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EFFECTS OF ALKALINE-STEEP TREATMENT ON THE MALTING PROPERTIES OF TWO NIGERIAN RICE CULTIVARS

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ABSTRACT

The effects of the alkaline-steep treatment on the malting properties of two Nigerian rice cultivars (WitA4 and SPP1) were investigated. The germinative capacity of 96.0% and 97.0% respectively showed that both cultivars had good malting potentials. Malts were produced from the cultivars after steeping 200grams of each rice cultivar in 1000cm^{3}of 1.0% solution of calcium hydroxide ($Ca(OH)_2$), sodium hydroxide (NaOH) and potassium hydroxide (KOH) for 48 hours and germinating for 5days. The results of the cold water extract, hot water extract and diastatic power of WitA4 $Ca(OH)_2$-derived malt were 41.5%, 220^{o}L/kg and 34.0^{o}L respectively, the Wita4 NaOH-derived malt had cold water extract, Hot water extract and diastatic power of 31.50%, 192.^{o}l/kg and 28^{o}L respectively. The Wita4 KOH-derived malt had cold water extract, hot water extract and diastatic power of 15.54%, 181.95^{o}L/kg and 12.0^{o}L respectively. The cold water extract, hot water extract and the diastatic power of SPP1 $Ca(OH)_2$-derived malt were 32.50%, 208^{o}L/kg and 28.0^{o}L respectively, while the cold water extract, hot water extract and diastatic power of NaOH–treated SPP1 malt was respectively 26%, 189^{o}L/kg and 24^{o}L. The SPP1 KOH-treated malt had cold water extract, Hot water extract and diastatic power of 12.20%, 151.95^{o}l/kg and 11.80^{o}L respectively. The WitA4 untreated malt sample had cold water extract, hot water extract and diastatic power of 26.0%, 192^{o}L/kg and 16.0^{o}L respectively while SPP1 untreated malt had CWE, HWE and DP of 26%, 188^{o}l/kg and 14^{o}L respectively. The overall results have shown that calcium hydroxide-treated malts had the highest value of cold water extract, hot water extract, and diastatic power, followed by sodium hydroxide-treated malt,the control sample and the least, the KOH-treated malts in both WitA4 and SPPI rice malts. The analysis of variance (ANOVA) of the values obtained from the malts showed that the cold water extract, hot extract and diastatic power of the malts was significantly ($p<0.05$) dependent on the nature of alkaline liquor, cultivar type and their possible pair-wise interactions.

Keywords: *Alkaline steep treatment, rice cultivars, cold water extract, hot water extract, diastatic power.*

INTRODUCTION

The quest for the total indigenization of the raw materials base for brewing operations in Nigeria has compelled many scientists within and outside the brewing sector to embark on innovative research relative to the needs of the industry. In various researches on our local cereals, attention has been primarily focused on the enzyme component of the cereals, the nature of their starches, their gelatinization temperature and climatic conditions favoring their growth (Agu, 1996). Local cereals such as rice, sorghum, millet and maize, which are abundantly available in Nigeria, could certainly provide cheaper sources of brewing fermentables than those used in Europe. The poor diastatic power of these cereals presents difficulties for their use as soul sources of enzymes for brewing purposes, as reported by Novellie (1960), Nout and Davis (1982), Agu and Palmer (1996), Okolo and Ezeogu (1995, 1996) and Okungbowa *et al*. (2002).

Rice is a staple food for nearly 50% of the world's population. According to the Food and Agriculture Organization (FAO) of the United Nations, global paddy rice production in 2015 was about 738.2 million tons (490.3 million tons, milled basis). Rice does not contain gluten-like proteins, so it is particularly suitable for consumption by individuals with celiac disease. Thus, rice could be a useful raw material for the production of a gluten-free beer-like beverage. Beer is an alcoholic beverage obtained from water, barley malt, hops and yeast. Apart from barley, other cereals can be used as raw materials or adjunct for brewing. Globally, rice is a staple cereal crop grown in both the tropical and temperate regions of the world. The two major species are *Oryza sativa* and *Oryza sativaJaponica*. The former is said to be more adapted to a tropical climate, while the latter grows better in temperate regions (Eneje and Ogu, 2000). The Origin of rice cultivation is lost in pre-history, but it is generally believed that rice cultivation began in Asia and spread to other parts of the world, with special reference to the Mediterranean regions later.

