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Effect of microwave treatment on phytochemical, functional and rheological property of Kodo millet (*Paspalum scrobiculatum*)

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Abstract

Present study investigates effect on phytochemical, functional and rheological properties of microwave treated Kodo millet. The results obtained from study shows significant difference in the colour characteristics. L^* value decrease from 75.22 to 67.93. ΔE values highest at sample treated at highest power and time setting. TPC was increase from 2.64 to 4.67 mg GAE /100g and Free radical scavenging activity found decrease from 91.12 - 87.94% at higher power and time level. WAC increase from 0.98 g/g to 1.12 g/g and OAC decrease from 0.84 g/g to 0.78 g/g at higher power and time setting. Similarly, power level time setting shows significant effect on pasting property on peak viscosity, holding viscosity, breakdown viscosity, final viscosity and setback from trough, from 2856 to 609.5, 1355 to 255.5, 1409.5 to 365.7, 4721 to 1501, and 3365 to1245 respectively. The microwave treated Kodo millet flour with enhanced functional and rheological and antioxidant property. It could be used for the functional food product development, bakery extrusion and products.

Keywords: Kodo millet, microwave treatment, pasting property, total phenols, antioxidant activity

1. Introduction

Numerous minor annual grass are grown in rain fed ecosystem, usually in general called as 'small millet'. This are ancient grain, which consumed by the human population earlier widespread acceptance of fine cereals. This cereal are nutritionally good and these are all together called as "nutricereals". Kodo millet (*Paspalum scrobiculatum*) is one of the nutricereals. Kodo millelt widely distributed damp habitats across world tropic and it was around 3000 year ago demonstrated in India (de Wet *et al*., 1983) [8]. In India, kodo millet is largely grown in tribal region now it is largely consumed by the many people because of its nutritional value. It is also known as various names as Khoddi in Urdu, Arikalu in Telagu, Varagu in Tamil and Kodra in Gujarati, Punjabi and Marathi. It is use as whole grain for preparation of idli, dosa, chapati, pongal, soup etc. Among all benefits kodo millet is known for various health benefits. In various studies the kodo millet superior in antioxidant and phenolic content (Vali Pasha *et al*., 2018) [20]. Moreover, kodo millet has the potential to control lipid peroxidation in human cholesterol through antioxidant and phenolic property (Chandrasekara *et al*., 2012) [4]. For avoiding diabetic complication kodo millet and their product are useful due to lower glycemic index (Chaudhary Kanchan, 2013) [5] Because of nutritional benefit of kodo millet is used in the various product as a main ingredient or part of the product such as pasta, curd, probiotic, beverage, functional ingredient (Arya & Shakya, 2021; Bora *et al*., 2019) [2, 3].

Several researches were undertaken on kodo millet mainly because of its nutritional benefits. The research are focused on drying (Yogendrasasidhar, Energy, and 2018) [21], kodo based extruded products and pasta (Deshpande *et al*., 2015; Geetha *et al*., 2014) [9, 10], nutritional evaluation of germinated kodo millet (Sharma *et al*., 2017) [9], functional ingredient study for obesity management, effect of hydrothermal processing on millet (Chandrasekara *et al*., 2012) [4]. Therefore more research needs to be undertaken to explore effective utilization of kodo millet and effect of various processing treatment on its various quality parameters. Microwave treatment wildly use in processing of the grain for disinfestation and fugal contamination control quality improvement (Das *et al*., 2014) [7]. Moreover, microwave processing used in heating, cooking, roasting, sterilization, tempering and thawing alternate to conventional method (Hojjati *et al*., 2015) [11]. Effect of microwave on various grain have been investigated such as millet, groundnut, cashew nut, etc. (Oyeyinka *et al*., 2019) [5].

There is need to generate logical data on millets for the further utilization of microwave treated kodo millet for product development and industrial use. The present study is mainly focused on the effect of microwave on kodo millet properties (Color, functional property, phytochemical, rheological properties). This study will benefit researchers and industry to develop microwave treated kodo millet based value added functional food.

