World Applied Sciences Journal 4 (2): 183-187, 2008
ISSN 1818-4952

The Effect of Acetic and Lactic Acid on the Oil Uptake, Texture and Color of Rice (Sang Tarom) During Cooking

[1]E. Ghasemi, [1]M.T. Hamed Mosavian and [2]M.H. Haddad Khodaparast

[1]Department of Chemical Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
[2]Department of Food Science and Technology, Ferdowsi University of Mashhad, Mashhad, Iran

Abstract: The effects of edible acids' addition to rice during cooking at three levels (distilled water (control sample), 0.05M acetic acid and 0.05 M lactic acid) on the textural and morphological properties, gelatinization temperature (GT) and color of cooked Sang Tarom rice were investigated. The results show that acid' addition to rice during cooking, cause a decrease in hardness and GT, but had no significant effect on adhesiveness and whiteness index of samples. Using scanning electron microscopy technique, the microstructure revealed that the outer layer of cooked rice with 0.05M lactic acid and 0.05M acetic acid became less porous compared to the control sample. Since Iranians use oil during or after cooking rice to provide a better appearance, glossiness and kernelness, the effect of edible acids addition on oil content of the end-product, has been investigated, too. By attention to amylography and SEM results, we found that acidic treatments had less oil in inner structures of rice kernels.

Key words: Rice · cooking · acetic acid · lactic acid · gelatinization · texture · oil · color

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the important staple foods of almost half of the world population. There is about 90% of its production and consumption in Asia. It is consumed as cooked milled kernels. Cooking of milled rice is one of the most important processing steps that is done to provide desirable texture in the kernels for direct eating. It involves heat and mass (water) transfer. The rice kernels are boiled in limited or excess amount of water for cooking. About 90% of the dry mass of milled rice is starch [1]. The starch content of the milled rice kernel absorbs moisture and swells during cooking due to its gelatinization [2].

In general, the rice qualities are evaluated based on its color, flavor, texture, eating qualities and other properties like glossiness, looseness and kernelness [3].

For the color of rice, the white is usually preferred. Eating qualities of cooked rice can be evaluated by instrumental tests [4]. The texture of cooked rice is not a single attribute, but it is a composite of several attributes such as hardness or firmness (or its opposite, tenderness), stickiness or adhesiveness [5], chewness and cohesiveness [6], as well as moistureness to touch [7].

There are some methods to change and improve the rice texture, flavour, color and other properties. It has been reported that the transparency, glossiness and stickiness of rice cooked with acetic acid were increased and hardness was decreased with respect to control sample depending on molar concentrations of acetic acid ranging from 0.05 to 0.2 M [8]. Also, the effects of acetic acid on the rice gelatinization and pasting properties of rice starch during cooking have been investigated. It has been reported that acetic acid promoted water absorption of starch and the structure of rice starch became more fluid by addition of acetic acid [9].

Iranians add oil to rice during or after cooking to provide the better flavour, more glossiness and less stickiness of kernels together. So, the large part of oil consumption in Iran is attributed to oil which is consumed with rice daily. Oil consumption, especially saturated fat is recognized as one of the major factors that has an adverse effect on health and leads to some diseases such as coronary heart disease (CHD), cancer, obesity, diabetes, etc.

There is no information about oil uptake of cooked rice and especially the Iranian rice varieties. As edible acids such as acetic acid, lactic acid and citric acid affect on the gelatinization behaviour of rice during heating and

Corresponding Author: Dr. M.T. Hamed Mosavian, Department of Chemical Engineering, Ferdowsi University of Mashhad, Mashhad, Iran

cooking, it is expected that adding them to rice during cooking, will be effective in its oil absorption behaviour, too. The objective of this work was to study the effect of acetic and lactic acids' addition to rice during cooking on oil uptake, texture and color of kernels.

