lemon and Persian lime juices are presented in Tables 2 and 3, respectively. Enzyme activity in unheated lemon juice, pH 2.4 and pulp content 8.0%, varied from 10.1 to 10.9 units per gram of soluble solids.

Inactivation of pectinesterase in lemon juice heated to 155° F. was 68.3% for 12 seconds, 62.5% for 6 seconds, 17.3% for 3 seconds, and 15.4% for 0.8 second. Complete inactivation of the enzyme was obtained at 165° F. when heated to this temperature for either 12 or 6 seconds, 175° F. when heated for 3 seconds, and 185° F. when heated for 0.8 second.

Pectinesterase activity of unheated lime juices, pH 2.5 and pulp content 6.0%, varied from 12.9 to 17.1 units per gram of soluble solids. Persian lime juice used for determining inactivation of the enzyme in 0.8 second was extracted from a different lot of limes and had a pH 2.4.

Partial inactivation of pectinesterase obtained in lime juice heated to 155° F. was 83.6, 63.3, 32.9 and 31.0% with 12, 6, 3, and 0.8 seconds retention times, respectively. Complete inactivation of the enzyme in lime juice was accomplished by heating 12 seconds to 175° F., 6 and 3 seconds to 185° F., and 0.8 second to 190° F.

SUMMARY

Pectinesterase activities and total pectins were determined on the peel, rag, juice sacs, seeds, and juice of Villafranca lemons and Persian limes. The highest activity was found in the peel and the order of component parts for pectinesterase activity per gram of dry solids for lemon and limes, from highest to lowest activity, was found to be peel, juice sacs, juice, rag, and seeds.

The pectic content on dry solid basis was found to be highest in the rag for lemon and equally distributed between peel and rag for limes.

Relationships for heat inactivation of pectinesterase in Villafranca lemon and Persian lime juices with retention times of 12, 6, 3, and 0.8 seconds were determined. Complete inactivation was obtained at 165° to 185° F. for lemon juice and 175° to 190° F. for lime juice.

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IS THERE A PLACE FOR LEMONS IN FLORIDA?

A PANEL DISCUSSION

Recorded by HARRY W. FORD, *Moderator*

Florida Citrus Experiment Station

Lake Alfred

Moderator: Before 1894 the lemon industry in Florida was of considerable importance, but the severe freeze of that winter destroyed most of the trees and the industry never rebuilt since other citrus fruits were more dependable and profitable. At the present time, the production in the United States is confined almost exclusively to California. Is there a place for lemons in Florida at the present time? Ten gentlemen have consented to participate in this discussion and they are: Drs. Camp, Wenzel, Suit, Sites and Mr. Thompson and Mr. Hendrickson from the Citrus Experiment Station; Mr. Lawrence and Mr. Thor, University of Florida, Gainesville; Mr. Frank Chase; Mr. Walker, Florida Citrus Canners Association; and Dr. Roy, Minute Maid Corporation. Your moderator today is Harry Ford. Dr. Wenzel, what has been responsible for the talk about increasing the lemon acreage in Florida?

Dr. Wenzel: The consumer demand for frozen lemonade concentrate has resulted in an increase in the use of lemons and this has

been largely responsible for the recent interest in increasing the production of lemons in Florida. The demand has increased even though lemonade is used chiefly during the summer months. Production was started in 1949 in California and about 8,000,000 gallons were packed in 1952-1953. The quantity of lemons, now available in Florida for processing is extremely small with considerable variation in fruit quality. Florida concentrate plants could be easily utilized for the production of lemonade concentrate which, like limeade concentrate, does not conflict with the orange season. The financial return from frozen lemonade concentrate has been excellent in California up to the present time, which of course is also one of the reasons for the current interest in lemons in Florida. I would like to emphasize that prior to the planting of additional acreages in Florida, considerable thought should be given to the selection of lemon varieties that will satisfy processing requirements. Fruit size, juice, acid, Vitamin C content, flavor and quality of both the juice and peel oil are of utmost importance.

Moderator: Thank you, Dr. Wenzel, for telling us some of the reasons for the current interest in lemons in Florida. You indicated that the present supply is small and in talking with Zack Savage it would seem that the actual tree count is extremely small. Zack said the 1950 census showed the equivalent of only 322 acres of bearing trees scattered over most of the counties of the state. The yield was about 1¾ boxes per bearing tree. Dr. Sites, you have recently visited the lemon producing areas of California. How rapidly is California expanding production and what do growers think about the future in lemons?

