Microwave Treatment of Rice

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Abstract

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The effect of microwave treatment on wet rice was studied. Power output used was 90, 160, 350 or 500 W; final heating temperatures were 40, 60 and 80°C; initial moisture content of rice was 11, 21 or 30%. Temperature of treated sample during microwave heating was measured by means of NoEMI fiber-optic temperature system. Temperature of rice gelatinization, expressed as alkali spreading values and total starch content, was used to evaluate the influence of microwave heating on physicochemical properties of rice. Drying time reduction and the stability of total starch content during microwave treatment of rice makes it possible to recommend the combination of microwave and conventional rice drying for further use.

Keywords: microwave; drying; rice; starch

The use of the microwave (MW) heating allows to achieve the following effects in rice: to improve its physical and chemical characteristics; to optimize cooking conditions (save energy and cleanup time); to keep its nutritional and sensory properties; to substitute steaming and conventional drying during rice parboiling process by microwave treatment; to optimize the processing of puffed rice products.

Parboiled rice (rice partially boiled, cooked) exemplifies the application possibilities of MW heating (BHATTACHARYA & ALI 1985; MARSHALL & WADSWORTH 1994). The conventional parboiling process consists of the soaking of rough rice in water until it is saturated, draining of excess water and then steaming or other heating to gelatinize starch. The temperature of gelatinization reaches about 65°C. Grain is then dried and the drying method is very important for the parboiling process. The flow chart on Fig. 1 shows the possibilities of MW heating application in the processing of parboiled, expanded and flaked rice.

High heating rates and the absence of surface changes in food belong to common virtues of microwave energy. On the other hand, uneven product heating and local temperature differences in heated material are the main disadvantages of microwave application. Microwave ovens are widely used for cooking and food tempering (nemá zde být heating?), drying and processing. In some applications the duration of MW exposure has no pronounced influence on sensory evaluation (WADSWORT & KOLTUN 1986; DOOS *et al*. 1993). Many studies showed equal or better retention of some vitamins (B_1, B_2, B_6, C and folic acid) after MW heating compared with conventional heating (CROSS & FUNG 1982; HOFFMAN & ZABIK 1985). However, conversion of vitamin B_{12} to inactive degradation products occurs in foods during MW heating (WATANABE *et al*. 1998). The efficiency of drying of grains and seeds is improved by microwave finishing and consequent reduction of drying time.

The main task of this paper is an evaluation of the influence of microwave treatment on physical and chemical changes in rice.

MATERIAL AND METHODS

Parameters of microwave oven: Whirlpool MT 243/UKM 347, frequency 2450 MHz, MW power output: 90, 160, 350, 500, 650, 750, 850, 1000 W, inner cavity volume 25.4 l.

Measurement of absorbed power: Before each measurement the MW oven was preheated by heating 2 l of water for 5 min and the absorbed power according to IEC 705 test was determined. The relationship between the absorbed power and power output is plotted in Fig. 2, the vertical bars represent standard errors of the means (*n* = 15). A 200 g sample of rice (in an open plastic rectangular vessel, dimensions 165 × 112 mm) was heated in the oven, without the rotation of the turntable. There was