MATERIALS AND METHODS

Rice samples and materials: Sang Tarom variety of milled rice grain that is one of the most important varieties is used in this study. This variety is grown in the northern part of Iran. The milled rice was placed in air-tight polyethylene bags and kept in a cold room. The average moisture content of raw rice was equal to 8% (w.b.). Lactic acid 95% (v/v) with a density of 1.21 gr/cm^3, acetic acid 5% (w/w) (Golchekan Zamani vinegar) and sunflower liquid oil (Shadgol) which were purchased at a local market in Iran were used.

Cooking method: The rice grains were cleaned from foreign materials and washed for five times using water. Rice cooking was performed as follow: 10 g of crude rice and 100 ml of distilled water or acid solution (0.05 M acetic acid and lactic acid) were subjected to constant boiling for 15 min in a 250 ml beaker. Cooking water was eliminated and cooked rice was allowed to cool [10].

Oil uptake: The cooked rice grains were immersed in a beaker of liquid oil in room temperature for 15 min to ensure that the maximum of oil uptake to rice occurs. Then the beaker content was transferred to a leach for dripping and removing the excess oil for sufficient time (20 h).

Oil uptake was measured by the four hours soxhlet extraction using petroleum ether as a solvent.

Amylography: The raw rice was cleaned and ground in a grinder for rice flour preparation. The rice gelatinization behaviour was studied with a Brabender amylograph (type 800120, Germany) using rice flour slurry with a concentration of 6% on a dry basis (d.b.) [11]. The mixture was made up to 460 g with distilled water or 0.1 M acetic acid or0.1 M lactic acid and heated from the room temperature to 90°C at a rate of 1.5°C/min.

Texture measurement: A texture analyzer (QTS, CNS FARNELL) was utilized to examine the texture of cooked rice samples using the back extrusion test. A 15 gram sample of cooked rice was placed inside the test cylinder of 6 cm diameter and pressed with a 100 gram weight for 30 s before conducting the cylindrical test cell was compressed by a spherical plate plunger of 35 mm diameter. Pre-test speed, test speed and post-test speed of plunger were set at 1.0, 1.0 and 10 mm/s, respectively. Compression distance was 50% strain [12]. A force-time curve was obtained from the test and the following textural parameters were determined:

- Hardness-the maximum compressive force during extrusion (N).
- Adhesiveness-the negative area under the curve (Ns).

Color assay: Whiteness of cooked rice was measured using a colorimeter (Model D25 optical Head, Hunter associates laboratory INC., U.S.A). Measurement was based on the Hunter system of color values of L (lightness), a (redness), b (yellowness) [13]. The measurement was performed in triplicate. The L, a and b values of the white color standard were 94.99, -0.7 and 0.2, respectively. Furthermore the whiteness index (WI) was calculated as follows [12].

$$WI = 100-[(100-L)^2+a^2+b^2]^{0.5}$$

Scanning electron microscopy (SEM): The morphological changes of cooked rice kernels was observed using scanning electron microscopy (LEO 1450VP, Germany) at 10 KV.

The cooked rice kernel was freeze-dried by liquid Nitrogen. The outer surface on the lateral side of the kernel was observed. Samples were attached to a SEM stub using a double-backed cellophane tape. The stub and sample were coated with gold-palladium by a sputter coater (SC 7620), examined and photographed.

Statistical analysis: The experiments were done in completely randomized (CR) technique with 3 treatment and 3 replications. An analysis of variance was used to analyze the data and significant differences between the treatment means were compared at a significant level of 95%.

RESULT AND DISCUSSION

General: The macroscopic changes of cooked rice as a result of cooking conditions (with distilled water, 0.05 M acetic acid and 0.05 M lactic acid) were described in terms of textural and color alteration, as summarized in Table 1.