Dr. Sites: My impression was that the number of lemon plantings is increasing. Although, the most recent statistical summary of Sunkist Growers shows that the total lemon acreage (bearing and non-bearing trees) has decreased about 7000 acres during the period from 1948-1949 to 1953-1954. Growers in Ventura County, which was one of the major lemon producing areas I visited, told me that about 1200 acres of new plantings had been made during the past year, while about 400 acres had been pulled, giving a net increase of about 800 acres in this specific area. Lemon plantings are increasing in the desert areas of both California and Arizona. I heard estimates of as many as 6000 acres of lemons were being planted in the Yuma area next year.

Most growers are rather pessimistic about Florida getting into commercial lemon production. Of all the people I contacted only two were optimistic, and felt there was plenty of potential market for both California and Florida. The general feeling is the lemon future is good if left largely in the hands of California.

Moderator: Getting back to Florida. Production problems are always an important phase of citrus culture. Fred Lawrence, you've been concerned with production problems of citrus. Is there anything peculiar about lemons, exclusive of diseases that make them more difficult to grow than, say, oranges, for example?

Mr. Lawrence: An important production problem is that of selecting a suitable location for the grove. Lemon production is best suited to the warmer, semiarid sections of the United States and other countries, where rainfall is light and the humidity low during a season when fruits are maturing. Florida lemon trees, because of our climate, have a tendency to develop fruits too large to satisfy current fresh fruit market requirements, and in our humid climate will not mature properly. However, with the renewed interest in lemons the processors might find the large size of Florida lemons an asset. With this in mind, prospective growers should select the warmest area possible for their future groves, as far as I can ascertain, the actual culture of lemons differs very little from that of oranges and grapefruit. However, I would like to emphasize that we know very little about the culture of lemons in Florida.

Moderator: Thank you, Fred. Let's get the lowdown on those production problems by talking with a grower who has grown lemons in Florida. Mr. Chase, could you tell us some of your experiences with lemons?

Mr. Chase: Dr. Ford, we have had at Isleworth about 100 trees of the Villafranca variety since 1914. All of the lemons have been on sour stock. Our lemons have all been for the fresh fruit market. The lemon market has determined largely whether the fruit was harvested or not. Some years they just were not worth picking. The quality has been good, but the size usually runs larger than

the market acceptance. Actually, the Florida fruit has all the aroma, acidity, flavor, of the California lemons. We have never had any certified budwood so that a gumming condition is present on all of our trees, and the lemons do not keep well. Trees seem to survive in spite of this disease. Scab, which has been often cited as a determining factor for lemons in Florida, has not been a problem with us. We have had scab on the sour orange sprouts but never on the lemons. In fact, we have never sprayed for scab. The same cultural methods have been used for lemons as for oranges. Lemons are more tender than oranges and need a more protected location. Our trees have been vigorous growers and bear in about ⅔ the time of an orange tree.

Moderator: Thank you Mr. Chase, for a most informative presentation of your experiences with lemons in Florida. Mr. Chase reported that his trees were infected with gumming disease. Dr. Suit, how important is the disease problem with lemons?

Dr. Suit: Scab early assumed commercial importance, however, scab is not uniformly serious throughout the citrus growing sections of Florida and might not be a problem on lemons in some areas. It is possible that a satisfactory spray schedule would control the disease. In general, the same type of diseases that are present on oranges in Florida would also be a problem on lemons. In the lemon production picture in Florida, diseases will be important and suitable methods of control will need to be used if lemons are to be grown successfully.

Moderator: Mr. Thompson, do you have anything to add concerning insects?

Mr. Thompson: Lemon trees are in the same category as other types of citrus as far as being susceptible to infestations of mites and insects. A heavy infestation of rust mites will prevent normal growth of young fruits, which results in a thick peel. Purple mites also infest lemon trees and may cause defoliation. Purple scale is a serious pest at times but where proper syrays are applied, an infestation is not likely to develop. Aphids have not been a serious pest of lemons in Florida.

Moderator: Mr. Chase stated that his trees were of the Villafranca variety. Dr. Camp, what is the present status of lemon varieties in Florida?

