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Effect of Microwave (Mw) Treatments of Resistant and Native Starches

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***Abstract:** Instead of consumption of traditional natural foods the refined foods containing high calories are consumed every day leading several diseases. The consumption of a high amount of resistant starches may improve glucose and lipid metabolism can reduce the risk of several diseases. The main aim of the study was to examine the effect of microwave (MW) treatment of resistant and native starches as in present day there is an increasing trend to use the microwave in food preparation. The objective of the study was to examine the effect of microwave (MV) treatment on resistant and native starches. Two samples of untreated native starches and resistant starches were microwaves treated according to 2^2 experimental design. The result shows that the cooking step affects significantly higher degradability in wheat, maize, and Rs4 stanches compared to RS2 starch. Different types of RS behave similarly in the case of dry heat treatment moreover; the more intense moisture heat treatment causes different changes in the properties of RS.*

***Keywords:** Native Starch, Resistant Starch, Microwave (MW), Enzymatic Digestibility, Food Process.*

INTRODUCTION

In present, a lot of changes have been seen in eating habits of the population. Instead of consumption of traditional natural foods, the refined foods containing high calories are consumed every day. Sedentary lifestyle and changes in the eating habits caused obesity worldwide. Obesity leads the risk for hypertension, dyslipidemia, diabetes mellitus type II, heart disease and many other chronic diseases. Diet rich in dietary fiber is considered to generally low in saturated fat and have several other health benefits. Therefore, many national authorities have recommended greater consumption of grain and fiber rich products to control weight. The national academy of sciences of the Institute of medicine has recommended a daily intake of the fiber of 38g/day for adult men and 25g/day for adult women. However, the mean intake is now maximum 20g/day. The consumption of dietary fibers seems to be a promising solution according to the definition. Dietary fibers are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fibers promote beneficial psychological effects including lavation, and/or blood cholesterol attenuation, and or/blood glucose alteration. Resistant starch that escapes digestion in the human small intestine appears to have a unique combination of physiological and functional properties compared to traditional types of fibers. The consumption of a high amount of resistant starches may improve glucose and lipid metabolism can reduce the risk of diabetes mellitus type 2, coronary and heart diseases and well as colorectal cancer and other gastrointestinal disorders. Additionally, commercial resistant starches have desirable physicochemical properties making it useful in a variety of foods. Moreover, resistant starches do not influence the sensory properties of starch based products (bread, pasta, cookies, pudding, yogurt etc.) significantly. The demand for the application of resistant starch as a functional ingredient is growing. Thus, the analysis of it structural, Thermal properties have great importance. The understanding of the relationship between structural characteristics and functional as well as nutritional properties of resistant starches can help food producers in optimizing the industrial application.

Starch is the dominant carbohydrate reserve material of higher plant being bound in leaf chloroplast and in the amyloplasts of storage organs such as seeds and tubers. The fraction of starch that escapes digestion in the small intestine and cannot be digested within 120 minutes is defined as resistant starch (Rs). Resistant starch has been classified into four general subtypes called RS 1, RS 2, RS3 and RS 4.

There are several mechanical and physical treatments in the food production, which affects the extent and rate of starch hydrolysis, the amount of resistant starch, as well as the role, played by resistant starch in human digestive fact. In the present day there is an increasing trend to use microwave energy in food processing. It was aimed to examine the effect of microwave conditions on RS enriched food products.

Starches can be beneficial for nutritional purposes in view of the decreased digestibility as a result of the applied treatment (Anderson and gray, 2006)[1]. Almost all food is heat treated before being eaten. A wide range of techniques is being used by the food industry for processing the various food materials. The different processes cause alterations in food structure and also influence the nutritional characteristics of the food (Singh et.al. 2010)[2].The extent and type of the changes depend on the variety of the starch as well (lewandowiez et.al. 2000)[3].

OBJECTIVE OF THE STUDY

The objective of the study was to examine the effect of microwave (MV) treatment on resistant starch and native starches.