Table 1: Summary of textural and color changes of cooked rice samples undergoing various cooking conditions [A]

Cooking conditions	Hardness (N)	Adhesiveness (NS)	Whiteness
With distilled water	8.38[a]	-0.19[a]	76.793[a]
With acetic acid 0.05 M	6.31[ab]	-0.22[a]	77.386[a]
With lactic acid 0.05 M	4.89[b]	-0.52[a]	77.32 [aA]

Different letters within the same column indicate significant difference (P<0.05) using Duncan's multiple range test

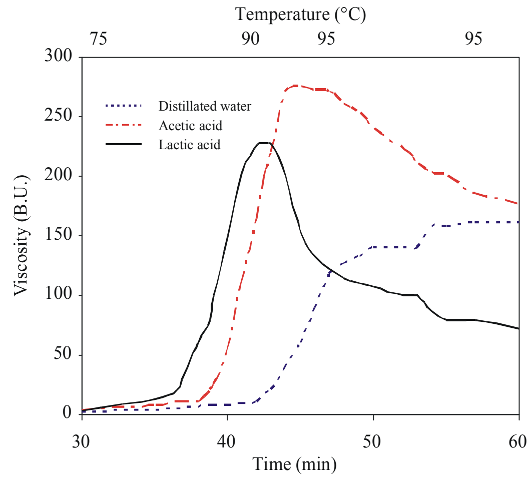

Fig. 1: Effect of acidic conditions on the pasting behaviour of rice flour (6% d.b.)

Textural properties

Hardness: The hardness of samples that cooked in acidic conditions was significantly lower than control sample hardness. This may be due to that the acidic conditions promoted water absorption of amylopectin in rice starch. Also acetic and lactic acid cause easy to gelatinization and more fluidity of rice starch structure. Zhou *et al.* reported that the hardness and adhesiveness are likely to be associated with the hydration process of starch granules [14]. During cooking, the rice granules absorbed moisture and swelled to great extent compared to their original size. The expansion of granule caused ruptures and, hence, amylose leaching. The leaching components can be responsible for decreasing hardness of cooked rice samples [12].

Adhesiveness: There were no significant difference between the adhesiveness of cooked rice samples by addition edible acids, but is seen a little increase in adhesiveness of acidic samples especially lactic acid treatment in comparison with control sample. This may be due to the more leaching of amylose from the starch granule during gelatinization in these treatments. Also lactic acid may cause to protein extraction from the surface of the rice kernel. Proteins present in cooking water may bind with leached amylose at the surface of rice[15]. Many researches found that stickiness of cooked rice depends on the amount of leached amylose. When amount of leached amylose was higher, cooked rice was stickier [16, 17]. This result correlated with the work by Nopharatana *et al.*, which investigated the effect of soaking chemicals on properties of cooked rice and reported that the stickiness of cooked rice soaked in 0.1% lactic acid was significantly higher than of other soaked samples. They also found at 100% gelatinization, the leached amylose content of cooked rice soaked in 0.1% lactic acid was significantly higher than other samples [18].

In addition, it was demonstrated that the dissolution and degradation of proteins in the acidic condition might accelerate the absorption of starch. These mutual changes in starch and protein can affect the textural changes such as the increasing stickiness and the decreasing hardness of acidic treatment [9].

Whiteness: There was no significant difference between the degrees of whiteness of cooked rice samples by addition edible acids.

Amylography: Figure 1 shows the Brabender Viscograms of 6% rice flour (control and acidic samples). The gelatinization temperature (GT) of rice cooked by distilled water, 0.05 M acetic acid and 0.05 M lactic acid was 90, 87 and 84°C respectively. This obvious decrease in GT by acidic samples may be due to the starch granules that became fragile and broke down relatively rapidly after acidification. Acidic rice flour paste showed lower tendency of retro gradation. This may be ascribed to the short-chain starch molecules that appear due to acid hydrolysis, which were very active to form a highly ordered crystalline structure[11]. Ohishi *et al.*, showed by DSC measurements that the rice starch heated with acetic acid was easy to gelatinize compared to that without acetic acid [9].

Scanning electron microscopy: The acidic cooking conditions, produced noticeable changes of microstructure of cooked rice kernels at acidic treatments (Fig. 2(b) and (c)), in comparison with the control sample (Fig. 2(a)). The SEM displayed a more even structure with fine porosity. In acidic treatments, the porosity seemed to be gradually dispersed and the surface at high acidic cooking conditions appeared to be smooth and solid.

