional quality of tomato puree by preserving endogenous antioxidants and color characteristics compared with the control treatment,” the report notes. “High retention rates of the thermally unstable L-ascorbic acid and formation of only minor amounts of HMF after radio-frequency heating indicated that the pasteurization process was gentle and did not result in increased levels of HMF.”

In a review of literature on the use of RF to treat post-harvest almonds for pest

control, Campden BRI found that quality was unaffected and shelf life extended for in-shell and unshelled almonds.

“Almond quality was reportedly not affected by the RF treatments because peroxide values, fatty acid, and kernel color of treated almonds were better than or similar to untreated controls after 20 days at 35°C, simulating 2 years of storage at 4°C.”

Real-World Applications and Real-World Results

Benexia Chooses RF Biocidics for Processing Chia Seeds



Figure 2. "Sentinel machine used for drying/disinfection at Prunesco in Chile.

Benexia, a Chia seed supplier and producer based in Santiago, Chile, continually refines its agricultural practices to retain high standards of quality. The importance of investing in technology and innovation became particularly apparent to Benexia in 2008, when increased humidity led to high microbiological counts in agricultural products in Chile. Benexia recognized that it needed to standardize production practices so that it could guarantee low, stable micro-counts in its seeds, regardless of climate fluctuations. Benexia investigated and tested several processing systems, including those that used steam, ionizing radiation, ozone as well as RF Biocidics' chemical-free solution. After benchmarking the results of each system, the company chose RF Biocidics.



Gabriel Van Dyck, Quality Assurance Manager at Benexia, says, “Thanks to this technology, we say to our customers that you can be sure, 100 percent, our products are good because we make sure of it through the use of this system.”

The company values RF technology because it eliminates the problems associated with chemical residues left by competing systems. Benexia is careful about the use of chemicals in its agricultural and processing systems because Chia plants are sensitive to many of them and easily die. The company also recognizes the preferences of consumers, who are increasingly concerned about the health effects of chemical processing and are seeking more organic alternatives.

Additionally, Benexia found the RF Biocidics system to be more energy efficient, and therefore more environmentally friendly. Steam sterilization devices, by comparison, were found to require more energy because they are larger in size and have longer processing times.

“With the RFB system, 80 to 100 percent of the energy used in the device goes into the product, so we have less energy lost in the process,” Van Dyck says.

RF Biocidics Meets Almond Board of California Standards

The RF Biocidics APEX system passed the rigorous standards set by the Almond Board of California for the disinfection of raw almonds. By meeting these standards, RF Biocidics has shown that the APEX maintains a suitable temperature across the entire process of almond treatment. The testing also shows that the APEX removes dangerous pathogens without adverse effects to the sensory and quality characteristics of the almonds, such as flavor, color and texture.

“We achieved 4 log kill, demonstrating that our unique APEX process can work to industry standards,” said Dr. Parastoo Yaghmaee, Director of Process Technology at RF Biocidics and a recognized Process Authority.

With the success of this testing, RF Biocidics installed a system in Australia for the first time, expanding the company’s international reach. RF Biocidics tested the APEX against the Almond Board’s standards at the request of Nut Producers Australia (NPA), one of Australia’s leading growers and processors of almonds as well as its largest grower and processor of pistachios. NPA requested testing to the Almond Board’s standards because they exceed the regulations currently in place in Australia.

