5. Dezman, D. J., S. Nagy, and G. E. Brown. 1986. Postharvest fungal decay control chemicals: treatments and residues in citrus fruits. Residue Rev. 97:37-92
6. Eckert, J. W. 1977. Control of postharvest diseases. P. 269-352 In: M. R Siegel and H. D. Sisler (eds.). Antifungal compounds. Vol. 1. Marcel Dekker, Inc., New York, NY.
7. Eckert, J. W. and G. E. Brown. 1986. Postharvest citrus diseases and their control. P. 315-359. In: W. F. Wardowski, S. Nagy, and W. Grierson (eds.). Fresh citrus fruits. AVI Publishing Company, Westport, CT.
8. Eckert, J. W., M. J. Kolbezen, M. L. Rahm, and K. J. Eckard. 1979. Influence of benomyl and methyl-2-benzimidazolecarbamate on the development of *Penicillium digitatum* in the pericarp of orange fruit. Phytopathology 69:934-939.
9. Katchansky, M. 1973. Fumigation of produce storage rooms with thiabendazole thermal dusting tablets for control of pathogenic fungi. Proc. 2nd International Citrus Congress. 3:343-346.

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MEASURING AIR EXCHANGE RATES FOR CITRUS DEGREENING ROOMS

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Abstract. **A technique was developed and tested to measure the air exchange rates (AER) in citrus degreening rooms. The procedure entails a step function introduction of CO_2 and monitoring its subsequent decay to the ambient background level. This decrease was modeled by a first-order equation, $C(t) = C_b + (C_o - C_b)e^{-kt}$. In the commercial rooms tested, the AER varied from 16.5 air exchanges/hr to a low of 0.6 air exchanges/hr in newly constructed rooms.**

Degreening of Florida citrus is an importation unit operation to market early season fruit that has achieved internal maturity with little or no change in external appearance from green to yellow or orange. Also, some degreening is used on later season fruit, especially 'Valencia' in February to April harvesting period. Conditions for degreening have been extensively studied since the early 1950's in Florida (2) and has led to standard practices (3, 7) for control and implementation of ethylene, humidity, temperature, and fresh air exchange rate (AER). Air exchange rate is number of room air changes per unilt time based on the volume of an empty room. These general procedures have been implemented in other countries (1) where citrus degreening or coloring is required. Similar processes are also used on other commodities such as tomatoes (6). The essential process is one of removing green pigment via ethylene and to accelerate the process by controlled temperature and humidity while mitigating fruit desiccation and the potential for decay.

Most of the variables in degreening rooms that require control, specifically temperature and humidity, can be readily measured. Ethylene requires either estimation via an absorbing media sampling tube or gas chromatography equipment. The AER has not been measured directly but has been obtained inferentially by estimating a fresh air inlet area and air velocity through that inlet. However, other openings may exist where air either infiltrates or escapes from the room. Since the AER is important in designing the heating requirement, etc. and associated operating costs of degreening rooms, this study was directed toward developing a technique to directly measure AER. The techniques may be suitable for other produce storage facilities, greenhouses, or growth chamber facilities (5). Principal objectives of this study were to:

a. develop a procedure to measure AER in citrus degreening rooms.
b. evaluate the technique in pilot plant and commercial degreening rooms.

Methodology

The procedure that was utilized to measure AER required the introduction of CO_2 into a degreening room in a short time and then to monitor the attenuation of CO_2 as a function of time. This reduction should follow the well-known decay rate equation:

$$C(t) = C_b + (C_o - C_b) \exp(-kt)$$

where $C(t)$ = conc at any time t; C_b = baseline conc; C_o = initial conc and k = decay rate constant. For this study, the k value is of direct importance as it represents AER/V where V is room volume.