(a)
(b)
(c)

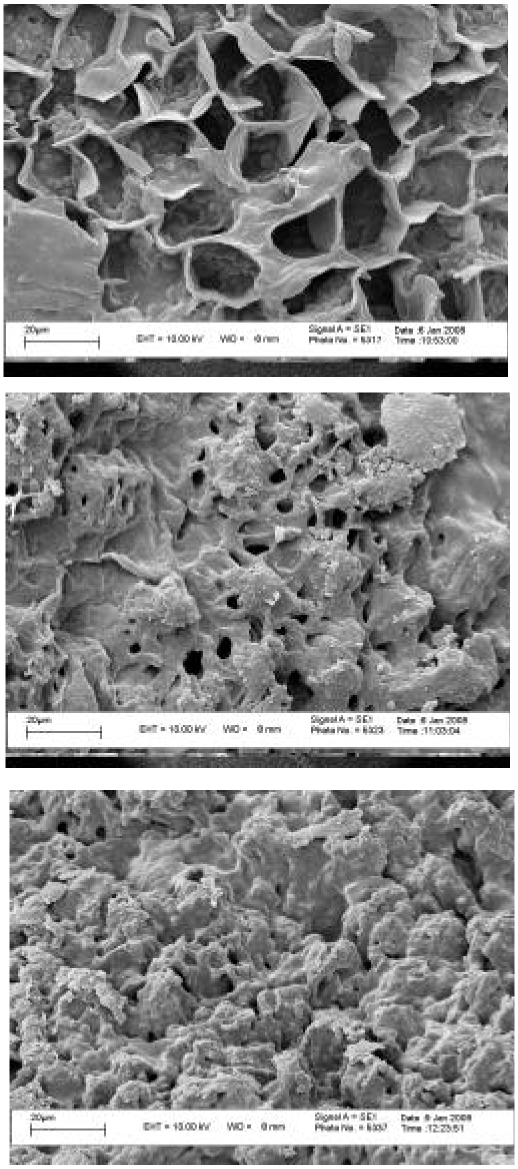

Fig. 2: Scanning Electron Micrographs of the outer surface of cooked rice, (a)with distilled water (b) with 0.05M acetic acid (c))with 0.05M lactic acid

It seems that the better gelatinization and swelling of rice starch due to acid addition, cause decrease in pore size.

3.6. Oil uptake: By considering the SEM and amylography results, we found that the acid addition during cooking rice, results the better gelatinization and the closer pores and channels on the surface of rice kernels. Therefore, this acts as a barrier for oil penetration to the inner structure of the rice kernel. By attention to the oil uptake measurement method that applied in this work, increase in oil content in sample cooked with 0.05M lactic

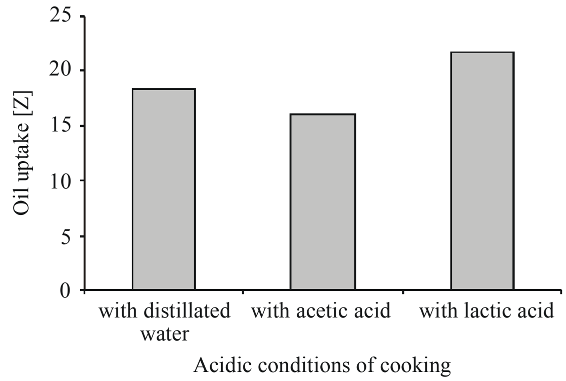

Fig. 3: The percentage of oil uptake in samples

acid rather to control sample (Fig. 3) may relate to only surface oil, not to the oil which has diffused to the inner structure of the rice kernel. It may be refers to the more adhesiveness in this treatment. These kernels sum the more oil in own around and due to the closer ways to oil penetration on the surface of kernels, the lower oil goes to the inner layer of rice endosperm and rest on the outer surface.

Thus, by consumption of less oil, is provided the desirable appearance, glossiness and other properties.