India has the largest acreage of rice production, amounting to 30% of world rice acreage. The major exporters of rice in the world are the U.S.A and Thailand, while the major importers are Iran, Hong Kong, India, Bangladesh and Korea. Rice production in commercial quantity in the U.S.A is centered especially in the southern states of Arkansas, Louisiana, Mississippi, Texas and California. Rice cultivation in Nigeria is more favored in the south than in the north, with Abakiliki in Ebonyi State leading in commercial production.

Compositionally, the endosperm, which is rich in starch, occupies over 80% of the volume of rice. The embryo lies in a slanting position at the ventral side of the kernel and occupies about 1.5-3.5% of the grain mass. The embryo is rich in proteins, oil and vitamins. The oil which is removed during milling help preserves the rice from lipase action, which often results in rancidity. The rice starch is made up of the amylose and amylopectin fraction. The higher the proportion of amylose, the drier and more separated the grains are after cooking; moreover, the rice swells better than that with a high amount of amylopectin (rice with mealy endosperms). The mealy rice (amylopectin-rich rice) has a poor cooking quality, as the grains easily soften and become mushy and glutinous on cooking. Rice is highly digestible and has become indispensable for use as energy food and popular diet for babies and ill. A nutritional deficiency disease called beriberi is associated with the consumption of too much polished rice, which lacks vitamin B1. Rice husks are rich in pentosans and glucans and therefore can be used in the production of furfural (Eneje, 2000).

BREWING USES OF RICE

In today's beer brewing industry, rice is primarily used as an adjunct in combination with barley malt. As a brewing adjunct, rice has a very neutral flavor and aroma, and when properly converted in the brew house, it yields a light clean-tasting beer (Ombretta*et al.* (2017). Recently, there is a growing interest about the use of rice malt for brewing an all-rice malt beer. Malt is the product obtained from steeping, germination and drying of cereals, generally barley. The aim of malting is to develop enzymes needed for the brewing process. Some rice varieties showed good aptitude to be malted due to their good germinative energy and protein content. Rice malt beer can be produced by obtaining a gluten-free beverage comparable to conventional beer. The beverage represents a good alternative in the diet of individuals with celiac disease.

In Nigeria, the edible value of rice tends to surpass other uses of it. The brewing value of rice is limited, due to the poor diastatic power of rice malt. The poor starch-degrading enzyme complement of rice malt limits its use as a principal brewing material, and therefore, it is mostly used as an adjunct in brewing production. Rice constitutes up to 40% of starch used to brew beer in the U.S.A and Japan. In Japan, rice is used to brew beer called sake. Beer produced with a rice adjunct has lighter taste and body than that produced from barley malt only (Okafor, 2007). In the orient countries, rice is used to make wine and vinegar.

The rice composition makes this cereal particularly suitable for human nutrition. The chemical composition of the grains varies widely, depending on environment, soil and variety. The dry matter consists of about 70% starch, 5–8% protein, 0.2–2.2% oil and small amounts of inorganic substances. The chemical composition of rice, especially the high starch content, makes this cereal also perfectly suitable for brewing.

Usually, brewer's rice is a byproduct of the edible rice milling industry. Hulls are removed from paddy rice, and this hulled rice is then dry milled to remove the bran, aleurone layers and germ. The objective of rice milling is to completely remove these fractions with a minimal amount of damage to the starchy endosperm, resulting in whole kernels for domestic consumption. The broken pieces are considered esthetically undesirable for domestic use and sold to brewers at a low price. Rice is preferred by some brewers as adjuncts because of its lower oil content compared to corn grits. It has a very neutral aroma and flavor, and when properly converted in the brewhouse it results in a light, dry, clean-tasting and drinkable beer. The quality of brewer's rice can be judged by several factors: cleanliness, gelatinization temperature, low mash viscosity, lower oil and protein content Rice grains contain more starch on a percentage dry weight basis than barley or wheat and they contain lower levels of fiber, lipid and protein, thus possessing some inherently useful properties for the brewer.