A schematic of the experimental equipment is presented in Fig. 1. A cylinder of gaseous CO_2 was located external to the room and plumbed into a manifold which was modified to introduce CO_2 across the width of the room under test. To measure the CO_2 level, an infrared portable gas analyzer was employed with the analyzer output directed to a strip chart recorder. Typically, an initial concentration of 1500 to 3500 ppm was introduced with room circulation fans operating and the curtains closed. The analyzer had a full scale capability of 5000 ppm. Degreening room vents and curtain or both were then opened to a predetermined setting. All tests were done in empty rooms in order to make a more precise volumetric calculation and to avoid CO_2 evolution from fruit. It was also necessary to establish baseline readings without internal combustion engines in the immediate vicinity.

For both pilot plant and field work, tests were conducted in triplicate. A test was considered complete when the CO_2 level reached a steady state level for at least 10 min. Values at 5 min intervals were taken from the chart for model analysis. Also, the time corresponding to a 50% reduction in $(C_o - C_b)$ was noted.

Tests were conducted at three sites: pilot plant facility at Lake Alfred Citrus Research & Education Center, Haines City CGA (HCCGA) and A. Duda & Sons (LaBelle, FL). The rooms of A. Duda & Sons were recently constructed while the Haines City CGA degreening facility

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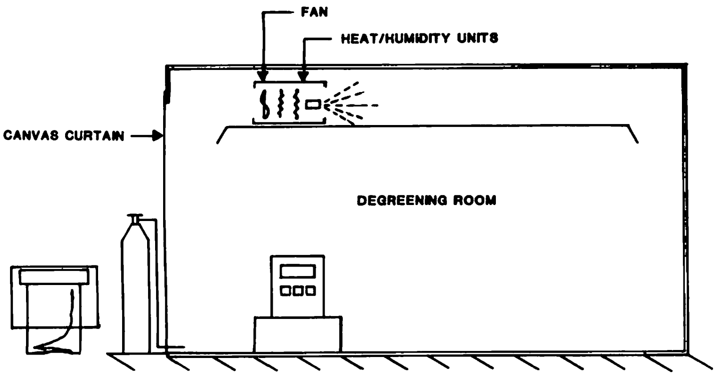

Fig. 1. Schematic of CO_2 introduction and measurement system for degreening rooms.

was quite dated. For both the pilot plant facility and HCCGA, leakage areas were significant and rework was required. At Lake Alfred CREC, a new polyisocyanurate insulated ceiling was added while at HCCGA, exterior walls were insulated with a urethane insulation. Tests were done before and after these upgrades. Design fan capacity for the Lake Alfred CREC installation was ca 1.5 air exchanges per min while estimates from fan data sheets for the commercial installations were 0.8 air exchanges/min (HCCGA) and 1.25 (A. Duda & Sons).

Results and Discussion

All data were analyzed in two fashions. First, a k value was determined at the 50% reduction level, that is 0.5 = exp(–kt). The t value was obtained directly from the strip chart ouput. Secondly, an advanced statistical package allowing log transformations and regression analysis was used to obtain second estimate of k. A summary of all test results has been compiled in Table 1.

In the LA-CREC degreening room, the vent opening area was approximately 0.006 m^2 (0.065 ft^2). Opening the curtain to 30 or 50 cm (12 or 20 in) increased the area to 0.89 m^2 (9.60 ft^2) and 1.33 m^2 (14.31 ft^2), respectively. In all cases before remodeling (Table 1), the air exchange rates far exceeded the recommended 1 air exchange/hr (7). This was also encountered with the commercial rooms at HCCGA. At HCCGA, the addition of sprayed-on urethane insulation significantly reduced openings on exterior walls (Table 2). The ceiling was not insulated which probably accounts for the AER only being reduced to 6 to 8 air exchanges per hr. At LA-CREC, the addition of ceiling insulation reduced the AER to the recommended 1 air exchange per hr. With the new rooms at A. Duda & Sons of concrete block construction with canvas fronts, AER of less than one were achieved (Table 1).

Table 1. Values of air exchanges per hr determined by regression and graphical techniques before remodeling.