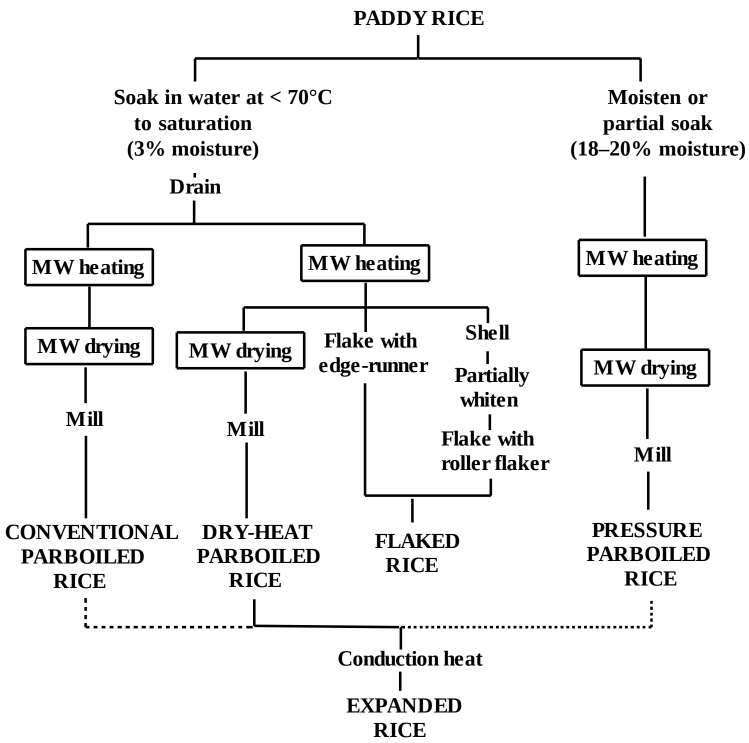

Fig. 1. Flow chart of the possibilities of MW heating application in processing of parboiled, expanded and flaked rice – modified according to BHATTACHARYA and ALI (1985)

a 30 min. break between each two measurements in the oven.

Temperature measurement: During the heating periods sample temperature was recorded using the NoEMI fiber-optic temperature system – table-top unit ReFlex, with 2 channels, Nortech Fibronic Inc., Canada. General characteristics: ultra-fast general purpose miniprobe, temperature range –40 to +250°C, response time 0.25 s, computer interface RS-232-C, data logging function to spreadsheet-compatible file MS Excel, analogue output 0–20 mA. The teflon probeguide was made to position NoEMI optic probes into pre-determined locations inside the oven and in the samples measured (Fig. 3).

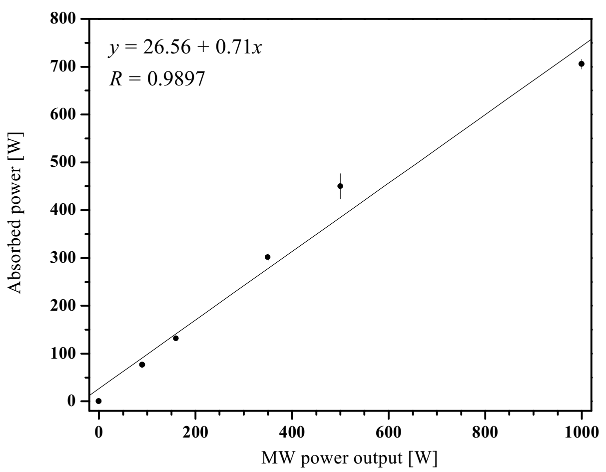

Fig. 2. Relation between absorbed MW power and MW power output

Time-temperature dependence during MW heating: Rice temperature increased rapidly during microwave heating as a result of exposure to microwave energy, but little drying occurred during that time. After reaching of required temperature, MW power was switched off and the rice sample was retained in the MW cavity for 1 min. Then the sample in the vessel was removed from the oven, mixed, cooled to ambient temperature (again for 1 min) and returned to the oven. This cycle of heating, mixing and cooling was repeated five times. A typical course of time-temperature relationship during a MW treatment to the final temperature, 60°C is illustrated in Fig. 4. Temperature was measured by one probe 50 mm on the right from the middle, in location where the highest temperature there was (see Fig. 3).

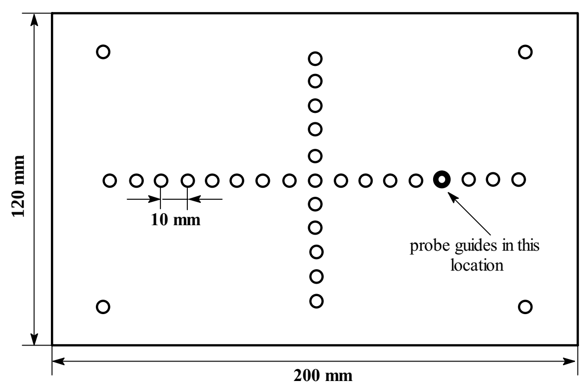

Fig. 3. Top of view of plastic probeguide used to guide temperature probes into pre-determined locations