Many Nigerian researchers have worked extensively on improving the malting properties of millet and sorghum through the use of malting additives, such as potassium bromate, Gibberelic acid and alkaline-steep treatment, with improved results (Agu and Obanu, 1990), Okolo and Ezeogu (1996) and Okungbowa*et al.* (2002). The present studies are aimed at improving the malting properties of our local rice cultivars, with special reference to the cold water extract, hot water and diastic power, using alkaline-steep treatments.

MATERIALS AND METHODS

Sources of materials

The two rice cultivars Wita4 and SPP1 were procured from the Institute of Agricultural Research, Ahmadu Bello University, Zaria, Nigeria.

The alkalies, which are of analytical grades, were procured from Resource Concept Laboratory in Enugu, Nigeria. The alkalis were calcium hydroxide, sodium hydroxide and potassium hydroxide.

Grain analysis

The two rice cultivars were analyzed for their percentagegerminative energy, germinative capacity and thousand corn weight to determine their sustainability for the study.

Determination of germinative energy

Germinative energy refers to the percentages of the grains capable of germination at a given condition of temperature, moisture and time.

One hundred grains of each cultivar were counted out from the lot, after sorting out broken kernels and foreign seeds, and placed in whatman no. 1 filter paper wetted with 4 ml of water inside a petridish. The petri dish was placed in a desiccator half-filled with water, and the set-up was left for 72 hours at 28^{o}C. At the end of 72 hours, the grains that showed signs of germination were counted and used to calculate the percentage germinative energy thus:

%GE(4 ml H_2O), 28^{o}C, 72 hours) =100-x

Where x = number of ungerminated grains

Determination of germinative capacity

Germinative capacity refers to the percentage of viable grains in a given quantity of a sample under a given condition of moisture, temperature and time.

The hydrogen peroxide method was used, in which a 0.75% solution of hydrogen peroxide solution was prepared and two hundred grains from each cultivar added to the solution contained in a 250 ml conical flask. The flask containing the grain was left for 48 hours at room temperature. At the end of 48 hours, the steep liquor was drained off and replaced with 200 ml of fresh water and left for 24-hour period, the grains which showed signs of germination were counted to represent the number of viable seeds.

%GC(0.75% H_2O_2, 28^{o}C 72 hrs) = (200-n)/2,

Where n = the number of unviable grains

Determination of thousand corn weight (T.C.W)

Thousand corn weight refers to the weight of one thousand grains. The thousand cornweight is directly proportional to the size of the grains and extract content.

Forty (40)grammes of each of the grain sample were weighed out and the number of grains counted and noted. The thousand corn weight was calculated by direct proportion based on the number of grains obtained from the 40 g of the grains.

MALTING USING ALKALINE-STEEP TREATMENTS

Malting procedures

Steeping

500 grams of each variety of rice were steeped in 1000 ml of each of the three 1.0% solutions: calcium hydroxide, sodium hydroxide and potassium for 48 hours, with air resting every 12 hours for 2 hours.

Germination

Germination of grains was allowed to take place on a wet jute bag for 5 days. Water was sprinkled on the germinating grains every 6 hours and the grains turned at in interval of 6 hours to avoid root matting. Germination lasted for 5 days to produce the green malts.

Kilning

The green malts were dried in a thermostatically controlled oven at 40^0C for 24 hours to reduce the moisture content, impart the desirable malt flavor and to arrest enzyme activity.

Malt analysis

The rice malts obtained from different alkaline steep treatments were subjected to the analysis of cold water extract, hot water extract and diastatic power.

Cold water extract.

Cold water extract provides information on the amount of performed sugars leached into the cold water solution under conditions that preclude the intervention of enzymes.