METHODOLOGY

Wo samples (20.0 ± 0.1g of untreated samples in open glass vessel, 120 mm in diameter, the height of the starch layer was 5 mm) of the native (maize and wheat starches) and resistant starches (its-maize™ 260 and Fibersym™ RW) were microwave (MV) treated according to a 2^2 experimental design. The two part of the same sample were mixed resulting 40.0g from each sample. Maize was marked as M, wheat as W, Hi-Maize™ 260 as H and fibersym™ RW as FW. Irradiation was carried out for 30 (factor one, level one) or 150 S (factor one, level two) with a Samsung microwave oven under 300 (factor one, level one) or 600 W (factor two, level two) of microwave power. Table - 1 shows the MW treatment in the increasing order of the hypothetically transmitted MW energy. In the coding of samples the intensities followed given below:

Coding of the treatment	Time (S) power	Microwave energy (KJ)
O (untreated)	-	-
1	30*300	9
2	30*600	18
3	150*300	45
4	150*600	90

RESULT AND DISCUSSION

The effect of microwave (MW) treatment on resistant and native starches. The effects of the microwave treatments on RS were followed up using enzymatic and rheological methods. Two different near infrared spectrophotometers were compared to each other investigating their sensitivity in the analysis of the MW-treated starches.

The result of the in vitro enzymatic digestion of microwave-treated starches.

The enzymatic digestibility curves of starches can be seen in Figure 1 while the typical kinetic parameters are shown in Table 1. The characteristics of the kinetic curves of untreated samples are in agreement with the previously observed facts. The W starch was the most digestible, M and H starches showed similar characteristics while Fw starch was the most resistant to alpha-amylase due to its phosphorylated and cross-linked structure. The MW treatments did not cause significant differences in the shape of the kinetic curves (Figure 1) in the case of the different starches. The curves are running mostly together, no tendencies can be observed by increasing the MW energy. Additionally, the rate constant of the digestion. (Table 1) which is the velocity of glucose liberation did not show any significant tendencies caused by the increasing energy of the treatments. Similarly to the k parameter, the two other digestibility parameters were not significantly different before and after the most intense treatments in case of W, H, and Fw starches. In the case of M starch, the presumable final glucose concentration (Y180) increased (M0-M4); however, no tendencies could be observed by increasing the energy of the treatments. The AUC value of M starch remained significantly not different after the most intense treatment. These results are in accordance with the study of Anderson & Guraya (2006) who studied waxy and non-waxy rice starches and found only minimal changes in digestibility even after longer MW treatments (60 mn, from 300 to 1200 W of power) compared to this study.

Results of the RVA method

The RVA curves of the native and resistant starches before and after treatments can be seen in Figure 1. According to Gelencser et al. (2008a), the resistant starches do not gelatinise below 100°C. It was found that they did not gelatinise even after MW treatments independently on the time and the power of the treatments or the type of RS (Figure 1c and 1d). Therefore, mixtures were made by using a single treated resistant starch in 40% and a single untreated maize starch in 60%. The RVA curves of the RS containing mixtures are depicted in Figure 2c and 2d.

