KEN JONES

is Chief Science Officer for Aloecorp, a multinational company providing research-proven, bioactive Aloe vera ingredients to world markets. Ken oversees the Quality Assurance program, manufacturing process development, validation, new product development, and technical support to customers and Sales and Marketing for Aloecorp. He was a research scientist at the University of Colorado Health Sciences Center in Denver , Colorado for 13 years prior to joining Unigen Pharmaceuticals in 1997 where his work with Aloe vera began. Since then he has played a pivotal role in process development and research to identify and preserve the biological activities of aloe. Ken joined Aloecorp in 2001 as a technical consultant and has become a well-known author and speaker on Aloe vera.

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Conclusion:

Results of this study support the conclusion that this novel self limiting radiant heat, RW™ dehydration technology produces a superior quality *Aloe vera* product compared with spray dried aloe products. Due to the large surface area to volume ratio of approximately 7,000:1, rapid evaporation is possible with a relatively low transfer of radiant heat to the product and resident product temperature is further reduced by the cooling effects of evaporation. We found output of the RW™ dryer directly correlated with product viscosity and is based on polysaccharide content and molecular weight rather than total solids content. Due to the energy efficiency and relatively low cost of RW™ drying technology compared with other fourth generation drying technologies, we found that an optimized output of 14 kg/hr, combined with improved quality of biologically relevant components and physical performance of the product, supports previous studies on which our selection criteria were based.

In this extensive evaluation, we found that the aloe polysaccharide content was increased by 10.10% and most significantly, lactic acid content, a marker of bacterial degradation, was decreased over 15 fold compared with unpreserved juice concentrate stored under optimal conditions for one week. We also confirmed previous studies that suggested RW™ drying technology reduces bacterial load.

Solubility studies demonstrate that both 10 mesh and 80 mesh RW™ dried products have superior dissolution properties than 80 mesh spray dried product and most significantly, 10 mesh RW™ dried product shows a 19 fold increase in dissolution rate compared with 80 mesh spray dried product. Moisture absorbance rate and bulk density were also positively impacted by RW™ drying, which is of particular importance to formulators of finished products.

Throughout our evaluation of RW™ drying technology we were aware of the wide range of liquid products that have been successfully dried by this technology. Recent studies have shown increased bioavailability of vitamins C and E[6] when taken with *Aloe vera* and new data (unpublished) showing increased bioavailability of vitamin B12 when taken with aloe was presented at the 2006 International Aloe Science Council conference. In 2005 Aloecorp began development of new products containing combinations with aloe such as berry purees, tea and others. These new patent pending products provide the benefits of established RW™ drying quality advantages along with the unique characteristic of a homogeneous final product that does not separate due to differing bulk densities, as is the case with dry blended products, a significant advancement in dehydrated product technology.

RW™ drying has proven to be a significant advancement in the processing of *Aloe vera* products consistent with Aloecorp's focus on advances in Ecology, Economics and Quality. This technology provides a superior proprietary product in the Aloe industry with new product development capabilities. With the addition of RW™ drying technology to previously published quality advancements at Aloecorp we believe we have developed the highest quality *Aloe vera* product available in the industry. These branded products are distinguished by the Qmatrix™ brand and are available only through Aloecorp product distributors.

Acknowledgments: MCD Technologies Inc., 2515 South Tacoma Way, Tacoma, WA 98409 Robert Espinoza, QA Manager, Aloecorp Inc., Ramiro Gallegos, QC Manager, Aloecorp Inc., Nancy Rivera, QC Manager, Aloecorp Inc., Marisol Hernandez, Microbiologist, Aloecorp Inc., Jim Perez, QC Technician, Aloecorp Inc., Yvonne Turrubiates, QA/QC Assistant, Aloecorp Inc.

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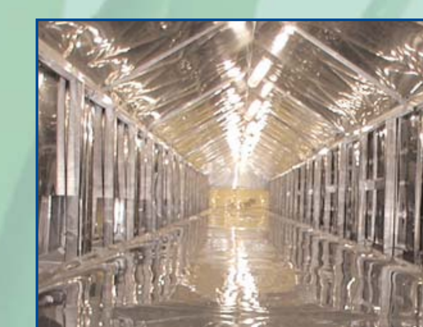
ALOECORP

ALOE PROCESSING TECHNOLOGY:

A novel energy efficient low temperature/short time (LTST) method for the dehydration of aloe to maximize product quality, solubility and stability



Ken Jones, Chief Science Officer, Aloecorp, Inc.