10.0 grammes of coarse-ground grist was measured into 200 ml of distilled water containing 12 ml of 0.1N ammonia solution and mixed every 30 minutes for 3 hours. At end of the three hours, solids were allowed to settle and the supernatant filtered to obtain the cold water extract. The percentage cold water extract was calculated as follows:

$$\%CWE = \frac{G \times 20}{36}$$

Where G = 1000 (SG-1), SG = specific gravity of the cold solution

Hot water extract

50.2 grammes of coarse-ground grist was measured into a tarred stainless steel beaker and placed in hot water bath at 100^0C and preheated for 15 minutes.

350 ml of distilled water at 68^0C was added to the beaker and the content of the beakerstirred, a temperature of 65^0C was achieved on mixing, and this temperature was

maintained for one hour, stirring every 10 minutes. After one hour the mash was quickly cooled to 20^0C. The mash was transferred into a 1000 ml measuring cylinder and made up to 515 ml with distilled water. The mash was mixed thoroughly and filtered using Whatman no. 1 filter paper. The specific gravity of the filtrate was determined using a hydrometer. The hot water extract was calculated as follows:

HWE = G x 10.13

Where G = Excess gravity (SG = 1), SG = specific gravity of the extract

Diastatic power

Diastatic power refers to the degree of amylolytic activity of the malt. Diastase is the name given to all the enzymes involved in the breakdown of starch, principally alpha- and beta-amylases.

Ten grammes (10gms) of coarse grist were dissolved in 200 ml of water containing 12 ml of 0.2N ammonia solution. The grist was thoroughly mixed in the solution for 3 hours, with stirring every 30 minutes. The mixture was filtered after 3 hours and 10ml of the filtrate was added to into 100 ml of 2% starch solution at 30^0C to digest the starch for one hour, after which 30 ml of 0.1N NaOHsolution was added to stop the conversion of the starch, the total volume was made up to 250 ml with distilled water and titrated against mixed solution. 5 ml of mixed Fehling solution was added into 250 ml conical flask, boiled and titrated against the starch digest in the burette. Boiling and titration was continued for one minute. Three (3) drops of methylene blue indicator were added to the boiling solution and titration continued until the end point was indicated by the decolourization of the methylene blue to orange-red colour. Thediastatic power of the sample was calculated as follows:

Diastatic power (Dp) = 2000/XY,expressed in degree litner (^{0}L)

Where X = volume of cold water extract used to digest the starch, and

Y = volume of the starch digest used to reduce the mixed Fehling solution

RESULTS AND DISCUSSION

The effects of alkaline- steep treatment on the malting properties of the two rice cultivars were investigated. The wita4 and SPP1 cultivars yielded agerminative energy of 92% and 93%,geminative capacity of 97.0% and 96.0% respectively, indicating that they had good malting potentials.

***Table 1*: Result of grain analysis**

Rice sample	% germinative energy	% germinative capacity	Thousand corn weight (g)
Wita4	92.0	97.0	26.2
SPPI	93.0	96.0	26.60

Wita4 and SPP1 rice malt steep-treated with calcium hydroxide had cold water extracts of 41.50% and 32.50% respectively, hot water extracts of 220.0^{o}L/kg and 2080^{o}L/kgrespectively and diastatic power of 34.0^{o}L and 28^{o}L respectively.

Table 2: Results of calcium hydroxide steep treatment

Malt sample	% C.W.E	H.W.E. (^{o}L/KG	D.P. (^{o}L)
Wita4	41.50	220.0	34.0
SPPI	32.50	208.0	28.0

The samples treated with NaOH had cold water extracts of 31.50% and 26.0% respectively, hot water extracts of 192.0^{o}L/kg and 189.0^{o}L/kg respectively and diastatic power of 28.0^{o}L and 24.0^{o}L respectively.

Table 3: Results of sodium hydroxide steep treatment

Malt sample	% C.W.E	H.W.E. (^{o}L/KG)	D.P. (^{o}L)
Wita4	31.5	192.0	28.0
SPPI	26.0	189.0	24.0

The Wita4 and SPP1-malts treated with KOH had cold water extracts of 15.54% and 12.20% respectively, hot water extracts of 181.95^{o}L/kg and 151.95^{o}L/kg respectively and diastatic powers of 12.0^{o}L and 11.80^{o}L respectively.

