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THE PROCESSING SYSTEMS OF MANITOBA LAKE AND PADDY WILD RICE

BY

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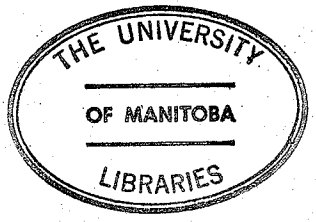

TO MY PARENTS

ABSTRACT

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Jimmy K. Chung

Colour, flavour, percent breakage and cleanliness are the main criteria for judging the quality of finished wild rice. The present study is an attempt to investigate some of the problems in the wild rice industry today. The study was designed to evaluate the optimum processing system for Manitoba lake and paddy wild rice. Results indicated that good quality wild rice was obtained when low temperature curing and parching processing were used. In addition, the hulling study indicated that extended curing periods and hulling after storage would increase the breakage of the rice. Above all, the percent yield can be maximized if the processing system is carefully controlled. The flavour characteristics of wild rice were also investigated in this study, and 24 sensory characteristics were identified. Specific sensory characteristics such as swampy odour, mouldy and strong, earthy taste and mushy texture were noted to be the main factors which contribute to unacceptability of finished wild rice.

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I. INTRODUCTION

Wild rice is an aquatic cereal, native to North America. The species common to Manitoba are annual pollinated grasses. This rice has been used by Indian Tibes of the tall grass prairie region as a staple food for over 300 years. Paddy production of wild rice was not started until the white man decided to expand the wild rice industry in the mid-1960's. Since then, the production of paddy rice has increased to two or three times that of the lake wild rice. Wild rice, including its several varieties has an extensive distribution in eastern North America, reaching from the northern end of Lake Winnipeg eastward along the northern shores of the Great Lakes and the St. Lawrence river to eastern New Brunswick, from the central Dakotas, western Nebraska and eastern Texas, to the Atlantic Ocean, and along the coast as far as central Florida (34,33). Among these areas, Minnesota, Manitoba, Wisconsin and Northern-Western Ontario are estimated to have the highest production.

Wild rice is a nutritious food when compared to the other cereal products. Wild rice is relatively high in protein and low in fat content (33). The first recorded analysis of wild rice was made in 1862 by Peters (6,29) who reported that the seed contained 6.71 percent of protein, and was made up of 12 percent hulls and 88 percent hull free kernels. Woll, in 1899 (6,37) stated that wild rice was richer in both protein and nitrogen-free extract than other cereals and hence should have a higher food value. The protein content of the wild rice sample studied by Woll averaged about twice that reported by Peters. Kennedy, in 1929 (20) showed that wild rice resembled other grains by the fact

that it was relatively rich in vitamin B and relatively deficient in vitamin A and some other minerals. In 1942, Nelson and Palmer, (28) further showed that parched rice could be regarded as a good source of thiamine, riboflavin and nicotinic acid. Recent studies (15,12) showed that 100 grams of raw wild rice contained 353 calories, 6.2 mg of niacin and 14.10 gm of protein.

At the present time, wild rice is no longer used as a staple food by the Indians, however, it still remains as a most important supplementary food and a source of much needed income for them. The price of the rice has been raised from 10 cents a pound before the First World War to approximately $6.00 per pound in 1972 (36). Due to the high cost, not many people can afford to consume the rice. In spite of this, the white man has introduced about 45 recipes for the preparation of wild rice, ranging from game-bird stuffings to tempting desserts (33). The common way to prepare wild rice is by cooking it in boiling water until the rice becomes tender.

In the wild rice industry today, quality standards have not been established for the finished product. Wild rice that appears on the markets usually has a poor appearance, lacks proper colour and is without a standard grading size.

The present study examines the different methods of wild rice processing and has the following purposes: (a) To evaluate the different methods of wild rice processing by using different periods of time and temperatures. (b) To determine which method will improve the overall quality of the finished wild rice. (c) To study the effect of curing and parching on the yield and ease of hulling of wild rice. (d) To characterize the flavour of finished wild rice.