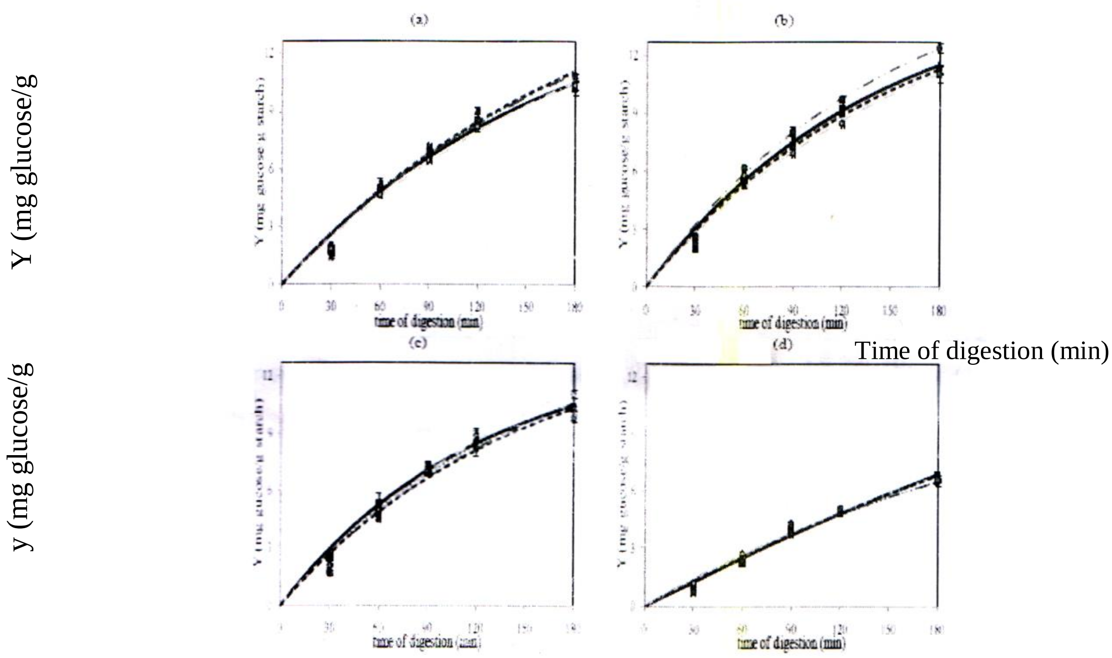

Figure 1 : The digestibility curves of the untreated and microwave treated native and resistant starches (a) M starch, (b) W starch, (c) H starch, (d) Fw starch

Table 1 : Changes of the typical kinetic parameters of M, W, H and Fw starches affected by microwave treatments

	(a) M samples		
Sample	*AUC* (mg/g)*min	*Y180 (mg/g)*	*k (1/min)*
M0	1104.3±31.4ab	10.26±0.35a	0.0063±0.0009a
M1	1106.5±7.8ab	10.69±0.22ab	0.0052±0.0006ab
M2	1126.3±31.5ab	10.87±0.16bc	0.0051±0.0010ab
M3	1061.7±41.8a	10.41±0.48ac	0.0046±0.0010b
M4	1130.7±9.0b	10.92±0.21bc	0.0052±0.0009ab
	(b) W samples		
Sample	*AUC* (mg/g)*min	*Y180 (mg/g)*	*k (1/min)*
W0	1223.3±31.6a	11.26±0.23ac	0.0071±0.0008a
W1	1218.7±16.1ad	11.39±0.07a	0.0066±0.0004ab
W2	1309.5±16.3be	12.17±0.43b	0.0068±0.0007ab
W3	1149.0±31.2c	11.04±0.14c	0.0059±0.0008b
W4	1194.0±57.4acde	11.06±0.92abc	0.0066±0.0013ab
	(c) H samples		
Sample	*AUC* (mg/g)*min	*Y180 (mg/g)*	*k (1/min)*
H0	1146.0±61.2ab	10.38±0.55ab	0.0080±0.0015a
H1	1131.7±31.1ab	10.37±0.43ab	0.0067±0.0004ab
H2	1098.3±18.8a	10.37±0.25ab	0.0058±0.0005b
H3	1158.3±21.8b	11.12±0.40a	0.0050±0.0014b
H4	1093.3±27.0a	10.10±0.17b	0.0065±0.0003ab
	(d) Fw samples		
Sample	*AUC* (mg/g)*min	*Y180 (mg/g)*	*k (1/min)*
Fw0	634.5±10.1a	6.78±0.19a	0.0016±0.0014a
Fw1	631.4±8.0a	6.46±0.12b	0.0031±0.0004a
Fw2	640.0±10.0a	6.28±0.29ab	0.0036±0.0012a
Fw3	647.0±12.9a	6.61±0.28ab	0.0025±0.0009a
Fw4	642.5±22.8a	6.64±0.11a	0.0023±0.0018a

Values represent means of triplicates ± SD. Within the same column, the values with the same superscript are not significantly different ($p < 0.05$).