OBJECTIVE OF STUDY:

The objective of this study was to evaluate and select an energy efficient method for the dehydration of Aloe vera that could provide superior quality characteristics, including organoleptic and physical performance, stability, and excipient free product to manufacturers and formulators in relevant markets.

Qmatrix®
PROPRIETARY PROCESSING

Methods:

A review of academic publications on fourth generation drying technologies such as high vacuum, microwave, radio frequency and Refractance Window™ (RW™) drying were evaluated with consideration of the unique composition of biologically relevant components of Aloe vera.

Moisture content of samples was determined by a modified AOAC 950.27 oven method.

Acetylated aloe polysaccharides were evaluated using a Waters' Breeze System with a 2414 Refractive Index and 2487 UV detector for juice concentrates before and after drying.

Lactic acid was evaluated using a Waters' UPLC System with an Acquity TUV, Sample Manager and Binary Solvent System before and after drying.

The bulk density of RW™ dried product was determined using USP Method 616.

Microbial load reduction was determined by USP method 61 for APC before and after RW™ drying. Log reduction was calculated by the formula: $\log_{10} APC_f/APC_i$ where APC_f is the microbial load final and APC_i is microbial load initial.

Summary:

Fresh juices are typically unstable due to available water for chemical reactions and microbial growth in the absence of preservative agents. In contrast, sufficiently dehydrated organic matter can be stabilized to a greater extent; extending the shelf life of the product but at the expense of desirable flavor, color and biologically/nutritionally important components depending on the drying system utilized. Therefore we investigated a system capable of high output, low cost and energy efficiency for dehydrating *Aloe vera* while preserving desirable characteristics.

A novel dehydration technology, Refractance Window (MCD Technologies Inc., Tacoma WA), met our selection criteria due to its energy efficiency, relatively high output, and excellent retention of color, flavor and gentle LTST characteristics. Superior retention of heat labile components and organoleptic properties were previously demonstrated and reported by Abonyi[1,2], Bolland[3] and Nindo[4,5]. In this study a Model 3 (DRYER-3WCUA) RW™ dryer consisting of an endless Mylar® plastic belt measuring 1.56 m wide and approximately 0.2 mm thickness was used. The effective heating section consists of covered water circulation compartments of 18.3 m total length and a cooling section of 1.15 m. This technology is based on the creation of a "window" for the transfer of infrared heat from an underlying bed of heated water to a moist mono-layer of product. The uniform film of semi-concentrated aloe juice approximately 0.2 mm thick adheres to the Mylar® film by passing through a tray containing the juice concentrate. This process is uniquely self-limiting as the radiant energy transferred decreases as the product dries.

Acetylated aloe polysaccharides (polydispersed beta-(1, 4)-linked acetylated mannan) are a primary biologically relevant component of aloe that are degraded by exposure to prolonged heat, mechanical shearing and bacterial contamination. We, therefore, initiated a pilot study to establish several quality parameters, including polysaccharide retention, bacterial load reduction and output rate, and the feasibility of drying aloe using Refractance Window dehydration technology.

Output: During the process of optimization of the RW™ drier output (n=305) we determined that deviations from an average of 5 kg/hr to14 kg/hr were dependent on viscosity due to polysaccharide content of the aloe concentrate rather than solids content alone (Chart 1). The primary contributing factor for output was determined to be polysaccharide content. However, a further contributing factor was the content of mid to large molecular weight polysaccharide (50-2000kDa).

Polysaccharide Content and Lactic Acid: Seven trials were conducted to determine the effect of RW™ drying on polysaccharide and lactic acid content for comparison of unpreserved concentrated aloe juice and RW™ dried product. Both products were stored for one week at 4°C prior to analysis. The result of this study showed that polysaccharide content increased 10.10% from an average of 9.74% dry weight in juice concentrate to 10.72% dry weight in RW™ dried product, while lactic acid content was decreased by over 15 fold from an average of 259 ppm in the juice concentrate to 71 ppm in RW™ dried product (Table 1).

