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Report on studies on pop rice research in collaboration with JIRCAS

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Objectives:

- Understanding "pop" phenomenon in pop-rice relating to gelatinization
- Exploring up-scalable equipment for pop-rice technology

Understanding "pop" phenomenon of pop-rice

Studies at JIRCAS

Pop-rice technology was available traditionally in Asia; however, it was not well investigated. Since whole grain could be used as final product, it is attractive even in Africa. Moreover, the pop-rice technology is usually achieved with simple technology. We had tested possible factors that affect the "pop" phenomenon, such as variety or moisture content. We had used one kind of equipment based on circulating fluidized bed, that can achieve only one temperature, around 200°C. Therefore, we applied "heat gun" with mesh to achieve different temperatures applied for rice to "pop". Treated samples were measured with single kernel differential scanning calorimetry (DSC) to check whether gelatinization occurs or not.

Five (5) rough rice kernels for each treatment were treated with heat gun (HAG-1550, Ryobi, Japan) set as 90, 250 and 400°C. Kernel was weigh separately, and treated until popped, except 90°C, then husk was removed. Each sample was powdered with a super-centrifuge mill (ZM-200, Retch, Germany) with 0.5mm screen to obtain homogenate particle size of flour. Ten (10) mg of sample was put into 70uL DSC silver pan with 50μL water as sample, and 60μL water into the same DSC silver pan was used as reference. DSC was measured by Exstar 6100 DSC (Hitachi Hi-Tech, Japan) with the program as 30°C to 120°C at 0.5°C / min. Brown rice was used as control. Furthermore, to investigate if gelatinization that occurs in the presence of water was equivalent to gelatinization that occurs during popping, 25 mg of brown rice flour without water for gelatinization was heated in the same setup as above with 25 mg of α-alumina as reference. The DSC was program as 30°C to 300°C at 1°C / min

Results and Discussion

Kernels heated at 90°C did not pop while those heated at 250 and 400°C did pop. The DSC results showed that samples that did not pop after heating (90°C) had a gelatinization peak (71°C) like that of untreated brown rice (control). Whereas samples that popped after heating (250 and 400°C) had not gelatinization peak (Figure 1). These data confirm previous findings that popping leads to complete gelatinization of the starch and that this occurs at temperature above 200°C. Preliminary data indicated that gelatinization that occurs during the normal rice cooking process when starch granules absorb water, swell and burst is different from gelatinization that occurs during popping. This is demonstrated by two different gelatinization peaks and heat absorbed (71°C and 1.2mJ/mg for gelatinization in the presence of water and 208°C and 136.2 mJ/mg for gelatinization during popping) (Figure 2)