All RVA parameters of the curves except the peak time can be found in Table 2. The peak time did not show any significant differences, therefore, it is not shown.

Analysing the RVA curves and RVA parameters, it can be said that the more intense treatments caused changes in the rheological properties of the investigated starches dependent on the type of starch. The curves are running lower applying higher MW energy (Figure 2).

All RVA parameters except the pasting temperature (PT) showed decreases in the proper values of the native starches (Table 2). In the case of resistant starch containing mixtures and of M and W starches; the peak viscosity (PV), trough (TR) and final viscosity (FV) were lower after the treatments. However, the effects of the treatments were only significant in the case of the most intensive treatments (W starch and Fw starch containing mixtures) or the two most intensive treatments (M starch and H starch containing mixtures). Other studies also showed that the rheological properties of lentil starch or Canna edulis starch.

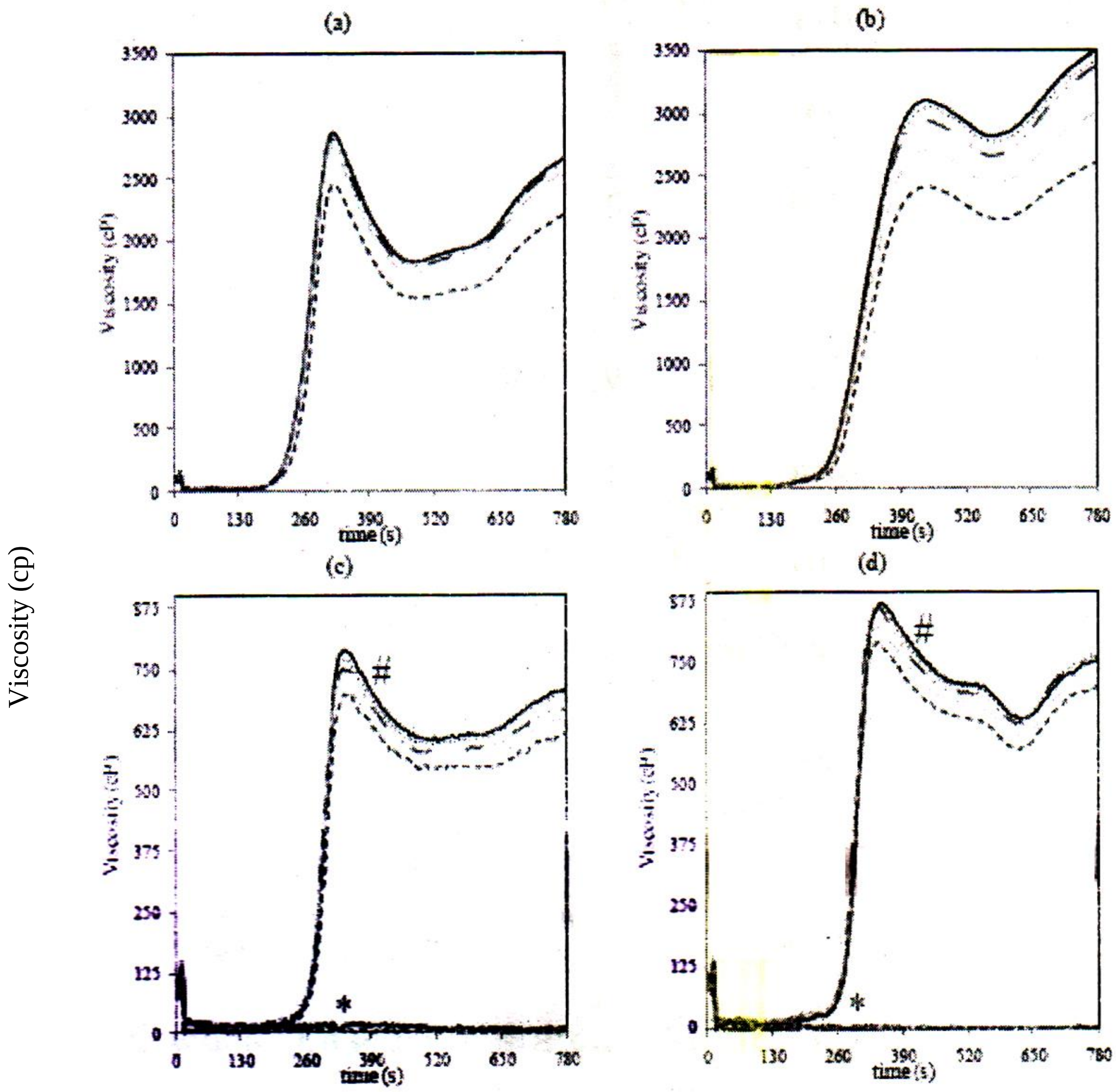

Figure 2 The RVA curves of the untreated and microwave treated native and resistant starches a) M starch, (b) W starch, (c) * = H starch, # = mixtures of 40% H and 60% untreated M starch, (d) Fw starch, # = mixtures of 40% F and 60% untreated M starch.

Were significantly lower after a six- minute's long MW treatment of 650 W power. The analysis of the experimental design showed that the alterations of the time of the treatment caused significant effects on some RVA parameters of samples (W starch: TR, FV; H starch containing mixtures: TR; Fw starch containing mixtures: PV, TR, FV) while in other cases not only the time but the power of the treatment was also significant (M starch: PV, TR, BD, FV, SB; W starch: PV, SB; H starch containing mixtures: PV, FV).

