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A comprehensive review of mathematical modeling of paddy parboiling and drying:
Effects of modern techniques on process kinetics and rice quality

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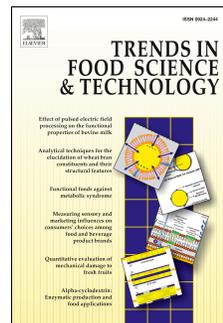
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1 A comprehensive review of mathematical modeling of paddy parboiling and
2 drying: Effects of modern techniques on process kinetics and rice quality

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9 **ABSTRACT**

10 *Background:* Paddy is one of the most important food crops in the world. The major
11 operations of paddy processing are soaking, parboiling/steaming, drying and milling. The
12 paddy processing is an energy-intensive process with the substantial wastewater
13 generation.

14 *Scope and Approach:* The knowledge of mathematical modeling in different stages of
15 paddy processing helps to improve the final rice quality and reduce the energy
16 consumption. The present article analyzes the results of the recently published research
17 work on different models used in paddy soaking, parboiling and drying operations. In
18 addition, the article discusses the effects of modern methods of parboiling and drying
19 operations on the process kinetics, microstructural changes and rice quality.

20 *Key Findings and Conclusions:* Hot water soaking (40-80°C), single steaming, double
21 steaming, pressure cooking and microwave heating are used to parboil or gelatinize the
22 starch in rice. Also, acids/alkaline solutions can gelatinize the rice starch. The open sun (2-
23 4 days), hot air (50-80°C), superheated steam, vacuum, infrared (0.167-0.625 W cm⁻²),
24 and microwave drying (2.45 GHz) are employed to dry the parboiled paddy up to 12-14
25 % moisture content (db). Modelling and simulation tools have been used to study these
26 complex processes during paddy hydration, starch gelatinization and drying. Fick's law of
27 diffusion, Peleg model, and exponential equation are used to describe the water sorption in
28 paddy. Arrhenius equation, Ozawa Model and Kissinger equation are useful in
29 understanding the starch gelatinization kinetics. Several empirical and semi-
30 empirical models are used to study the drying kinetics of gelatinized paddy. In drying, the
31 models are given by Page, Henderson and Pabis and Newton describe the drying kinetics
32 better than other models. The effects of modern methods of the parboiling and drying can
33 be understood from the kinetic and other constants of the models as well as from
34 the change in the microstructure of starch that takes place in the process of

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