ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 1997 - December 31, 1997

PROJECT TITLE: Rice Utilization and Product Development

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

1. PHYSICOCHEMICAL PROPERTIES: The objective of these experiments was to determine physical characteristics of rice starch using instrumental methods and relate them to eating and cooking quality. Instrumental methods that require small samples of rice resulting in objective characteristics would be useful to breeders and producers of rice to meet customer specifications. The experiments performed were characterization of rice samples collected the previous year using newly developed methods. Rice starch structure was characterized by size exclusion chromatography in dimethylsulfoxide (DMSO) to separate the different forms of starch (amylose and amylopectin) and laser light scattering detection to determine the size and shape distribution of the starch molecule. New separatory columns were evaluated and improved the separation of the starch types. Common starches used in the food industry as well as Calmochi were characterized and these results compared to published results.

Experiments were performed to determine the cooking characteristics of California rice after storage. A new viscoamylographic method developed by this project in 1996 that is more precise and requiring 100 mg of sample was utilized. California rice varieties from the 1996 and 1997 crops provided by the field station were/are being analyzed at timed intervals. The same rice samples are also being evaluated for consumer textural properties such as hardness, stickiness, toughness, optimum water to rice ratios, 1hr and 24 hr characteristics, and others. Koshihikari and akitakomachi are being used as reference materials for Japanese rice varieties. The problem of storage effects on the eating texture of rice are also being evaluated for the two crop years.

1. NUTRITION: The objective of this experiment is to determine if rice bran contains additional antioxidants that reduce aortic fatty streaks that progress to atherosclerosis in test animals. We have shown that two antioxidants found in cereal brans, vitamin E and catechin,

reduce aortic fatty streaks in test animals at levels normally consumed by humans. Rice bran contains all the known forms of tocopherols and tocotrienols of which alpha tocopherol or vitamin E is the most well known. Tocopherols and tocotrienols are chemical antioxidants and retard free radical reactions. USDA and UCD have developed an animal model that is similar to humans in the manner in which cholesterol is metabolized and in which atherosclerosis develops. This animal model has higher proportions of low density lipoprotein (LDL) cholesterol like humans and the develops fatty streaks in the aorta that evolve into atherosclerosis. Other animal models were unable to demonstrate this effect due to the low levels of LDL and high levels of high density lipoprotein (HDL). In this experiment, the content of vitamin E was determined in the different rice ingredients. Twelve hamsters were fed the diet inducing high LDL cholesterol. The diets contained stabilized full fat rice bran, defatted rice bran, rice bran oil, vitamin E at three levels, or catechin. The study was designed to determine if vitamin E as well as other fat soluble, solid and water soluble antioxidants unique to rice bran reduce aortic fatty streak formation.

SUMMARY OF 1997 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

1. PHYSICOCHEMICAL PROPERTIES: The method developed by this laboratory to determine the molecular size and shape of cereal starches was recognized as a significant accomplishment and awarded an outstanding paper award at the national meeting of the American Association of Cereal Chemists in October 1997. The characterization of cereal starches, including rice, is difficult due to incomplete solution and extremely large molecular size. The appropriate combination of DMSO stable size exclusion column, reagents and light scattering detector was used to demonstrate that rice varieties developed by the Experiment station have different forms of starch indicating that at the molecular level the main component of the rice grains are different. An example of this type of rice starch characterization is shown in Fig 1. L203, M202 and S102 are compared. Each rice starch profile has two peaks. The peak at the right is amylopectin, the major form of starch in rice. The profiles show distinct differences between varieties. The objective is to relate these structural characteristics to eating quality and texture.

The viscoamylographic study of stored rice samples show a systematic change upon storage. Due to the increased precision of the viscoamylographic method, storage changes in the gelatinization of the rice starch is clear, as shown in Fig. 2. The trapezoid line at the top indicates the temperature whose scale is to the right. The temperature starts at 45 °C and rises to 95 °C. The starch is suspended in water and as the temperature increases the starch granules swell and the viscosity increases. Increasing size and stability of the granule results in higher peak viscosity. The higher peak viscosity may be related to increased cooking times and changes in texture.