II. LITERATURE REVIEW

Carr (6,9), in 1895 reported that wild rice served the Indian both as food and revenue; hence was of great importance to the various tribes of the Great Lakes region. Although the Indian had started to process wild rice many years ago, there was no literature written about their skill of practice and the economic importance of wild rice production. The earliest literature and records indicated that extensive harvesting of wild rice has been carried on for only three to five hundred years (33). This source of information was based on the culture of some Indian tribes. When white man migrated to the wild rice regions around the mid-18th century, records revealed that he had to depend upon this crop as a staple and winter food. Before the 20th century, the Indians harvested the rice, hand processed the crop and sold the finished rice to the white man. However, since the turn of the century, the white man has started to harvest and process wild rice.

An increased demand for the product since World War I has placed a much higher requirement on production. Mechanical harvesting methods and semi-mechanical processing methods were introduced. There has been a greatly increased production of wild rice in the past two decades especially after the wild rice industry was modernized by utilizing paddy production. The first true commercial paddies were developed in Minnesota in 1964, and since then, the paddy development expanded rapidly into Wisconsin, Manitoba, and some areas in Ontario, Saskatchewan, Alberta and Michigan. Paddies are usually built in those regions where wild rice grows naturally. After ten years of paddy production, problems such as lateness of maturity, susceptibility to helminthosporium disease and uniformity of type and non-shattering of seed are still troublesome

for the growing of paddy wild rice (5).

2.1. Methods of wild rice processing.

Harvesting of wild rice usually takes place in late August and can be done either by hand or by machines. Two or three gatherings are made during the harvesting season, extending over a period of 15-20 days. After harvesting the wild rice has to be processed before it becomes a marketable product. The purposes of processing wild rice are to change the overall quality and yield of the rice as well as to allow the final product to have a longer storage life.

All methods of wild rice processing include the following steps:

(a) Curing: A stage in which the immature grains are allowed to pass into a riper stage of maturity. Many soft grains become firm accompanied with the development of a darker colour (14) and product flavour is enhanced. The degradation of hulls through curing will facilitate hull removal in the later stage of the process (13). During the curing period, the rice kernels not only change their colour but also become less fragile (35). Curing can be done by spreading the rice on the floor in open air or by storing it in a controlled atmosphere. The former one is called natural curing and the latter one is called controlled curing.

(b) Parching: In this second stage of the process, all the chemical, physical and biological changes that have been taking place in the rice during the curing procedure will be stopped by this drying process. The purpose of parching is to lower the moisture content of the rice to an acceptable level which is between 7%-10% moisture content. This level of moisture content will help the rice to have a longer shelf life and

a higher hulling efficiency. Like curing, parching will also effect the fragility and flavour of the product (13).

(c) Hulling and cleaning: Hulling is a process that separates the outer hull from the hard rice kernel. After parching, the kernels are firm and hard and lie loosely within their dry and brittle hulls. It is the rubbing and beating action that separates the hulls from the hard kernels. Different machines have been designed to hull rice and they all follow the same principle. During this process, breakage and scarification will occur in the rice. Care must be maintained when operating the hullers, because breakage of rice will cause a lower yield of head rice (whole rice) and scarification of rice will change the cooking characteristics of the rice (35). The hulling and cleaning process takes place at the same stage. Once the hulls are separated from the rice kernels, a counter-current air stream blows the hulls off into a collecting pan.

2.1.1. Old methods of wild rice processing.

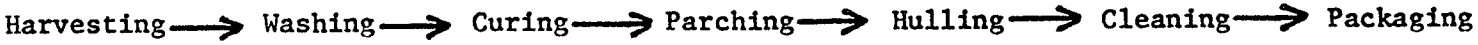
In the past, harvesting and processing of wild rice were done by the Indians. Their methods of processing were simple, primitive but practical. No mechanical method was involved. During the curing process, the freshly harvested grains were allowed to dry under the sun. In some Indian tribes, curing was done by means of small fires (6,18). After this process, the dry grains were kept until it was convenient to do the parching. When parching, a small amount of rice was put into a copper or iron kettle over a small fire and heated rather strongly for 15 minutes to half an hour until the hulls became dry and brittle. The rice was stirred from time to time with a wooden paddle so as to prevent any rice being overheated. The rice was allowed to cool after parching.