The pasting temperature did not change in W starch and wheat-based Fw starch-containing mixture while in M starch and maize-based H starch enriched mixture it increased significantly compared to the control one in the case of the most intensive treatment. These results are in accordance with the observations of Lewandowicz et al. (2000)[3] who found a shift in the gelatinisation range to higher temperatures in longer treated native starches.

Table 2: Changes of RVA parameters in M, W starches, and mixtures containing 40% of H and Fw starches affected by microwave treatment

(a) M samples

Sample	PV (cP)	TR (cP)	BD (cP)	FV (cP)	SB (cP)	PT (°C)
M0	2871.5±9.2a	1830.5±21.9a	1041.0±31.1a	2658.5±14.8a	828.0±7.1a	78.2±0.0a
M1	2859.5±2.1a	1834.5±19.1a	1025.0±17.0a	2658.5±13.4a	824.0±5.7a	78.6±0.5ab
M2	2815.5±34.6ab	1794.0±19.8a	1021.5±14.8a	2612.0±45.3ab	818.0±25.5a	77.9±0.5a
M3	2751.5±2.1b	1740.0±25.5a	1011.5±23.3a	2548.0±2.8b	808.0±22.6a	77.8±1.7ac
M4	2456.5±37.5c	1538.0±11.3b	918.5±26.2a	2208.5±12.0c	670.5±0.7b	81.1±0.7bc

(b) W samples

Sample	PV (cP)	TR (cP)	BD (cP)	FV (cP)	SB (cP)	PT (°C)
W0	3063.0±15.6a	2528.5±38.9a	534.5±23.3a	3490.5±41.7a	962.0±2.8a	84.3±0.5a
W1	2988.5±37.5a	2453.0±90.5a	535.5±53.0ab	3404.5±79.9a	951.5±10.6a	85.2±0.6a
W2	2917.5±77.1a	2437.5±152.0a	480.0±75.0ab	3361.5±191.6a	924.0±39.6a	85.6±1.2a
W3	2671.5±145.0ab	2208.0±132.95ab	463.5±12.0a	2998.0±209.3ab	790.0±76.4ab	85.9±1.8a
W4	2380.5±7.8b	1964.0±15.6b	416.5±7.8b	2594.5±6.4b	630.5±9.2b	87.2±1.1a