Table 4: Results of potassium hydroxide steep treatment

Malt sample	% C.W.E	H.W.E (^{o}L/KG)	D.P. (^{o}L)
Wita4	15.54	181.95	12.0
SPPI	12.20	151.95	11.80

The results of the cold water extract, hot water extract and diastatic power of Wita4 untreated rice malt was 26%, 192.0 ^{o}L/kg and 16.0^{o}L respectively. The results of cold water, hot water extract and diastatic power for the SPP1 untreated rice malt was 26%, 188.0^{o}L/kg and 14.0^{o}L respectively.

Table 5: Result of analysis of untreated malt samples

Malt sample	% CWE	HWE (^{o}L/kg)	DP (^{o}L)
Wita4	26	192	16
SPP1	26	188	14

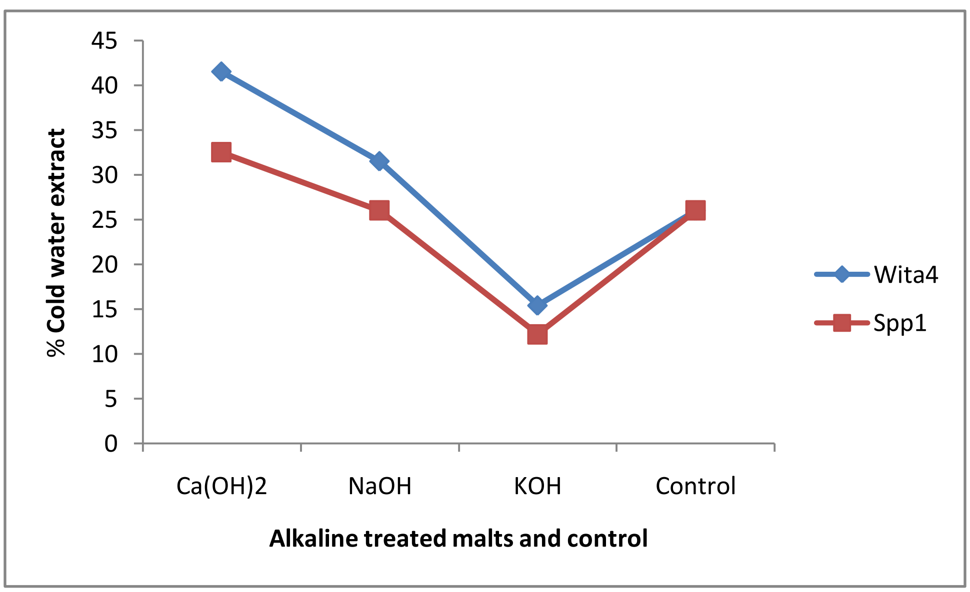

Fig1: Effects of alkaline steep treatment on the cold water extract of two malt rice cultivars

