

Comparison Of Energy Requirements Of Some Alternate Parboiling Methods For Paddy

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ABSTRACT: An analysis was carried out for the energy consumption in some alternate parboiling methods than the popular CFTRI method of parboiling to study their feasibility of adoption under Indian rural conditions. The methods studied were the high temperature drying-cum-parboiling process, short soaking tempering process, parboiling using thermic fluid, parboiling by simple soaking in hot water and the pneumatic pressure parboiling. It was observed that under the identical initial moisture condition, the high temperature drying-cum-parboiling method, which used essentially roasting in sand, used the maximum energy up to the gelatinisation process (1050.3 MJ/tonne) followed by the parboiling method using thermic fluid (615.2 MJ/tonne of paddy). This was mainly due to the conductive heating method, which also in turn resulted in maximum amount of heat loss to surroundings. The other methods used almost similar amount of energy as CFTRI method. The minimum energy consumption up to the completion of gelatinisation process was in case of the short soaking-tempering process at 363.6 MJ/tonne. When the energy utilization due to drying was also added, the maximum energy consumption was 1497.8 MJ/tonne for pneumatic pressure parboiling followed by 1304.8 MJ/tonne for the high temperature drying-cum-parboiling method. The minimum energy was for short soaking tempering method at 855.4 MJ/tonne. This analysis could help in designing and analysis of energy utilization pattern of rice processing operations.

INTRODUCTION

Parboiling is the hydrothermal treatment given to paddy, which changes the physical, chemical and organoleptic properties of rice kernels. Besides reduction in breakage during milling, other major advantages of parboiling include greater nutrient status and less loss during cooking, low susceptibility to insect attack during storage and higher oil content in bran with better storage stability. Parboiled rice is produced in India by a variety of traditional and modern methods (Pillaiyar 1988), which essentially include 3 steps namely, soaking, steaming and drying. In the single steaming/ double steaming/ CFTRI method, the soaked paddy contains 33-35% moisture content(w.b.) (Pillaiyar 1988). This high moisture content of the soaked and steamed grain, before the drying process, utilise substantial drying time and energy. In the pressure parboiling process, the parboiled paddy has a kernel moisture of only 24% before drying (Iyengar et al. 1974; Kulkarni and Bal 1984). But the process has not been accepted among the millers due to the dark colour, undue long cooking time and tough texture of the grain (Mohandoss and Pillaiyar 1982; Ali and Bhattacharya 1982). The paddy obtained from the modified pressure parboiling process, have been facing problems in marketing as about 20% of the grains have white core (Pillaiyar et al. 1993). The steaming process in almost all these methods imparts a dark colour to the grains and requires an additional boiler, which otherwise has no other use in the rice mill.

In commercial parboiling installations varieties coming under classifications common, fine, superfine etc. are pooled together and soaked together. Varieties under fine have different gelatinisation temperatures and other properties than common varieties. Under such compelling situations, slender as well as low gelatinisation temperature grains would undoubtedly over-imbibe moisture leading to grain splitting, leaching of solids, loss of about 2% weight and aggravation in colour (Bhattacharya and Subbarao 1966; Pillaiyar et al. 1993). So reduction of these undesirable characteristics of the processes and products has been a matter of concern for some times in the country and abroad.

Some of the comparatively recent developments in the field are-

1. High temperature drying-cum-parboiling
2. Short soaking-tempering method of parboiling
3. Parboiling by using thermic fluid
4. Parboiling by simple soaking in hot water
5. Pneumatic parboiling of paddy.

All these methods have been reported to provide acceptable parboiled rice comparable to the best available in the markets. Though the basic principles involved in bringing about the gelatinisation of starch in the above processes differ from each other, still one thing common in the first four processes is the low moisture content of paddy before drying process as compared to the hot soaking-open steaming method. This saves time and energy during drying and gives a product comparable with the best available methods in the industry. The pneumatic parboiling method has the advantage of eliminating the boiler, thus saving a substantial investment and energy. Hence, an attempt has been made to compare the energy requirement of these parboiling methods with the conventional CFTRI method to assess their economic utility and convenience of adoption.

MATERIALS AND METHODS

The different steps involved in the above parboiling methods are given in Table 1 in addition to the standard CFTRI method for comparison.

Table 1: Different steps involved in the parboiling methods under study

Parboiling process	Soaking	Steaming / gelatinisation	Drying	Reference
High temperature drying-cum-parboiling	In warm water up to 30% moisture content (about 12 h)	Roasting in hot sand at 250°C for 5 min (Final m.c. 20%)	From 20% (w.b.) to 14% (w.b.)	Ali and Bhattacharya, 1980; Pillaiyar et al. 1994
Short soaking-tempering process	At 70°C for 1 h, paddy-water ratio 1:1.2, Tempering hot for 4 h, Final m.c. 25% (w.b.)	At atmospheric pressure for 10 min, Moisture content raises to 26-27%	From 26% (w.b.) to 14% (w.b.)	Pillaiyar et al. 1993
Parboiling using thermic fluid	Soaking at 70°C for 1 h, tempering for 5-6 h. Final m.c. 25% (w.b.)	Using thermic fluid at 110-150° for 2 min, Moisture content is reduced by 3-8%	From about 20% (w.b.) to 14% (w.b.)	Pillaiyar et al. 1996
Parboiling by simple soaking in hot water	At 80-85°C for 1.5 to 2 h, Final m.c. 30% (w.b.), temepering hot for 1-2 h	-	From 30% (w.b.) to 14% (w.b.)	Unnikrishnan et al. 1982