Location	Test condition	AER[1] (graphic)	AER[1] (regression)
LA-CREC	Vent closed	3.3±0.3	3.2±0.7
	Vent open	3.9±0.7	4.4±0.9
	Vent open +30 cm curtain opening	5.1±0.4	6.3±0.6
	Vent open +50 cm curtain opening	5.1±0.2	6.7±0.4
Haines City CGA	Vent open	16.5±2.1	19.8±6.2
A. Duda & Sons	Vent open	0.6±0.1	0.6±0.1

[1]Air changes/hr ($\bar{x}$ ±sd).

Table 2. Values of air exchanges per hr determined by regression and graphical techniques after remodeling.

Location	Test condition	AER[1] (graphic)	AER[1] (regression)
LA-CREC	Vent open-no fan	0.4±0.1	0.3±0.1
	Vent open	1.0±0.04	0.9±0.05
	Vent open +30 cm curtain opening	3.5±0.4	2.6±0.3
Haines City CGA	Vent open	7.8±1.7	6.0±0.7

[1]Air changes/hr ($\bar{x}$ ±sd).

With respect to data analysis, variation between the regression and graphic technique varied from ca. 0 to 25.7%. The largest disparity was noted in the LA-CREC test after remodeling with vent and curtains opened. The general first-order equation provided a curve-fit of high r^2 value in all cases. Values for r^2 ranged from 0.952 to 0.994. Advantage of the graphical technique is that it can be easily

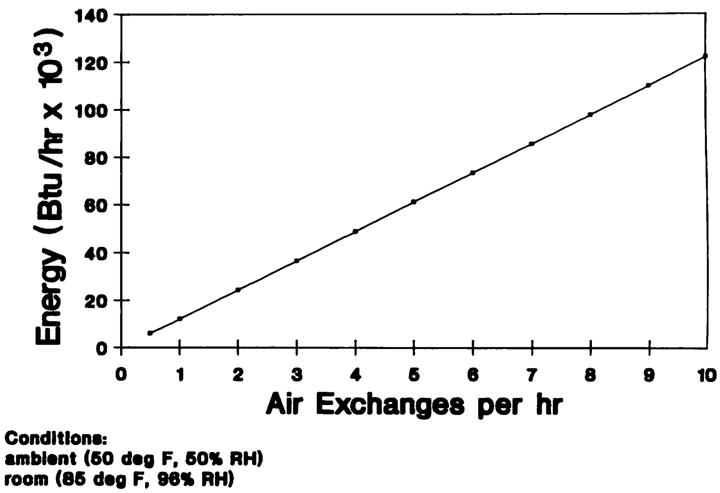

Fig. 2. Energy consumption requirement for makeup air as function of room air exchange rate based on a 100-pallet room size.

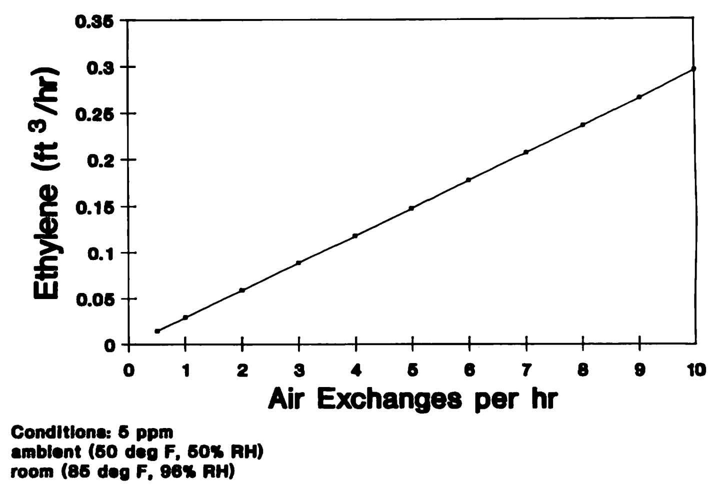

Fig. 3. Ethylene requirement as function of room air exchange rate based on a 100-pallet room size.