CONCLUSIONS

Acid addition during the cooking of rice affected the textural appearance, including color and texture as well as the gelatinization behaviour of rice starch. The SEM demonstrated the different microstructures of cooked rice undergoing three acidic treatments. The use of 0.05M acetic and lactic acid for cooking rice, compared to control sample, cause a decrease in gelatinization temperature, hardness and porosity and decrease in oil penetrated to the inner layer of endosperm due to a better gelatinization and closer pores in the outer surface of the rice kernel. Also, it had no significant effect on adhesiveness and whiteness index of samples.

REFERENCES

1. Ramesh, M.N., 2001. An application of image analysis for the study of kinetics of hydration of milled rice in hot water. International Journal of Food Properties, 4(2): 271-284.
2. Yadav, B.K. and V.K. Jindal, 2007. Dimensional changes in milled rice (*Oryza sativa* L.) kernel during cooking in relation to its physicochemical properties by image analysis. Journal of food engineering, 81: 710-720.

3. Yadav, B.K. and V.K. Jindal, 2001. Monitoring milling quality of rice by image analysis. Computers and Electronics in Agriculture, 33(1): 19-33.
4. Tan, Y. and H. Corke, 2002. Factor analysis of physicochemical properties of 63 rice varieties. Journal of the Science of Food and Agriculture, 82: 745-752.
5. Juliano, B.O., C.M. Perez and S. Barber, 1981. International Co-operative comparison of instrument methods for cooked rice texture. Journal of Texture Studies, 12: 17-38.
6. Yang, J.N.N. and J.J. Huang, 1996. Sensory analysis of cooked rice. Food Quality and Preference, 7: 263-270.
7. Ramesh, M., K.R. Bhattacharya and J.R. mitchell, 2000. Developments in understanding the basis of cooked-rice texture. Critical Reviews in Food Science and Nutrition, 40(6): 449-460.
8. Kasai, M., S. Tanihata, K. Ohishi, A. Shimada, K. Hatae, 2001. Effect of acetic acid on the palatability and physicochemical properties of cooked rice. Journal of Home Economics of Japan, 52: 1091-1097.
9. Ohishi, K., M. Kasai, A. Shimada, K. Hatae, 2007. Effects of acetic acid on the rice gelatinization and pasting properties of rice starch during cooking. Food Research International, 40: 224-231.
10. Iturriage, L.B., B.L. Mishima and M.C. Anon, 2006. Effect of amylose on starch pastes viscoelasticity and cooked grains stickness in rice from seven argentine genotypes. Food Research International, 39: 660-666.
11. Wang, H.H., D.W. Sun, Q. Zeng and Y. Lu, 2000. Effect of PH, corn starch and phosphates on the pasting properties of rice flour. Journal of Food Engineering, 46: 133-138.
12. Leelayuthsoontorn, P. and A. Thipayarat, 2006. Textural and morphological changes of Jasmine rice under various elevated cooking conditions. Food Chemistry, 96: 606-613.
13. Lee, Y.S., J.M. Cho and C.O. Rhee, 2001. Gelatinization characteristics of pigmented rice starch (suwon-415). Food Science and Biotechnology, 10(4): 397-402.
14. Zhou, Z., K. Robards, S. Helliwell and C. Blanchard, 2007. Effect of storage temperatureon cooking behaviour of rice. Food Chemistry, 105: 491-497.
15. Martin, M. and M.A. Fitzgerald, 2002. Protein in rice grains influence cooking properties. Journal of Cereal Science, 36: 285-294.
16. Eliasson, A.C. and M. Gudmun, 1996: Starch: physicochemical and functional aspects, in A.C. Eliasson (Eds.), Carbohydrates in food. New York: Marcel Dekker, pp: 431-503.
17. Ong, M.H. and J.M.V. Blanshard, 1995. Texture determinants in cooked, parboiled rice I: rice starch amylose and the fine structure of amylopectin. Journal of Cereal Science, 21: 251-260.
18. Nophatarana, M., P. Wuttisettarak and P. Vongsawasdi, 2006. Effect of soaking chemicals and temperature on properties of cooked rice. In: Proceedings of the international conference on innovations in food and bioprocess technologies. AIT, Pathumthani, Thailand.