Dr. Camp: Prior to the big freeze, Florida had a small lemon industry and the Villafranca lemon was developed in that industry. Following the freeze, this appeared to be about the only lemon that would survive under Florida conditions and was generally used for dooryard plantings. Probably today practically all of the varieties grown in dooryards of the true lemons are the Villafranca, or some variant of the Villafranca type. Various people also have grown varieties from seed and you hear of the Genoa lemon and Sicily lemon, which are seedy lemons probably grown from seed of Italian lemons by someone and then propagated. It would appear at the present time the Villafranca or some selection of the Villafranca offers the most possibility, but we really know very little about lemon varieties in Florida and particularly about lemon varieties in relation to concentrate. Actually we have a number of strains of lemons which have been tested here that appear entirely adapted to concentrate, have a high content of acid in the juice, and a true lemon oil in the peel, the latter being a very important characteristic. The so-called Meyer lemon is probably only a hybrid and its oil is certainly not like lemon oil, and probably this variety should only be a stopgap in the lemon industry if it is developed in Florida.

Moderator: Thank you Dr. Camp. We still haven't picked the fruit. Mr. Thor, based upon your California experience, have you any comments on the cost of picking and handling lemons?

Mr. Thor: I think that the high cost of picking and transporting to the concentrate plant will be a good deal less than the California costs. At the present time, it costs the California grower approximately 75-80 cents a box to have his lemons picked and delivered to the packinghouse. Based on our rather detailed cost studies we estimate that we will be able to pick and deliver lemons to the processing plant for not more than 40-45 cents per box. This difference in delivering fruit to the plant is thus about 35 cents per box, a difference which probably will be very significant when the folks try to figure out whether or not they are making money in California compared to Florida. In California, the real

money in lemons is in the fresh fruit business. It seems to me that the price of lemons in California, which go into processing, either lemonade or concentrate, will have to get very low before the folks out there will cease to process lemons. In fact, the price will actually have to get below the price that it costs to process the lemons. I don't think we will eliminate California, although I do think that we may be able to get a sizeable part of the business.

Moderator: Mr. Thor has certainly pointed up a timely word of caution for those persons who claim that volume packs from Florida will put California completely out of the picture. We've now harvested the fruit and delivered it to the processing plant. As you recall, Dr. Wenzel sounded the key note that the demand for processed frozen lemonade concentrate was primarily responsible for the current interest in lemons. Mr. Walker, what is your opinion of the profitableness of lemons for processing?

Mr. Walker: Well, Dr. Ford, when enough lemons are produced in Florida for packs of frozen lemonade I think there will be a good demand for them. Consumers are now buying one can of frozen lemonade for every nine cans of orange concentrate. I think the sale of frozen lemonade will continue to increase. Florida can successfully compete with California on lemonade as well as it has competed with that state on frozen orange concentrate. Our costs are lower than California costs, and our freight to northern markets is less than California's freight. California is likely to determine the market value of frozen lemonade for some years because of its heavy pack. The wholesale price of California lemonade is about $1.25 per dozen six ounce cans f.o.b., and that by the way, is the lowest the price has been. Florida packs of frozen limeade have sold as low as 90 cents per dozen six ounce cans this summer, which, depending upon juice yield, will return the grower from $1.50 to $1.85 for a 90-pound box of limes at processing plants. Frozen lemonade, at the present price of $1.25 for a dozen six ounce cans, would return the Florida grower from $4.50 to $5.00 at processing plants for a 90-pound box of lemons. Plantings of lemons, could of course, be overdone. A few boxes go a long way in making lemonade. A box of lemons will make from seven to eight gallons of lemonade while a box of oranges makes less than one and a half gallons of concentrate. A cold summer in northern markets also could greatly lessen the demand for lemonade in any one year.

Moderator: Thank you, Mr. Walker. I understand that lemons have a wide range of uses, even finding their way into industrial products. Can you enlighten us on this subject, Mr. Hendrickson?