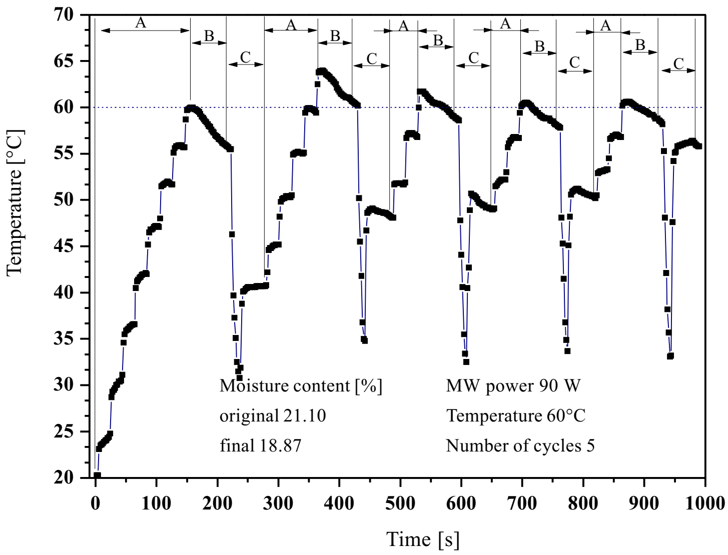

Fig. 4. Typical course of time-temperature relationship during MW treatment of rice to the final temperature 60°C

Conventional and MW drying of rice: Conventional thermal method of rice drying is a very energy-demanding process. Approximately 200 g of rice (soaked in distilled water to moisture content 28.50%) on a metallic sieve (diameter 200 mm, 1 mm mesh) was placed on the upper shelf of a laboratory hot-air drying oven at 80°C. Surface temperature and moisture content of the sample were measured repeatedly in 20 min intervals until a moisture content equilibrium was achieved (about 7 hrs). The data obtained were used for a quantitative description of the drying process.

Conditions of MW measurement: Power output was changed from 90 to 160, 350 and 500 W; final temperature of heated rice was 40, 60 and 80°C; initial moisture content of rice was 11, 21 and 30%.

Determination of starch gelatinization temperature: The alkali spreading value test was the simplest and fastest test of rice grain degradation. Six grains of rice were random selected from MW treated sample and incubated in 10 ml of 1.7% KOH at room temperature for 23 hrs. The degree of spreading was evaluated using a seven-point scale as follows: 1 – grain not affected, 2 – grain swollen, 3 – grain swollen, collar incomplete and narrow, 4 – grain swollen, collar complete and wide, 5 – grain split or segmented, collar complete and wide, 6 – grain dispersed, merging with collar, 7 – grain completely dispersed and intermingled. Alkali spreading values correspond to gelatinization temperature as follows: 1–2 high 74.5 – 80°C; 3 high-intermediate; 4–5 intermediate 70–74°C; 6–7 low, below 70°C (JULIANO 1985).

Determination of total starch: The Megazyme total starch analysis procedure (AA/AMG) (AOAC Method 996.11, AACC Method 76.13) allows the measurement of total starch in most cereal products, including rice. Starch hydrolysis proceeds in two phases. In phase I starch is partially hydrolyzed and totally solubilized. In phase II starch dextrins are quantitatively hydrolyzed to glucose by amyloglucosidase. Complete solubilization of starch is achieved by cooking the sample in the presence of thermo stable α-amylase.

Table 1. Selected results of alkali spreading values test during MW treatment of rice

Number of measurement	Temperature MW heating [°C]	Moisture content [%]	Absorbed MW energy [W × s]	Relative frequency of alkali spreading values for gelatinization temperature 70–74°C [%]	below 70°C [%]
37	original rice	11.90	0	72	28
3	40	11.89	5 431	72	28
2	40	21.10	10 241	72	28
15	60	11.93	13 304	67	33
1	40	29.02	13 965	61	39
14	60	22.68	25 304	67	33
36	80	12.12	28 644	78	22
13	60	28.58	34 434	50	50
35	80	21.43	47 124	39	61
34	80	28.79	52 668	39	61