(c) H starch containing mixtures

Sample	PV (cP)	TR (cP)	BD (cP)	FV (cP)	SB (cP)	PT (°C)
M-H0	790.5±4.9a	600.5±2.1a	190.0±7.1a	708.5±0.7a	108.0±1.4a	90.4±1.1ab
M-H1	771.0±0.0b	592.0±1.4b	179.0±1.4a	701.0±2.8a	109.0±1.4a	91.3±0.1a
M-H2	753.0±11.3abc	576.5±7.8ab	176.5±3.5a	667.5±7.8b	91.0±0.0b	90.8±0.7abc
M-H3	729.5±2.1c	541.5±3.5c	188.0±5.7a	649.5±12.0bc	108.0±15.6ab	90.4±0.1b
M-H4	697.0±1.4d	536.5±9.2c	160.5±7.8a	616.0±2.8c	79.5±6.4b	92.8±0.0c

(d) Fw starch containing mixtures

Sample	PV (cP)	TR (cP)	BD (cP)	FV (cP)	SB (cP)	PT (°C)
M-Fw0	877.0±5.7a	638.5±2.1a	238.5±7.8ab	760.0±11.3ab	121.5±13.4a	92.4±0.5ab
M-Fw1	873.5±7.8a	635.0±12.7ab	238.5±4.9ab	773.0±2.8a	138.0±9.9a	92.1±0.0a
M-Fw2	868.0±12.7ab	624.5±10.6ab	243.5±2.1b	767.5±24.7ab	143.0±14.1a	90.8±0.6ab
M-Fw3	832.5±2.1bc	602.0±5.7b	230.5±3.5a	732.5±4.9b	130.5±0.7a	91.7+0.6ab
M-Fw4	800.5±14.8c	576.5±14.8b	224.0±0.0a	706.5±24.7a	130.0±9.9a	91.2±0.0b

PV = peak viscosity, TR = trough, BD = breakdown, FV = final viscosity, SB = setback, PT = pasting temperature

Values represent means of duplicates ± SD. Within the same column, the values with the same superscript letters are not significantly different ($p < 0.05$)

CONCLUSION AND SUGGESTIONS

The cooking step affects significantly higher degradability in wheat, maize, and RS4 starches compared to Rs2 starch. Rs4 starch lost the majority of the enzymatic in susceptibility against alpha-amylase while Rs2 possibly.

Changed to Rs3 and because of more resistant in the applied test. In maize or wheat starch-based mixtures, the addition of Rs2 reduced the values of total area under the curve (totally liberated glucose during a three-hour period) as well as the rate constant of the digestion linearly. These results seem to be promising and important facts for the application of Rs2 in the food industry because K and KUC values can be predicted in the function and high amylase Rs2 addition. Additionally, no synergistic effects can be determined in maize or wheat base model systems, which is also notable information for product development. No significant tendencies can be observed in the digestibility of resistant starches coursed by increasing the microwave energy and characteristics of kinetic curves remain unchanged. The resistant starches don't gelatinise even after microwave treatment in the applied procedure. The microwave treatment deteriorated the rheological properties of all starches.

As the main conclusion that the resistant starches can be characterized using new methods in their analysis. Different types of resistant starches behave similarly in the case of dry heat treatment (Microwave, a newer investigated effect) however; the more intense moisture heat treatment causes different changes in the properties of RS. The newer applied method can help the food analysts to understand the properties of resistant starches (RS) more widely. Moreover, the knowledge of the effects of newer technologies and use of adjustment help food producers to preserve the beneficial properties of resistant starches even after various technological steps.

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