The same samples evaluated by viscoamylography were evaluated for eating quality by the single kernel rice kernel texture analyzer as shown in Fig. 3A. Each similar shaped point represents one of ten kernels evaluated. The vertical axis indicates hardness and the horizontal axis indicates stickiness. The hardness/stickiness measurements for M202 and M401 indicate that they are similar to Koshihikari, hardness = 1.47, stickiness = 0.32. The measurement is made again 24 hrs later, Fig. 3B. M202 becomes harder and stickier, whereas the hardness of M401 remains the same, but stickiness increases slightly.

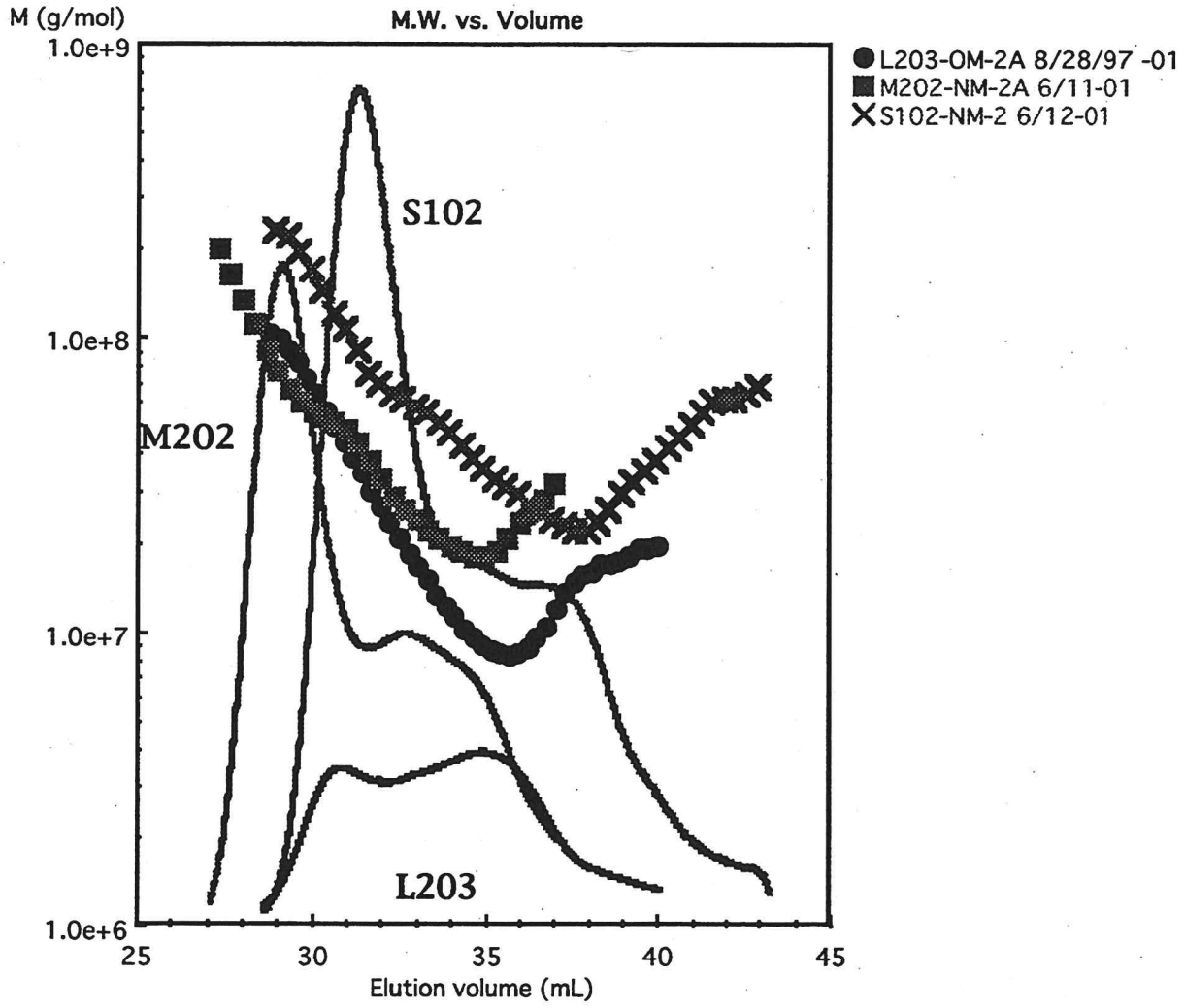
2. NUTRITION: The two month feeding phase of the study to determine the effect of rice bran and oil on aortic lesion formation study was completed in November. Blood plasma analysis has been completed. Unexpectedly, the crude rice bran oil diet reduced plasma cholesterol, the other diets were not different from the vitamin E controls. This may be due to binding of cholesterol in the diet by components of the oil. These components may not be available for binding in the intact rice bran. The cholesterol was dissolved in the rice bran and other fats prior to mixing with the solid ingredients. The aortic arch and heart were removed and preserved in formalin. The arches have been cleaned and will be stained and photomicrographed in Dec. 1997. Tocopherol and tocotrienol analysis of the plasma is expected to be completed early in 1998.