Pneumatic pressure parboiling	Treating paddy to 700mm Hg (vacuum), Soaking at 70°C by pneumatic pressure at 4 kg/cm ² . Final m.c. 38-40% (w.b.)		From 38% (w.b.) to 14% (w.b.)	Rao et al. 1997
CFTRI method of parboiling	Soaking at 85°C upto 30% moisture level (4-6 h)	Final moisture content 33% (w.b.)	From 33% (w.b.) to 14% (w.b.)	Bhattacharya and Shankara, 1994

The energy requirement of parboiling was calculated based on 1 tonne of paddy with the following assumptions.

1. The initial moisture content of paddy was 14% (wet basis), i.e. equivalent to 16% (dry basis).
2. The normal water temperature and the temperature of warm water (for soaking) were taken as 25°C and 70°C.
3. For methods such as sand roasting and use of thermic fluid, even though the laboratory tests were carried out in very small batches (Ali and Bhattacharya 1980; Pillaiyar et al. 1996), for energy calculation, continuous type roasters have been hypothesized with 50 kg sand (sand : paddy ratio 5:1 on weight basis), or 100 kg thermic fluid (in a rotary dryer type set up with continuous reheating / recirculation to compensate the heat loss to the paddy).
4. For a reasonable comparison of the energy need, the soaking and steaming were considered to be carried out in insulated vessels so as to minimize the loss of heat.
5. 20% extra energy is consumed in operating the vacuum pump and compressor in case of pneumatic parboiling or pumping of the thermic fluid. Similarly the sand roaster also needed 20% extra energy.
6. The heat loss to the surrounding are assumed to be 40, 30 and 20% in case of sand roasting (as in HTDP method), conduction heating by thermic fluid and during steaming operation respectively.
7. During soaking to maintain a constant soak water temperature, 10% extra energy was required for short soaking tempering, simple soaking in hot water and pneumatic parboiling methods.

RESULTS AND DISCUSSION

The energy requirement as calculated for the different methods of the above parboiling methods have been presented in Table 2.

Table 2. Energy requirement of the parboiling methods

Parboiling process	Energy requirement, kJ/ tonne of paddy				
	Soaking	Steaming / gelatinisation	Total	Drying	Total
High temperature drying-cum-parboiling	225720	824575	1050295	254512	1304807
Short soaking- tempering process	231739	131879	363618	491768	855386
Parboiling using thermic fluid	231739	383503	615242	254511	869753
Parboiling by simple soaking in hot water	463921	-	463921	621181	1085102
Pneumatic pressure parboiling	466789	-	466789	1030988	1497777
CFTRI method of parboiling	331056	153569	484625	880007	1364632

The parboiling method utilizes soaking to allow the grain to absorb the required moisture for gelatinisation and then the steaming / roasting for the actual gelatinisation. The drying operation is to bring back the paddy to a safe storage moisture level, the energy requirement in which would essentially depend on the moisture content of the grain after gelatinisation is over and the type of drying method used. The parboiling methods involving simple soaking in hot water and the pneumatic pressure involved no steaming / roasting, and complete gelatinisation is achieved only during soaking. Hence the soak water temperature is maintained almost in a constant manner during the entire period of soaking. This needs additional energy input and hence the methods had higher energy requirement for soaking as compared to other methods. In the CFTRI method also the water temperature was initially raised to 85°C before dipping the paddy grain in the soak tank. In other methods the comparatively lower water temperature during soaking involved less energy input.

For the short-soaking-tempering process and CFTRI methods of parboiling the steaming processes are almost identical with a little deviation with the steaming time. The thermic fluid treatment needed higher energy for gelatinisation than the above processes. However, the sand roasting method utilized the maximum energy, which might be due to the excessive loss of heat from the sand. The method could be made more economical by using a suitable roaster and minimizing the loss of heat during recycling.

The energy requirement for the gelatinisation process (soaking and steaming / roasting) was found to be maximum, i.e. 1050.3 MJ/tonne for high temperature sand roasting followed by the thermic fluid method at 615.2 MJ/tonne. Even though these methods raised the moisture levels to a comparatively lower level after soaking as compared to the other methods, the conduction heating method and heat losses to the surroundings made the difference. The minimum energy was utilised in the short soaking-tempering method (363.6 MJ/tonne). The other methods, namely simple soaking in hot water and pneumatic method utilized energy almost equal to the CFTRI method of parboiling.

The energy requirement of drying would be more for methods yielding rice with higher moisture content after gelatinisation. Adding the energy need for drying operations the pneumatic parboiling method was observed to involve the maximum energy with 1497.8 MJ/tonne followed by CFTRI method. The minimum energy consumption was in case of short-soaking-tempering method at only 855.4 MJ / tonne. Sun drying of the grain would reduce the drying cost and hence, for grains meant for sun drying the energy needed for soaking and steaming / roasting could be taken as the index for comparison of energy inputs.

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