It was then placed in shallow holes lined with clay and with animal skins around the side to serve as a mortar. A man who acted as the pestle would stand on the rice and tread the rice by a rhythmic movement of his whole body coupled with shuffling of the feet. This action caused the rice to rub against one another and the husks were then rubbed off (34). Different Indian tribes used different processing methods. However, the idea was the same.

2.1.2. Current methods of wild rice processing in Manitoba.

In the present wild rice industry, the techniques of wild rice processing are highly varied. Each processor has developed his own technique and designs his own equipment for the process. In Manitoba, the equipment used by the different processors are similar. Harvesting of wild rice is mostly done by the Indians from a nearby reserve. In certain areas of Manitoba such as Lac du Bois, machines have been constructed to do the harvesting (14). The freshly harvested wild rice is packed in cloth bags and transported to processing plants for immediate processing (Figure 1). Curing of wild rice takes place in open air. The green rice is spread out on the ground piling up to a height of about one to one and a half feet. Some processing plants even pile up the rice to a height of about three feet so as to accelerate the curing process. During curing, the rice is turned over or stirred at least once a day and water is added to the rice frequently. The purpose of doing this is to prevent any heat accumulation in the rice bed. The temperature of the rice bed usually ranges between 37.7 C to 48.8 C depending upon the bed depth. The rice is then kept under natural conditions for a certain period of time until the rice turns to a darker colour.

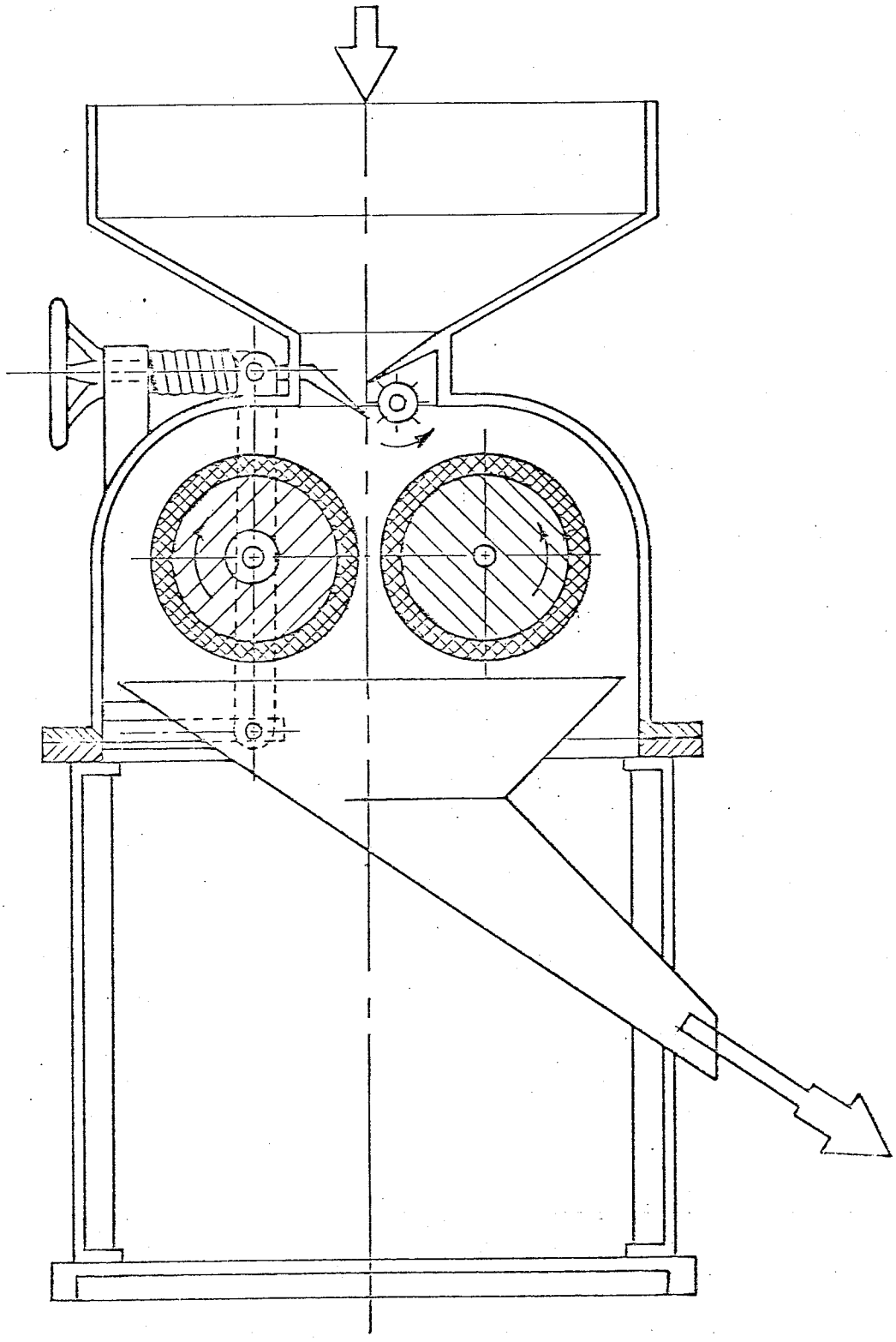
Figure 1. A Flow Diagram on Wild Rice Processing