PUBLICATIONS OR REPORTS:

1. Yokoyama, W. H., Renner Nantz, J. J. and Shoemaker, C. F. Starch molecular mass and size by size exclusion chromatography in DMSO/LiBr coupled with multi-angle laser scattering, Cereal Chem. Submitted for publication.
2. Xu, R., Yokoyama, W. H., Irving, D. W., Rein, D., Walzem, R. L., and German, J. B. 1997. Effect of dietary catechin and vitamin E on the hypercholesterolemic hamster. Nutr. Res. Accepted for publication.
3. Rein, D., Yokoyama, W. H., Xu, R., Walzem, R. L., and German, J. B. 1997. Dietary vitamin E in an atherogenic hamster model. Nutr. Res. Accepted for publication.
4. Yokoyama, W. H., Renner-Nantz, J., and Shoemaker, C. F. Molar mass and size of cereal starches by LiBr//DMSO size exclusion chromatography and light scattering. Annual Meeting of the American Association of Cereal Chemists, San Diego, Oct. 1997.
5. Ibanez-Carranza, A. M., Yokoyama, W. H., McKenzie, K. S., and Shoemaker, C. F. Precision viscoamylographic measurements of rice starches and waxy corn starch. Annual Meeting of the American Association of Cereal Chemists, San Diego, Oct. 1997.