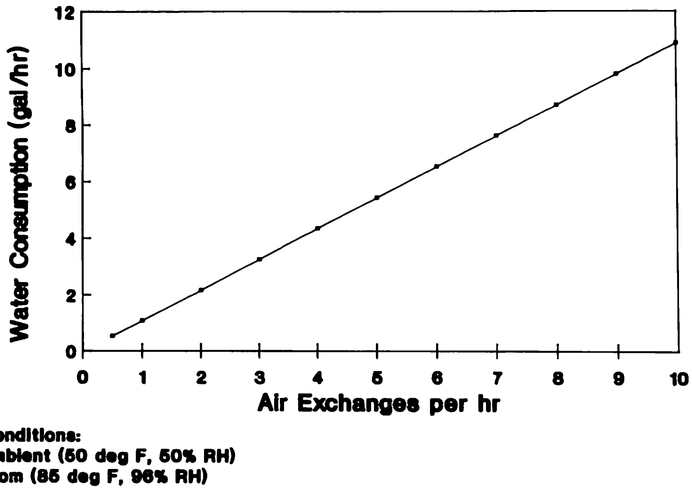

Fig. 4. Water consumption for humidity control as function of room air exchange rate based on a 100-pallet room size.

calculated immediately after the test to provide information to packinghouse management.

To assess the question of potential savings in reducing AER, a computer program (4) was used to calculate energy, humidity and ethylene consumption as a function of AER. These calculations were performed for a 100 pallet bin room for ease of extrapolation to other sizes. Consumption of ethylene, water for humidity control, and energy are presented in Figs. 2-4. All of these factors increased linearly with greater AER. For ethylene and water, the operating costs would be directly related to the AER. In the case of heating, the fruit load and exterior surface heat transfer constitute other major actors that must be added to the heating requirement established by the AER.

Conclusions

1. The air exchange rates in citrus degreening rooms can be measured by step function introduction of CO_2 and monitoring the decay rate of CO_2 to the background level.
2. Results from both pilot plant and commercial size rooms followed a first order decay model with r^2 values from 0.952 to 0.994.
3. Actual AER were as high as 20 air exchanges per hr before remodeling for older degreening rooms. Marked savings are possible when the AER is reduced to the suggested 1 air exchange per hr level.

Literature Cited

1. Gillespie, K. and B. L. Tugwell. 1975. New techniques for gas colouring rooms. Dept. of Agric. and Fisheries (South Australia) Bulletin 4.75.
2. Grierson, W. and W. F. Newhall. 1953. Degreening conditions of Florida citrus. Proc. Fla. State Hort. Soc. 66:42-46.
3. Grierson, W. and W. F. Newhall. 1960. Degreening of Florida citrus fruits. Univ. of Florida Ext. Bulletin 620.
4. Miller, W. M. 1986. Degreening room design program. Software Reg. No. TXU 251 909.
5. Sager, J. C., C. R. Hargrove, R. P. Prince, and W. M. Knott. 1988. CELSS atmospheric control system. Amer. Soc. Agric. Engrs. Paper No. 88-4018.
6. Sherman, M. and D. D. Gull. 1981. A flow-through system for introducing ethylene into tomato ripening rooms. Univ. of Florida Ext. Fact Sheet VC-30.
7. Wardowski, W. F. and A. A. McCornack. 1979. Recommendations for degreening Florida citrus fruit. Univ. of Florida Ext. Publ. 3-5M-79.

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PESTICIDE RESIDUES IN FOOD

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The Delaney Clause

In 1958 congress amended the Food, Drug and Cosmetic Act with the "Delaney Clause." The clause mandates that *NO* carcinogenic residues are acceptable in processed food. In 1958 our ability to analyze for residues in food was rudimentary. At that time "no detect" levels were in the PPM (parts per million) level at best. Today we can analyze at the PPB (parts per billion) and even PPT (parts per trillion) level. Clearly the Delaney Clause was aiming at a condition of "zero" risk.