After curing, the rice is parched in ovens which are cylindrical in structure. Gas heating is applied from below. The oven rotates during parching to provide agitation of rice so that certain portions of the rice will not be overheated. Upon completion of drying a conveyor belt carries the parched rice from the oven to the huller. The huller is also a cylindrical container mounted in a stationary position and the axle of the huller to which flails covered with pieces of rubber hose are attached, is rotated by motor power (14). The speed of the flails is carefully adjusted, so that breakage of the kernels caused by hulling can be minimized. The beating action of the flails on the rice and the rubbing action between the rice causes the hulls to be separated from the hard kernels.

Another type of huller, which is not currently used in Manitoba, is the Kyowa huller (Figure 2). This huller is manufactured in Japan and is designed for hulling white rice (31). In 1971, this huller was effectively adapted to the wild rice industry (30). Referring to Figure 2, dried rice gravity-feeds down between rubber surfaced rollers which turn in opposite directions and at different speeds. The pressure between the two rollers is regulated by a pneumatic cylinder and can be varied. This is one advantage for using this huller, because different varieties of rice require different shelling pressures. The efficiency of the huller is about 92% (31).

After hulling, the rice is cleaned and size graded by the normal seed-cleaning operations adapted from the grain industry. The average yield for Manitoba wild rice is 40%-45%. This percentage indicates that 40-45 lbs. of finished wild rice is obtained from 100 lbs. of green rice. The average for paddy wild rice is 10-20%. Although the present methods of wild rice processing are accepted commercially, some



KYOWA HULLER

FIGURE 2

ADDAPTED FROM RICE CHEMISTRY AND TECHNOLOGY

improvements in both the equipment and techniques are required if production and quality of wild rice are to be improved.

2.2 Laboratory research on wild rice processing.

Since the mid-1960, people have paid more attention to the quality of finished wild rice than ever before. Workers from various Universities have recently started research on wild rice processing and have tried to establish a standard processing method to improve the quality of the final product. The expectation is to produce a uniform final product which will satisfy the consumer demand. The University of Wisconsin started the research on wild rice processing in 1969. The specific goal of their research was to provide a better economic base for the people of the wild rice region through a sound product, processing and marketing program (35). Their program is still continuing.

2.2.1. Curing studies

The University of Wisconsin team initiated studies on the curing of wild rice. They tested three systems, namely, the dry, wet and cooler methods (35). Wooden bins were used to store the rice during curing. Their results indicated that the wet method showed a small increase in yield during curing, while the yield for the dry and cooler methods remained constant except for a slight decrease in the fifth week. Extended curing for all treatments resulted in decreased yield. This was due to excessive slimy formation which led to caking of the rice on the surface of the parcher and resulted in kernel damage through scorching and popping. In addition, respiration of the rice, microbial degradation and kernel fragility contributed to the loss.