Mr. Hendrickson: Yes, Dr. Ford, the lemon is most suited to making a variety of by-products, probably more so than any other variety of citrus. For example, the high citric acid content of lemon juice has made it a very important source of this chemical. Over two million lbs. of citric acid or calcium citrate are made annually from this source. Lemon oil, another product, is usually the most profitable item recovered from the waste peel. It is considered to be a cornerstone, and since it is in strong demand at good prices it is usually extracted from every possible ton of fruit. Approximately 750,000 lbs. of lemon oil is produced annually in this country as a cold expressed or steam distilled oil. The peel of lemon has also been found to be one of the best sources for pectin. Approximately 2,000,000 lbs. of 100 grade pectin are produced annually, from this source. The use of lemon peel in dried form, as a dried citrus pulp for stock feeding, is an alternative to its use in the manufacture of pectin. Another market for lemon peel has been brined peel. It is used principally by the bakery and confectionery trade who use annually about 5,000,000 lbs. of this product. The picture, therefore, is rather bright for lemon by-products if the past is any measure of the future.

Moderator: That, I believe, covers the essential facts, from production to processing, as we understand them at the present time. Dr. Roy, what subjects mentioned in our discussion should, in your opinion, receive special emphasis.

Dr. Roy: There are two points, Dr. Ford, that I would like to emphasize. The first one is that every processing plant in the state is seeking means of extending its production season beyond that usually considered the limits of the citrus season—December to June. Availability of lemons in Florida would permit

plants processing lemonade or lemon juice to extend their operating season for an additional few weeks each year. This, in turn, means utilization of facilities during periods when they would otherwise be idle and spreading of overhead costs through a longer operating season. The net result is a decrease in unit cost of all products. Longer periods of employment of factory personnel of the seasonal category is highly desirable.

The other point is one of caution. Marvin Walker has properly pointed out that a 90 lb. box of lemons will make from 7 to 8 gallons of lemonade as compared to a yield of less than 1½ gallons of concentrate from a box of oranges. Further, the demand for frozen lemonade is highly seasonal and is only about 10% that for frozen orange concentrate. Caution in planting lemons is urgently needed. If thousands of acres of lemons are planted and brought into production, the market will become flooded and the value of lemons will drop to the vanishing point. This could be of serious consequence, particularly since lemons grown in Florida will probably not be too suitable for the fresh fruit market, but suitable mainly for juice uses.

Moderator: The remarks by Dr. Roy should be weighed carefully by those who are interested in the development of lemon production in Florida.

MEASUREMENT AND CONTROL OF COLOR OF ORANGE CONCENTRATE[1]

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Lake Alfred

Processors and purchasers are aware of the variations that occur in the color of frozen orange concentrates. Uniformity of color in these products within practical ranges is desirable. If a processor is to include color measurements in his quality control program, then dependable methods for the determination of the color of orange concentrates are necessary.

A recent book by Judd (8) is a good source of information on the complex subject of color and its measurement. Munsell (11) or Maerz and Paul (10) notations, based on subjective methods (12), have been extensively used in the past to describe the color of food products. Eastmond (3) and recently Slater (15) have pointed out the trend to the utilization of instruments for measuring objectively the color or color differences in products and have discussed some of the types of instruments now available. The use of various instruments, including the Beckman quartz spectrophotometer, the Hunter Color Difference Meter, and the Photovolt Reflection Meter, for color measurement of tomato products have been investigated by Younkin (17) (18), Kramer (9), Buck and Sparks (1), Robinson et al. (13) and Desrosier (2).

A study of methods and instruments for specifiying the color of frozen strawberries was made by Shah and Worthington (14). Investigation of the use of the Photovolt Reflection Meter to measure the color of unclarified juices, including 10 samples of citrus juices, was reported by Worthington et al. (16). The Munsell notations for samples of canned orange or grapefruit juices, which were calculated by these authors from Photovolt reflectance readings, do not correspond exactly to colors usually typical of such juices. Huggart and Wenzel (5) recently reported on the use of the Hunter Color Difference Meter to determine color differences in orange, grapefruit, and other citrus juices and concentrates. They pointed out that this instrument was satisfactory for measuring color differences in these products, but that the Munsell color notations derived from these measurements did not correspond to colors that would match exactly the visual colors of the citrus juices used.

The purpose of this paper is to present and discuss information obtained when several instruments were used to measure color differences of over 200 samples of orange concentrate that were collected from Florida plants during the 1953-54 season. The authors used a Hunter Color Difference Meter to obtain most of the data presented, but also included

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