Today EPA can allow some residues, if benefits out weigh risks. They are trying to institute a "Negligible Risk" concept. A negligible risk (in theory) would be a one in a million chance (or less) that an additional cancer (above background levels) could occur from the residue of a given chemical. If residues are below this level EPA is saying, at least in theory, that you do not have to do a risk vs. benefits analysis.

To understand this issue, we need to be familiar with the terminology (see also Fig. 1):

Tolerance: A tolerance is the maximum residue permitted in food for human consumption or in feed for livestock. This is not a health based standard as commonly thought. It represents the maximum residue that might occur at maximum application rates and timings allowed on a label. Actual residues usually are much lower because farmers seldom use the highest rates, do not use as often, and not all growers use the same products on all their produce all the time. Many risk-assessment-calculations, however, do make such assumptions.

Maximum Daily Intake: By combining the tolerance with a "food factor" (an estimate of the percent contribution of that commodity to the daily diet) you can calculate a theoretical MAXIMUM DAILY INTAKE for each commodity.

TMRC (Theoretical Max. Residue Concentration): This is the sum of all daily intakes of the pesticide in different commodities.

NOEL (No observable effect level): This is the highest dose fed in toxicological studies that does not cause some effect in test animals. The next highest dose may cause some effect.

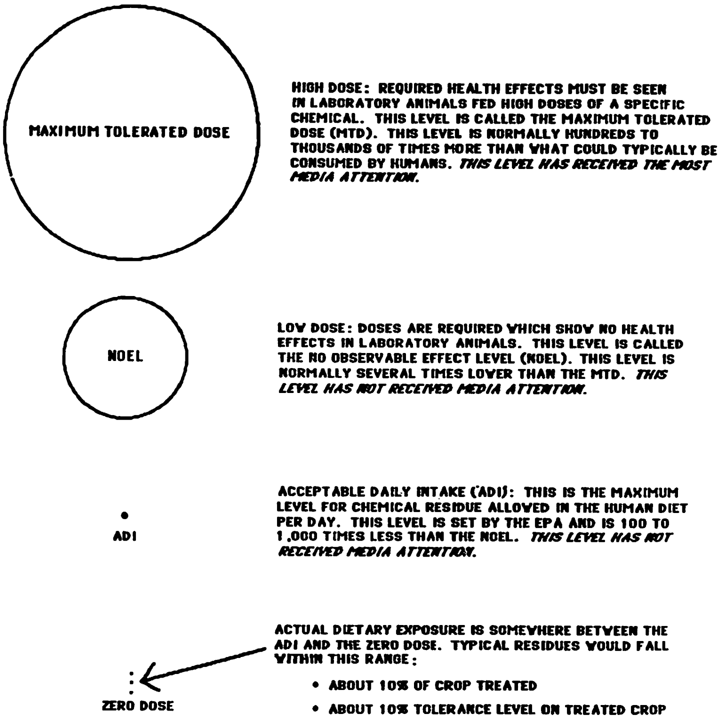

Fig. 1. Relationship of laboratory testing to dietary exposure.

ADI (Acceptable Daily Intake): This is the maximum level for a chemical residue allowed in the human diet per day. It is set by the EPA and is 100 to 1000 times less than the NOEL. A company such as DuPont can register new crop uses and tolerances until the theoretical max. residue concentration reaches the ADI for a non carcinogen or is estimated to pose an increased risk of cancer of more than 1 in a million.

Are Pesticides Needed?

So, are pesticides really necessary? We do not need to look very far to find proof of that. Without pesticides we could not produce the quality or the quantity that we do. As I said, our food is the safest, most abundant, diversified, and by far the cheapest in the world. We feed ourselves on 12 to 15% of our disposable income. Far less than any other country in the world, developed or undeveloped.