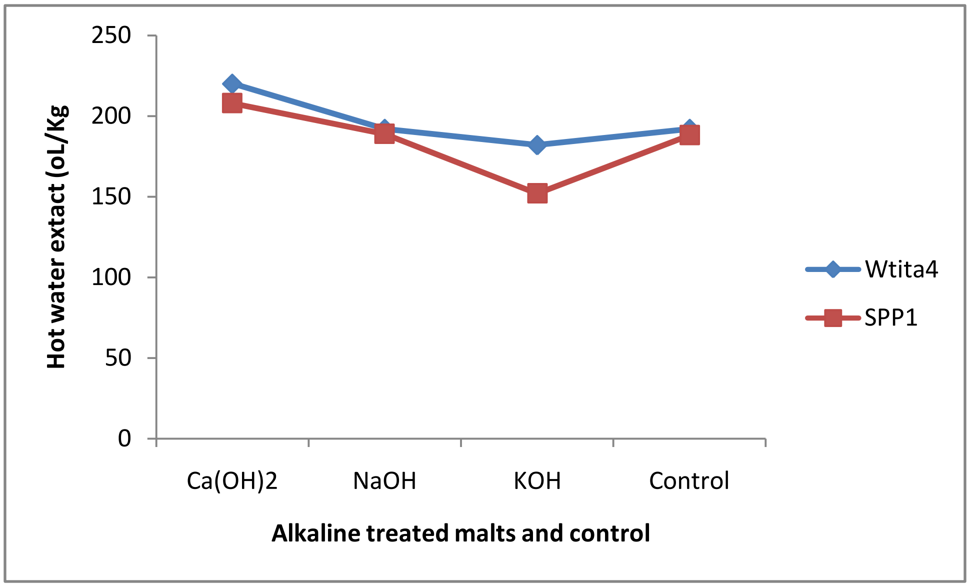

Fig 2: Effects of alkaline steep treatment on the hot water extract of two rice malt cultivars

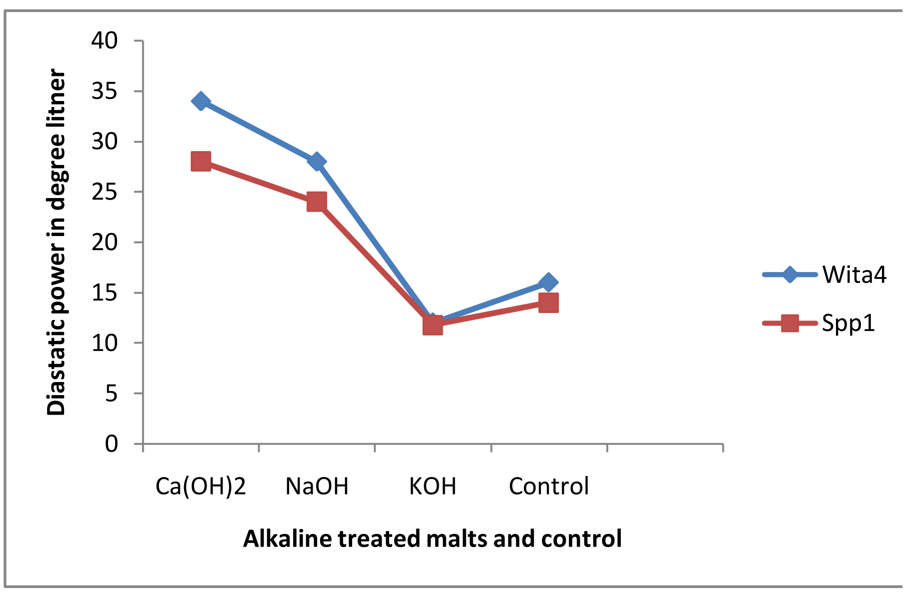

Fig 3: Effects of alkaline steep treatment on thediastatic power of two rice malt cultivars

The overall results have shown that steeping in calcium hydroxide solution had significant improvement on the cold water extract, hot water extract and diastatic power of both Wit4 and APP1 rice malt cultivars, while steep treatment with potassium hydroxide showed a decline in CWE, HWE and DP of the three malts. The sodium hydroxide-treated malts and the untreated malt samples (control) were comparable with respect to the hot water extract values and showed better results in CWE, HWE and DP than the KOH-derived malts.

These results are in agreement with the reports of Okolo and Ezeogu (1996) and Okungbowa*et al.* (2002) that steeping in alkaline liquor, especially ($Ca(OH)_2$and NaOH had the ability to break dormancy during malting to enhanceamylolytic enzyme activities, with the consequent increase in diastatic power and hot water extract of the resulting malts. The poor result of KOH-treated malts with respect to diastatic power and hot water extract was due to the repressive action of potassium hydroxide on enzyme activities, which resulted in a poor yield of extracts, thus confirming the report ofOkungbowa*et al*. (2002) that potassium hydroxide had repressive action ondiastatic enzyme activity.

CONCLUSION

In conclusion, the use of alkalis especially calcium and sodium hydroxide should be encouraged during steeping and malting of our local cereals, as they are capable of breaking dormancy to enhance the malting properties of the cereals for brewing uses. More researches should be carried out on improving the malting properties of our local cereals for brewing to eliminate completely the importation of barley malts and enzymes, which consumes significant amounts of our foreign exchange.

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