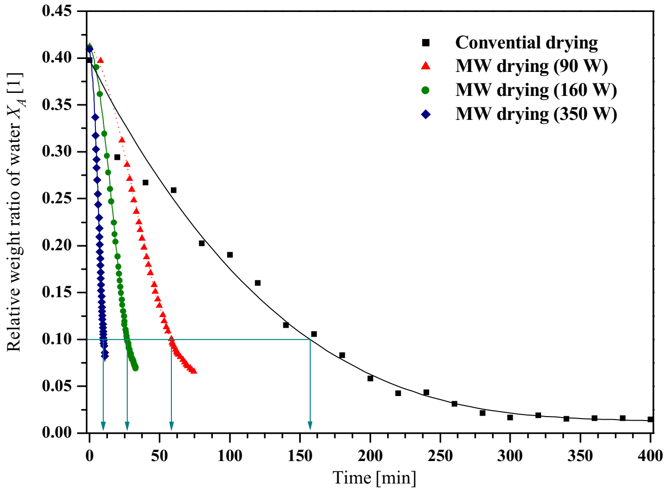

Fig. 5. Conventional and MW drying curves of rice

RESULTS AND DISCUSSION

Compared with conventional drying, the course of MW treatment of rice is much faster. Relative weight ratio of water $X_A = 0.1$ was achieved by conventional rice drying after 160 min, whereas by MW treatment this was achieved: at 90 W power output after 58 min, at 160 W after 27 min and at 350 W after 10 min (Fig. 5). The combination of MW treatment and conventional drying enables the reduction of the drying time, chiefly in final period of drying. This may constitute an economic advantage.

Table 2. Average content of total starch in rice during MW heating

Samples of rice					Average content of total starch related to dry matter [%]
P [W]	t [°C]	D_{in} [%]	D_f [%]	N [1]	
90	60	70.24	71.89	5	89.00
90	60	75.34	76.99	5	90.23
90	80	70.32	74.22	5	90.30
90	80	77.23	80.93	5	89.43
90	80	87.87	89.67	5	91.57
90	100	70.93	85.00	5	89.40
90	100	78.40	84.75	5	89.48
90	100	87.87	91.48	5	92.05
500	60	70.14	72.22	5	89.17
500	60	76.80	78.08	5	88.81
500	80	70.35	73.75	5	88.42
500	80	76.19	78.57	5	87.79
500	80	87.87	89.98	5	91.52
500	100	70.15	74.48	5	88.07
500	100	76.38	81.18	5	87.95
500	100	87.87	93.24	5	92.43
90	80	70.67	83.74	25	94.73
90	100	71.02	95.62	23	90.04
500	80	71.87	83.07	25	94.42
500	100	70.84	90.22	25	90.33
Rice without MW treatment					88.96

P – MW power output, t – maximum temperature of rice, D_{in} – initial dry matter, D_f – final dry matter, N – number of cycles during MW heating

Selected results of alkali spreading value test, along with the initial moisture content of rice and a basic characteristics of the MW treatment, are summarized in Table 1. The absorbed MW energy was calculated as absorbed power multiplied by exposure time. Low alkali spreading values (grain completely dispersed and intermingled), corresponding to the gelatinization temperature below 70°C, were observed in samples absorbing MW energy higher than 30 000 Ws at 80°C, moisture content 21 and 29%, and at 60°C, moisture content 29%. Other samples were classified as intermediate, which means that their gelatinization temperature was in the 70–74°C range.

Selected values of average total starch content in rice under various conditions of MW heating are summarized in Table 2. It is obvious from these results that MW treatment does not affect the total content of starch in rice.

Some results of these experiments were presented as oral communications and posters on conferences (KAASOVÁ *et al.* 2000; KADLEC *et al.* 2000a,b).

CONCLUSION

The gelatinization of rice starch is progressing faster during MW treatment than during conventional treatment. The initial moisture content of rice is one of the main limiting factors of MW exposure times: increased MW exposure requires higher initial moisture content of rice. Reduction of drying time and the stability of total starch content during microwave treatment allows recommending the combination of microwave treatment and conventional drying of rice for further use.

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Souhrn

KAASOVÁ J., KADLEC P., BUBNÍK Z., POUR V. (2001): **Mikrovlnné sušení rýže**. Czech J. Food Sci., **19**: 62–66.

Teplota vzorků rýže při mikrovlnném ohřevu byla měřena a vyhodnocována pomocí automatického systému NoEMI s optickými vlákny. Výkon zařízení byl měněn v rozsahu 90, 160, 350 a 500 W; konečná teplota ohřevu rýže byla 40, 60 a 80 °C a původní vlhkost rýže byla 11, 21 a 30 %. Teplota mazovatění byla vyjádřena pomocí alkalického testu a dále byl sledován obsah celkového škrobu. Vzhledem k tomu, že při mikrovlnném sušení rýže dochází k podstatnému zkrácení doby sušení a současně nedochází ke změnám v obsahu škrobu, je možné pro další využití doporučit kombinaci konvenčního a mikrovlnného sušení rýže.

Klíčová slova: mikrovlny; sušení; rýže; škrob

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