After three years' study on curing, they found that the dry method and non-turning of wild rice during curing could not be recommended because of the development of an excessive amount of mold and kernel damage which occurred during extended storage. This led to severe off-flavour and a potential mold-toxin health hazard in the finished product. The wet and cooler methods produced acceptable finished rice. An exception was noted for paddy-raised non-shattering wild rice which developed an excessive amount of slime during the ambient wet method of curing. It was suggested that the use of cooler methods (50^{o} F, 10^{o} C) for curing was beneficial in slowing down the rate of microbial action. This delayed the onset of kernel degradation and thereby extended the optimum processing time for wild rice. They further pointed out that microbial action began to degrade the protective hull after a period of time. This depended on the temperature and moisture content of the fermenting pile. Rapid degradation occurred at a high temperature and moisture. The partially degraded hulls became easier to remove during hulling, thus increasing yields by reducing kernel breakage in the huller. As curing progressed a point was reached where the microbes actually began to penetrate and to degrade the kernels themselves. This caused the kernels to become more fragile, and resulted in easily broken and pulverized kernels during hulling. The net result was a decrease in yield (35).

In 1972, they started using a controlled environment chamber for the curing of wild rice (13). This was an attempt to control the temperature and relative humidity of the environment through-out the entire period of curing. Metal bins were used to hold the wild rice for curing. Ambient temperature (cycled between 10^{o} C and 27^{o} C) and cooler temperature (10^{o} C) were used along with a constant relative humidity

of 95% (13). Data showed that the yield of wild rice cured at ambient conditions decreased progressively through the five weeks' curing while the yield of the cooler stored sample remained relatively constant for the first two weeks and then progressively decreased. Their yield data appeared to be in agreement with years past. However, a difference in pile temperature was observed between the two studies. A relatively higher pile temperature was recorded in the curing studies of 1970 and 1971 while, in 1972's curing study, a relatively lower pile temperature was observed. The reasons were due to the immaturity of the 1972 rice and improved aeration of the 1972 rice during curing. Other changes such as colour and odour were observed in the curing rice (13). Lake rice was darker initially than paddy rice and continued to develop darker kernels much faster than paddy rice. Swampy odours were detected during the later stages of the curing process.

The main objective of the 1973 study at Wisconsin was to evaluate the different techniques that could be used to extend the curing time for wild rice (29). One important result was the report of botulism-type organisms on the rice pile cured under an anaerobic condition. Their results indicated that aeration was an important factor for curing. It did not only effect the pile temperature of wild rice but also the pH of the rice. Both temperature and pH affected the type of micro-organisms found on the rice.

Kernel fragility is one of the main factors that effect the quality of wild rice. It was found that the length of the curing time did not markedly affect this factor. Freezing treatment before curing, however, increased kernel fragility (29). This was due to stress development during rapid freezing.

The Wisconsin study demonstrated that the temperature used in the

curing process and the length of time that rice is held in curing storage will affect the yield of finished rice. Their data indicated that the percentage yield of rice cured at a lower temperature will have its percentage yield decreased in a slower rate than rice cured at a higher temperature (29).

2.2.2. Parching studies

Parching studies on wild rice have been carried out at the University of Wisconsin since 1970. The purpose of their studies was not only concerned with how to dry the rice in the least possible time, but also with how to obtain the maximum whole rice yield after hulling (13). Their studies indicated that the design of the parchers, drying time and temperature effected the quality of the final product.

Wild rice was susceptible to popping and fragile kernels resulted if the rice was not agitated during parching. In addition, rice cured for an extended period of time was easily burnt if a temperature of 82.2^{o} C or above was used. Their data on wild rice texture indicated that scorched or burnt rice took up water faster during cooking. This change of cooking characteristics altered the texture of the cooked rice (13). Paddy rice was the most difficult among all the types of wild rice to parch. An advantage of parching, as reported by the researchers, was that it weakened the hulls of wild rice through scorching and thus promoted easier hulling (6).

Results of the 1972 studies demonstrated that the yield increased as drying time decreased (13). However, the high rate of drying was not considered a good method for practical purposes (4). The advantage in using this method was that it turned out a large volume of grain in a shorter period of time even when using a small holding capacity dryer (4).