Recently agriculture in general and pesticides specifically have been receiving a great deal of attention in the press. The book "Regulating Pesticides in Food" was a NAS (National Academy of Science) report, subtitled "The Delaney Paradox," on food safety. The "Delaney Paradox" which is sort of a CATCH 22, ie. you must feed a chemical to a test animal until you get an effect but when you get an effect, you can't register the material. This book tries to establish the "negligible risk" criteria for processed and raw commodities. It was basically a policy statement but was misconstrued by some groups to advance policy agendas.

In June 1988 "Pesticide Alert: A Guide to Pesticides in Fruits and Vegetables" was published by the NRDC (Natural Resource Defense Council). This book identifies potential hazards with consumption of fresh produce. Credible, recognized science/regulator groups have reviewed this report and found it badly flawed. It makes inaccurate claims or totally ignores the tolerance assessment system.

This past summer the NRDC published, in a very well thought out and orchestrated media event, its report "Intolerable Risk: Pesticides in Our Children's Food." It developed worst case scenarios ignoring scientific facts. The report tries to correlate animal studies with actual numbers of future cancer deaths. It tries to correlate cancer and neurotoxic effects to intake of pesticides in food. The study is badly flawed: it selects data, and doesn't use a broad base of the scientific community as support but uses only one or two selected sources.

And television, in another fit of "consensus journalism" spent an inordinate amount of time on this issue. According to Dr. Bruce Ames, University of California, Berkeley, the "60 Min." staff used the show to advance their personal agenda and distorted or ignored scientific facts.

Its OK Mom, Apples are safe!

If all these terrible pesticides are causing so many cancers, why are we not all dying of cancer. Cancer rates for all types except lung and skin (due to smoking and increased sun exposure) are actually down or staying level over the last 50 years.

As often said, we are living longer, healthier and more productive lives. Our life expectancy is greater than ever before and still increasing.

But we are fighting people's perceptions. Seventy five percent of the public perceives pesticide residues in food as a serious problem. A Roper Poll ranks pesticides in food as the 5th most serious environmental hazard. And because of this increased public concern and awareness politicians, both state and federal, are now interested and extensive legislation is pending. Much of this legislation will be detrimental to agricultural productivity. As an industry, we must begin educating and communicating with both the public and legislators about how safe our food is and what a good job we do keeping it that way.

We need to make the public and the legislators understand that the risks to their health from pesticide residues is so small as to be negligible. As Dr. Ames has often pointed out, there are carcinogens in almost everything we eat, natural or otherwise, if we look at them at the parts per billion level. Certainly the benefits accrued from the fresh wholesome produce that is available to us, partially due to the judicious use of pesticides, far outweighs any minuscule risks that may be involved.

What are the key issues?

Several main issues are:
*Are products adequately tested?
*How are risk assessments done?
*What is negligible rksk?

The testing process is exhaustive. Extensive field and greenhouse trials are run to determine efficacy and even more extensive studies are run to determine toxicity and set tolerances. Most of these tests are mandated by the EPA. We exhaustively test new chemicals and with the reregistration process we are thoroughly reevaluating old chemicals.

"Exposure x toxicity = Risk" is a basic premiss of the toxicology. Since toxicity is stable, exposure determines the risk. We do hundreds of toxicity tests: Acute (one day), subacute (several days), subchronic (90 days) and chronic (mice and rat lifetime feeding studies for up to two years). In addition, we do trials to determine terratogencity (to see if exposure over several generations causes birth defects) and mutagenicity.

Through this exhaustive series of tests we determine a NOEL and from this ADI is determined. This is a difficult concept to understand especially for the non-scientific public. The NOEL receives very little attention in the press. Also, if our detections limits are 1 PPB and we get a "no detect" on a residue trial, EPA doesn't use "zero" in its' risk models but will use half of the "no detect," in this example .5 PPB, assuming that even if we can't detect it there is some there. This often adds, rightly or wrongly, to the Theoretical Max. Residue Concentration (TMRC) and therefore the ADI.