CHART 1

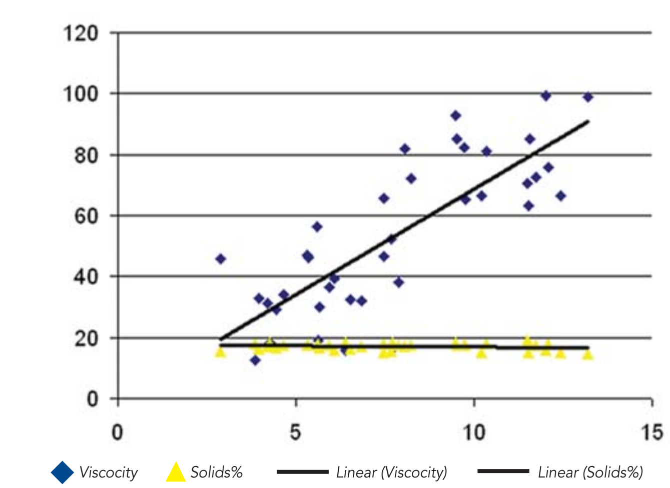


TABLE 1

Sample	Polyaccharide (%)	Lactic Acid (ppm)	Sample	Polysaccharide (%)	Lactic Acid (ppm)
Concentrate 1	10.16	379	RW 200X 1	10.26	102
Concentrate 2	6.53	411	RW 200X 2	11.84	32
Concentrate 3	7.20	103	RW 200X 3	10.54	0
Concentrate 4	11.69	166	RW 200X 4	10.45	0
Concentrate 5	11.00	80	RW 200X 5	10.16	0
Concentrate 6	10.64	582	RW 200X 6	10.38	179
Concentrate 7	10.94	92	RW 200X 7	11.42	186
Average	**9.74**	**259.00**	**Average**	**10.72**	**71.29**

quality

Bacterial Load Reduction: In an analysis of microbial load before and after RW™ drying (n=305), we determined that there was a 1 log reduction (89.13%) in total APC of the two materials. Juice concentrate contained an average of 47 CFU/ml prior to drying and an average of 5 CFU/ml following RW™ drying (Table 2). This finding confirms Nindo's previous report that RW™ drying reduces microbial load, increasing safety and quality of the finished product.

Moisture Content and Dehydration: Moisture content of the juice concentrate averaged 87.63% and was reduced to an average 2.57% (n=305) with a water bed temperature of 96.8°C and an initial product temperature of approximately 77.8°C, decreasing to approximately 27°C as moisture content decreased in the self limiting process.

Solubility, Moisture Absorbance and Bulk Density: Dehydrated *Aloe vera* products are extremely hygroscopic and notably difficult to rehydrate due to clumping. RW™ drying produces a unique sheet or flake of dry material providing the capability to mill finished products to specific particle sizes that impart different physical characteristics to the finished product. We investigated what effect particle size would have on solubility, moisture absorbance and bulk density.

Two solubility studies were carried out in triplicate for 80 mesh spray dried product compared with 80 and 10 mesh RW™ dried products with an initial moisture content of approximately 5% for all test materials. In both studies, 2.5 grams of dehydrated product were added to 500 ml deionized water at room temperature with magnetic stirring in process. In the first study the stirring rate was low, producing only a slight vortex on the surface of the water. The average times required for complete dissolution of 80 mesh spray dried product, 80 mesh and 10 mesh RW™ dried product were 19, 4.5 and 1 minutes respectively. In a second study, the stirring rate was moderate producing a significant vortex within the solution vessel. The average times required for complete dissolution of 80 mesh spray dried product, 80 mesh and 10 mesh RW™ dried product were 8, 3.3 and 1 minutes respectively (Chart 2). This study shows a 19 and 4.2 fold decrease in dissolution time for 10 mesh and 80 mesh RW™ dried product at low stirring and an 8 and 2.4 fold decrease at moderate stirring compared with 80 mesh spray dried product respectively.