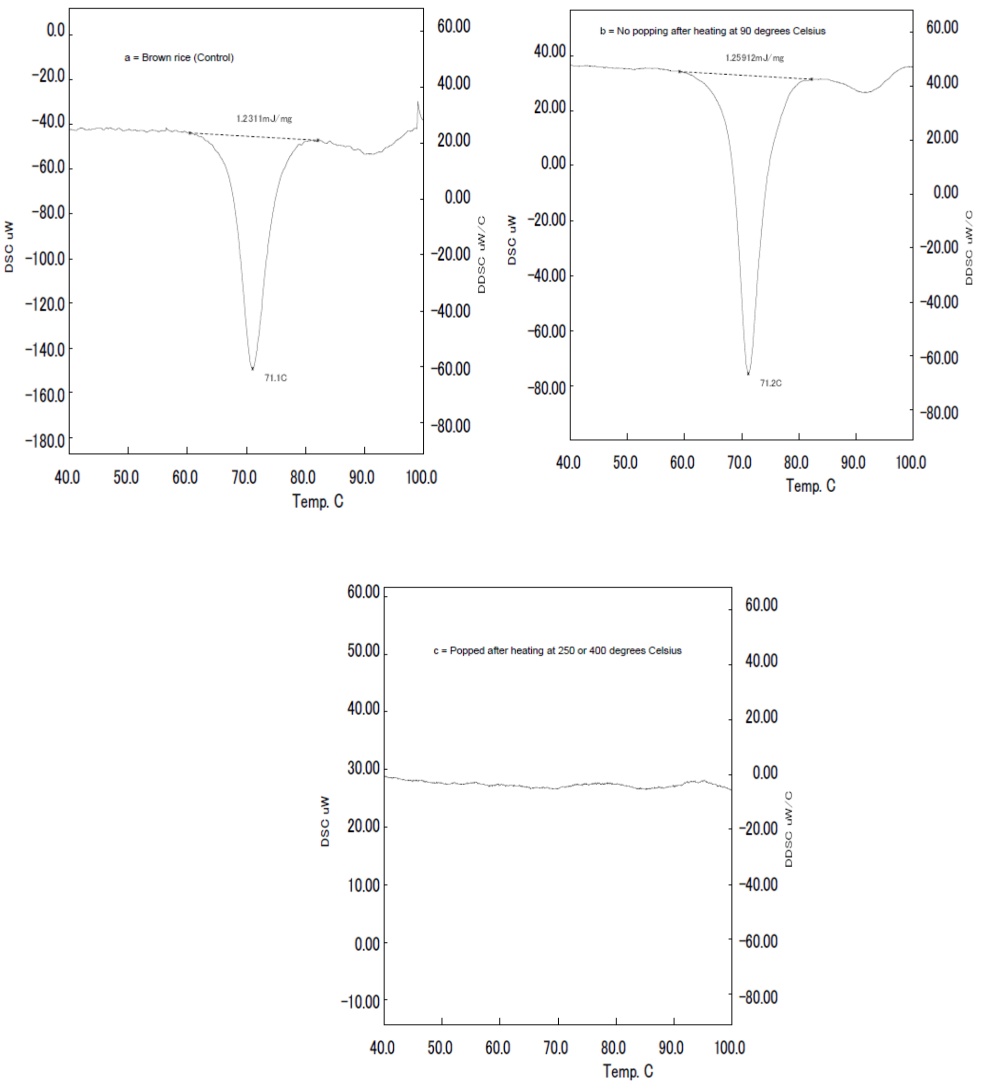

Figure 1: Differential scanning calorimetry charts for (a) Brown rice (control), (b) Samples heated at 90°C and (c) Samples heated at 250 or 400°C

Previous observations by Scanning Electron Microscopy indicated that gelatinization that occurs during the normal rice cooking process when starch granules absorb water, swell and burst is different from gelatinization that occurs during popping. This is demonstrated by two different gelatinization peaks and heat absorbed (71°C and 1.2mJ/mg for gelatinization in the presence of water and 208°C and 136.2 mJ/mg for possible gelatinization-like phenomenon during popping temperature) in the experiments (Figure 2).

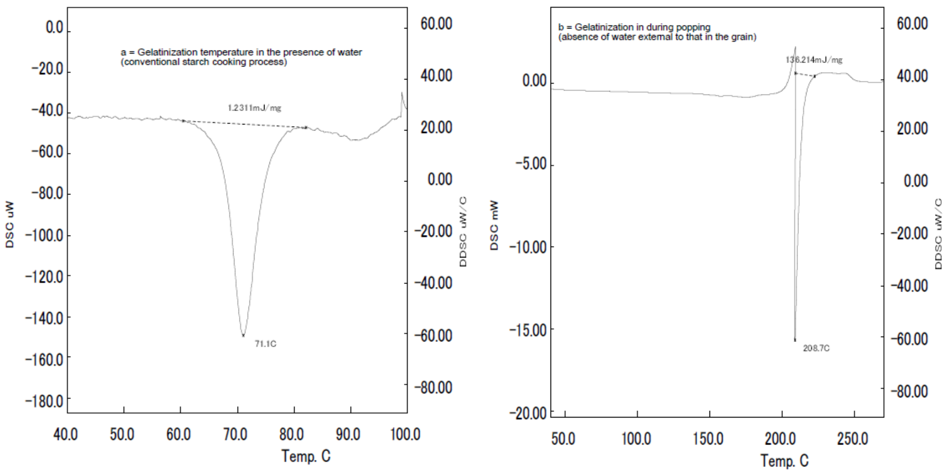

Figure 2: Comparison of gelatinization during (a) the conventional starch cooking process where external water is supplied to the grain and (b) popping where no external water is supplied.

Exploring up-scalable equipment for pop-rice technology

Presently, we have only two methodologies for pop-rice, pan-heating or circulating fluidized bed. Pan-heating, traditionally applied in Asia for pop-rice, could achieve extremely lower popping rate, which might be a barrier for application. Circulating fluidized bed equipment which usually applied for popcorn processing could achieve higher popping rate, however due to the requirement of high temperature, around 200°C, with wind, their scale should always be small. Since pop-rice technology has similar process as coffee roasting, we tried simple coffee roaster with fine hole, heated with burner, which is capable for up-scaling.

Fifty -(50) g of NERICA 1 rough rice was applied into a coffee roaster (2.5mm mesh model, Auvelcraft, Japan) with or without (covered with aluminum foil) holes into the vessel. The vessel was rotated once a second by hand, with burner heating. 50g of NERICA 1 rough rice also applied into circulating fluidized bed equipment for popcorn (KK-000285, D-STYLIST, Japan) to pop the rice (Figure 3). Each sample was measured number of popped or unpopped kernels by seed counter (Waver series, AIDEX Co Ltd, Japan).

Figure 3: Coffee roaster (left) and popcorn maker (right) used in popping experiment.

Results and Discussion

The coffee roaster could be used for pop rice production although the popping rate was lower compared to the popcorn maker (Table 1). The mesh-like structure of the coffee roaster appears to hamper smooth popping as some of the popped grains get stock on the mesh resulting in burning. It will thus be interesting to replace the mesh with perforated stainless steel (Inox 316-L) with pore sizes on 2 or 3 mm prior to up-scaling the equipment.

Table 1: Comparing the popping rate between coffee roaster and popcorn maker

Date	Equipment	Total grain	Pop	No-pop	Partially pop	Pop (%)
08/29/2019	Stainless roaster	837	356	415	66	43
09/02/2019	Popcorn maker	917	488	370	59	53
09/03/2019	Popcorn maker	999	518	422	59	52
09/05/2019	Popcorn maker	947	517	373	57	55

Studies at AfricaRice

Using the pop corn marker, varieties from the Rice Biodiversity Center for Africa are being screened for popping capacity. In addition, a prototype of the coffee maker fueled with rice husk (Figure 4) has been produced and will be tested and piloted with end users.

Figure 4. Pop rice (left) and prototype rice husk fueled pop rice marker (right)