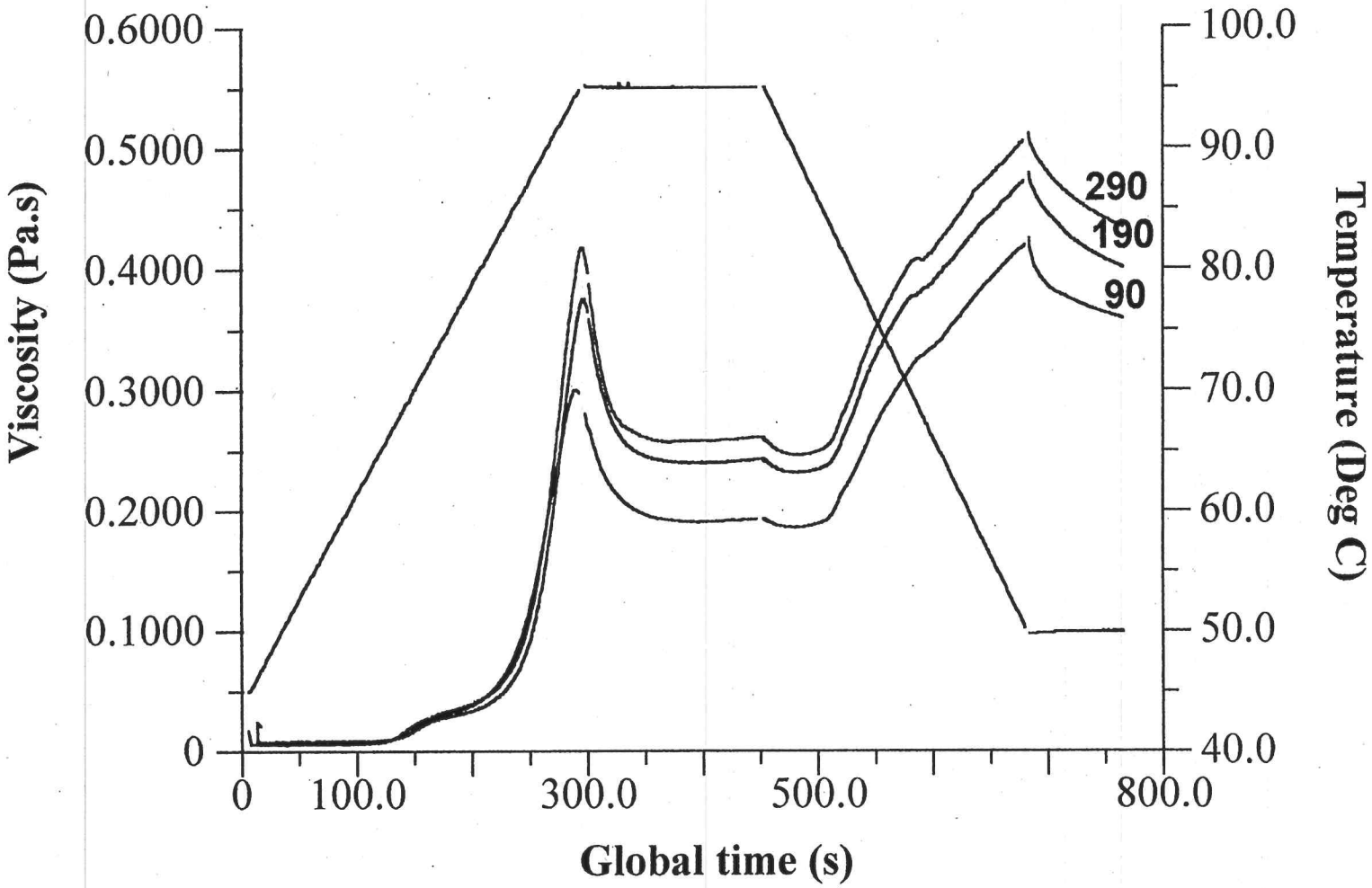
CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