For the moisture absorbance study, 80 mesh spray dried product, 80 mesh RW™ and 10 mesh RW™ dried product were oven dried to a near anhydrous state, weighed and placed in a humidified chamber at 30°C. Test products were weighed every thirty minutes to determine the percent moisture absorbance from T=0. During a total study time of 300 minutes, 80 mesh spray dried product and 80 mesh and 10 mesh RW™ dried products showed an increase in moisture content from 0% to 17.7%, 15.1% and 12.5% respectively (Chart 3).

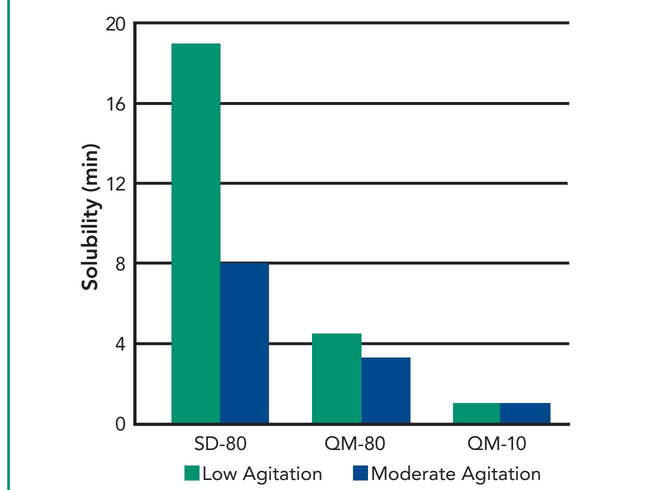
Results of the bulk density study show that the density of 80 mesh spray dried product and 10 mesh RW™ dried product are similar at 0.7699 and 0.7708 g/cc whereas the bulk density of 80 mesh RW™ dried product was significantly increased to 0.8565 g/cc (Table 3). This difference in bulk density has a significant impact on product flowability and provides physical performance characteristics relevant to formulators (e.g. encapsulation processes where higher bulk density increases yield and efficiency of the production run).

TABLE 2

RW™ DRYER APC ANALYSIS - NORMAL OPERATING DAYS

Samples (n=305)	APC_i (Mean)	APC_f (Mean)	$Moisture_i$ (%)	$Moisture_f$ (%)
	47	5	87.63%	2.57%
SDEV	23.57	19.19	0.660	0.630
SEM	1.35	1.1	0.038	0.036
Log Reduction ($\log_{10} APC_f/APC_i$)	0.97313			
Percent Reduction	89.13%			

CHART 2



solubility

CHART 3

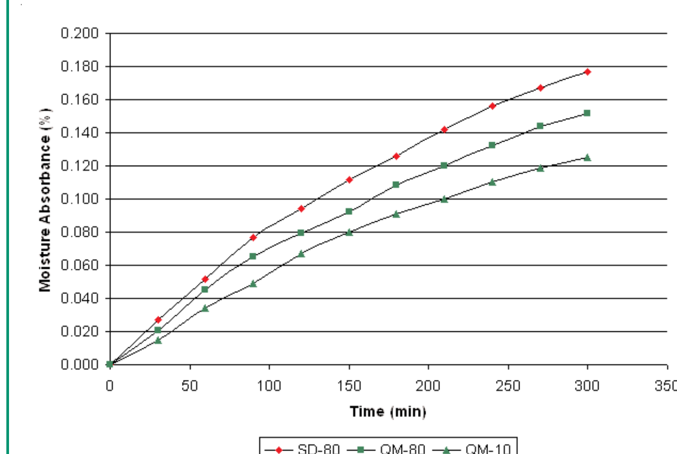


TABLE 3

RW™ Qmatrix™ Powder vs Spray Dry Solubility & Bulk Density

Sample	Low Agitation (minutes)	Moderate Agitation (minutes)	Bulk Density gr/cc
SD-80	19	8	0.7699
QM-80	4.5	3.33	0.8565
QM-10	1	1	0.7708
QM-80/SD-80	4.2X	2.4X	
QM-10/SD-80	19X	8X	

stability