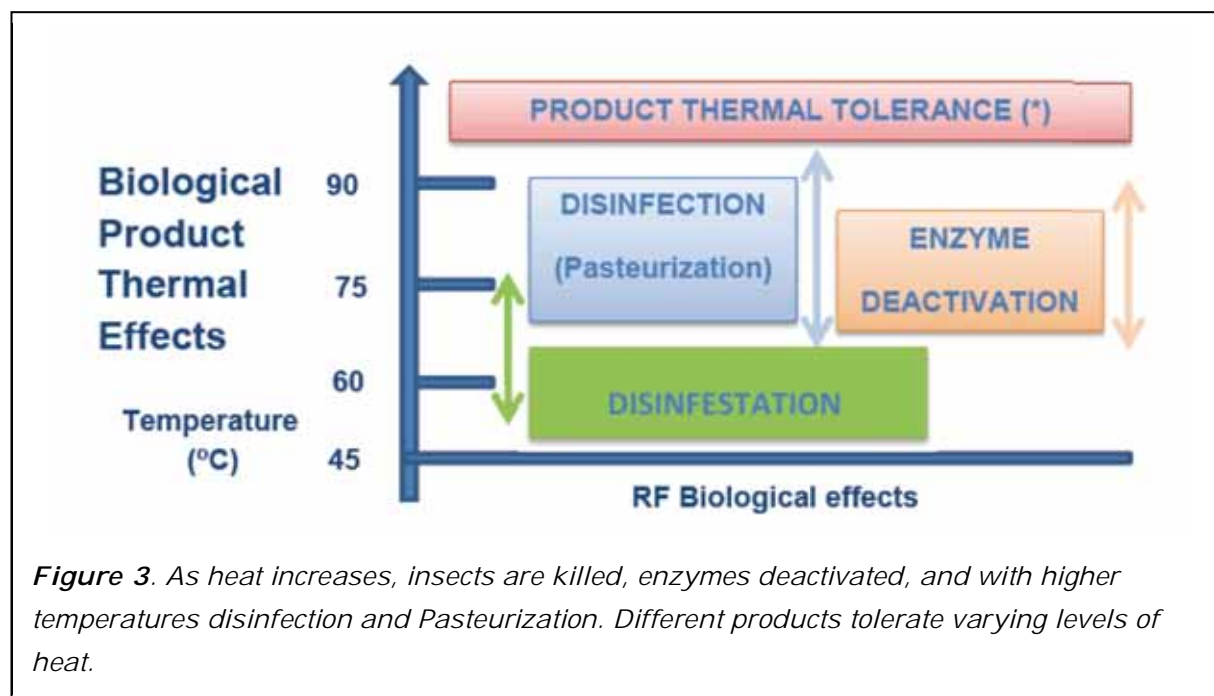
Robust Testing

A spectrum of tests – conducted internally, by third-party certified laboratories, and in collaboration with industry groups – have demonstrated the efficacy of RF technology across a number of commodities.

Validation experiments were conducted with research-level and commercial-size systems. All laboratory tests were conducted with accepted, industry-standard methods of measurement and analysis.

RF Disinfestation Experiment: “100% Mortality”

Field infestations by saw-tooth and dried fruit beetles in all varieties of dates pose serious infestation and quarantine problems that can restrict exports. Methyl bromide is commonly used to control infestation in dates, but its invasive use is being severely restricted via regulations, and alternatives are needed. Additionally, the industry in general is moving away from the use of chemical pesticides when chemical-free, effective and competitive alternatives are available.



The University of California, Riverside conducted validation testing of the RF disinfestation process using an RF Biocidics Sentinel 100 TO system. Testing was performed on dates that were infested with four life stages of saw-tooth (*Oryzaephilus surinamensis*) and dried fruit beetles (*Carpophilus hemipterus*). The infested boxes, as well as the control boxes, were prepared by the UC Riverside

Department of Entomology, using approximately 2400 beetles – 1200 for each test species.

During experiments, the presence of larva of Carob Moths (*Apomyelois ceratoniae*) was also detected.

The university team reported that the results and conclusions on these validation tests were conclusive and indicated that “the RF procedure resulted in 100% mortality in ALL treatments (temperatures) and ALL stages of insects.”

While this testing was on dates, these results can be extrapolated to all food products of similar composition.

RF Product Stability Experiment: “Essential Fatty Acids Unharmred”

The tree nut industry has benefited in recent years from research around the world on the healthy effects of Omega-3 and other beneficial essential fatty acids.

What happens to these heart-healthy fatty acids during RF treatment? Scientists studied the issue in tests using APEX systems on walnuts, almonds, pine nuts and pistachios.

All tests found the same thing: linoleic, oleic and other essential fatty acids were unaffected by RF treatment, while the nuts gained the protection of disinfestation and pasteurization.

Table 3. RF processing effects on Walnuts (Chemical Stability)						
Essential Fatty Acids (%)	Chandler Light Halves & Pieces		Light Medium Pieces		Chandler Light Halves	
	Control 1	RF Treated 1	Control 2	RF Treated 2	Control 3	RF Treated 3
Linoleic Acid C18:2	59.8	60.8	57.1	56.6	60.6	60.7
Linoleic Acid C18:3	14.6	13.9	12.6	13.6	14.7	14.0
Oleic Acid C18:1	16.0	15.2	19.8	19.2	14.8	15.1
Palmitic Acid C16:0	6.6	7.0	7.5	7.3	6.7	7.0
Stearic Acid C18:0	2.4	2.6	0.6	0.6	0.6	0.6
Other Fatty Acids (%)	0.52	0.55	0.60	0.59	0.57	0.57
Peroxide Value (meQ/kg)	0.25	0.20	1.77	0.86	2.45	0.65

Figure 4. Testing across 3 varieties of walnuts show the same good news: Essential fatty acids are unaffected by the RF energy that provides disinfestation and disinfection.

Figure 4 shows the chemical stability results for walnuts across three varieties. A comparison of the control groups to the RF-treated groups for each variety



illustrates that the essential fatty acids remain virtually unchanged (sometimes even increasing). To see the results for all of the other tree nuts tested, please see our comprehensive white paper, “Radiofrequency Power: A New Physical, Non-Chemical Alternative Process for Food Sanitation.”

Summary

In January 2011, food safety gained a new level of public and regulatory recognition when the U.S. Food and Drug Administration’s Food Safety Modernization Act (FSMA) was signed into law. That recognition was overdue. In the wake of a continued explosion in population, the spread of global wealth and the subsequent demand for food, there is a clear, critical need for solutions that produce safe, wholesome food at an industrial level. While the challenges are enormous, the long-term universal implications for efficient global food production are even greater.

RF processing provides an important set of tools for the food industry to address these challenges. This technology can meet the demands of disinfestation and disinfection while protecting product quality, all done with a chemical-free and residue-free physical process. In combination with the unique team that has been assembled at RF Biocidics, RF technology positions the company to meet the incredibly important challenge of providing next-generation food safety solutions.