What does this ADI mean? Currently the ADI for Benomyl, for example, is about 67% used. Using this across all crops and uses the negligible risk level of Benomyl is close to, if not under the "1 in a million" guideline. However, when considering certain subgroups, like non-breast feeding infants, and using EPA's models, that calculation was over 1 x 10(–6). Removing post harvest labels from citrus, apples and stone fruits, three major contributors to the ADI for that subgroup, we have been able to bring the risk assessment under the safe level (1x10[–6]) across the board.

For older products, the ADI is used up more so than for newer products. Less than 1% of the ADI for a classic herbicide is used. However, due to the very low toxicity, low use rates and types of crops used on, its ADI may never be fully used.

So what does this mean? It means a pile of reports that would take a pickup truck to haul the data submission for one pesticide registration package. It represents all the data that were used to set use rates and tolerances. The tolerances were set using highest rates, maximum number of applications, highest possible market penetration and shortest possible PHIs (pre harvest intervals). All this, in addition to the safety margin built into the ADIs increases the safety margin. Additional safety accrues in the field because residues diminish after a commodity leaves the farm gate. This pile of data represents 5 to 10 years of work and upwards of $40 MM.

How is the industry doing in providing safe crop protection chemicals? How do we measure and document how safe we really are?

The main way, other than the rigorous registration mandated and overseen by EPA, is by sampling produce in the field. The California Dept. of Food and Agriculture has one of the most comprehensive field monitoring programs in the country. In 1988 they took over 13,000 random samples from fields before harvest, from wholesale markets, distribution sheds, packing sheds, retail markets and points of entry into the state. The samples were analyzed for over 100 pesticides at the PPB level and 80% of the samples had no detectable residues. Eighteen percent had residcues within legal tolerances and less than 2% were illegal or no tolerance established. This was twice as many samples analyzed as in 1987 but the results were about the same. Also the U. S. Food and Drug Administration checked over 14,000 samples and their results are the same as California's. Well over half had no detectable residues and less than 1% had residues over tolerance levels.

Many people ask "What about imported produce?" Both FDA and CDFA also test imported produce and the results are the same. Well over half the samples have no detectable residues and less than 1% have residues over tolerance.

Nationwide over 30,000 samples are analyzed annually by various producing states and the results are consistent with CDFA and FDA. We really do have safe food. There is adequate monitoring around the country to prove it, and also to monitor its safety in the future.

How Can We Build Confidence?

What can we, as an industry, do to reserve this trend of lack of confidence in agriculture? One of the most important things we can do is educate ourselves and others, especfially our non-ag neighbors, on the issues. We must disseminate positive information about our industry before further negative perceptions, due to lack of information, are formed. We must remind people that today one farmer produces enough to feed 53 U. S. citizens and 26 people abroad. We must recapture public confidence that food is safe.

In addition we must promote government regulatory agencies as diligent stewards of public safety. Currently, EPA, which is trying to do a good and balanced job is perceived by the public as being a "lackey" to industry. We know this is not the case but because of the perception the public has little confidence in what it says or does. This perception is used by the "Environmental Advocacy Groups" Like NRDC, (referred as "environmental terrorists" by Dr. Elizabeth Whelan, president of The American Council of Science and Health) to further their agendas, both politically and in the press. We must help reestablish faith in the government regulatory agencies.

As world population continues to grow at alarming rates, the production of food must become a world wide priority. We cannot do this by sacrificing our productivity to attain a state of zero risk. As Dr. Earl Butts, one time U. S. Secretary of Agriculture once said, "We must keep on risking." We must continue to get better at everything we do. We must continue to find new ways to produce more and better and even safer food. We can't allow unwarranted fears of "phantom" dangers to slow or stop progress.

In closing, I would like to leave you with this thought. A man with bread may have many problems, but a man without bread has only one!