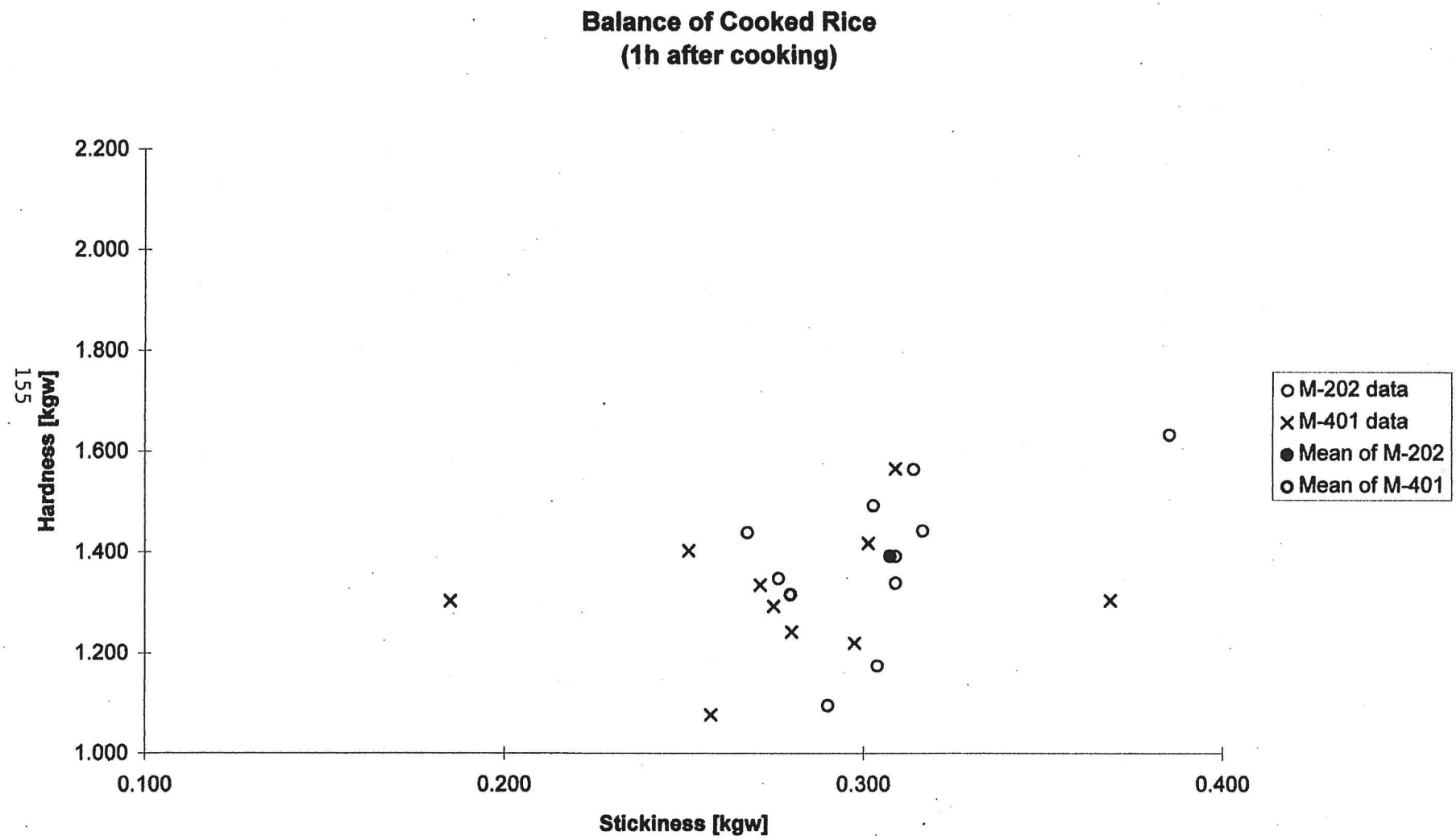
The determination of eating quality characteristics of California rice varieties and their relationship to instrumental methods of texture measurement and the molecular structure of their principal component, starch, were conducted for the crop years 1996 and 1997 (ongoing). Varietal differences can be determined at the molecular and cooking stages using DMSO/LiBr chromatography with light scattering and precision viscoamylography, respectively. Both methods were developed by this project. Single kernel texture analysis as a means of characterizing and comparing varieties and lots to standards has been used in Japan and is being used to characterize California rice varieties. Rice bran oil was shown to improve plasma cholesterol levels in test animals with human type LDL profiles, and the effect of unique rice components on aortic lesions will be completed in 1997.


M (g/mol)
M.W. vs. Volume
1.0e+9
1.0e+8
1.0e+7
1.0e+6
25
30
35
40
45
Elution volume (mL)
S102
M202
L203
L203-OM-2A 8/28/97 -01
M202-NM-2A 6/11-01
S102-NM-2 6/12-01

96-M202-NM Flour Viscosity Profile Analysis

Storage experiment at room temperature 90, 190, 290 days after harvesting




Balance of Cooked Rice
(1h after cooking)
Hardness [kgw]
2.200
2.000
1.800
1.600
1.400
1.200
1.000
0.100
0.200
0.300
0.400
Stickiness [kgw]
M-202 data
M-401 data
Mean of M-202
Mean of M-401