2. Material and Methods

The major ingredient such as kodo millet (Paspalum Scrobiculatum) was procured from South Indian Grain Corporation Ltd., Paramakudi, Tamil Nadu. Sample was stored in room temperature under clean and dried area. Moisture (10.05%) was determined by infrared moisture analyzer (SHIMADZU MOC-120H). All chemicals used in this study were of analytical grade and Gallic acid standard and 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) was procured from Sigma-Aldrich Co. LLC. (India).

2.1 Microwave treatment

The kodo millet (50g) was treated at 720 W, 540 W and 360 W power for different time interval of 150, 210 and 270 sec in the domestic microwave (MW) oven (Model: 30 SC2, IFB, India) having an operating frequency of 2450 MHz was used. For treatment sample kept in Petri dish and treated under different microwave power and time setting. Treated sample allow to cool in room temperature and store in airtight container further sample was analyze and all sample was grind and pass through BSS-sieve -355. The samples were stored in airtight container till further analyses.

2.3 Colour characteristics measurement

Color parameter denoted by L*, a* and b* for lightness, redness and yellowness respectively were measured lab colour hunter meter (Colourflex EZ model: 4510) Hunter Associates Laboratory, Reston, VA of all kodo flour sample. Total colour difference (ΔE) treated sample was calculated by equation (1) and in detail instrument first calibrated with a standard white and green board then sample in petri dish was evaluated.

$$\Delta E = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2} \quad (\ldots 1)$$

2.4 Determination of kodo millet flour functional properties

2.4.1 Kodo millet four water absorption capacity (WAC)

Water and oil absorption capacity were determined by Bora *et al*. (2019) [3] with slight modification for WAC three gram millet flour sample in previously weighed empty tube were measured and mixed with 25 mL deionized water for 25^{0}C, 30 min and centrifuged at 6000 RPM for 30 min. After excess water was drain and tube with sediment were dry for 25 min at 50 ^{0}C in hot air oven and WAC of kodo flour was determined by (Eq.2)

$$\text{WAC (g/g)} = \frac{\text{(weight of tube with sample} - \text{weight of tube)} - \text{sample weight}}{\text{sample weight}} \quad (\ldots 2)$$

2.4.2 Kodo millet four Oil absorption capacity (OAC)

For OAC (0.5g) flour sample was taken in previously weighed empty centrifuge tube and flour samples was mixed by adding 6 mL of soybean oil. Then, centrifuge tube mix was kept at 25^{0}C for 30 min in incubator. Afterward incubated sample was centrifuge at 5000 RPM for 25 min and oil poured to drain. Tube were reversed for 10 min to drain off excess not absorbed oil before weighing. OAC of the kodo flour samples was determined by (Eq.3). Oil in gram per gram of sample.

$$\text{WAC (g/g)} = \frac{\text{(weight of tube with sample} - \text{weight of tube)} - \text{sample weight}}{\text{sample weight}} \quad (\ldots 3)$$

2.5 Determination of total phenolic content (TPC) and free radical scavenging activity.

The total phenolic content (TPC) and free radical scavenging activity was determined according to procedure described by the Sharanagat *et al*.(2019) [18]. Kodo millet flour sample (0.6g) were mixed with the 15ml solution of 80% (v/v) water-methanol and incubated at in the shaking incubator (New Brunwick Scientific) for 1 h at 40^0 C, 150 rpm for sample extraction.

For TPC (100 µL) extract was add with 2.5 mL (10%v/v) FC reagernt (Folin – Ciocalteu) and neutralized with addition of 2.0 mL making Na_2CO_3 (7.5%) and then the solution was keep in a hot water bath at 45^{0}C for 45 minute and solution absorbance was read by using UV- spectrophotometer at 765 nm. Phenolic content was quantified preparation of gallic acid standard curve and data expressed for kodo flour as mg gallic acid equivalent (GAE)/100 g.

The kodo millet flour for Free radical scavenging activity of extract was measured using DPPH (1,1 –diphenyl-2 picrylhydrazyl). 2 ml of sample extract used for previously for TPC was mixed with 2 ml (1Mm) DPPH solution made with methanol and solution mix were incubated in dark place at room temperature for 30 min. and then mixture of solution absorbance was read using UV spectrophotometer at 516 nm. The free radical scavenger ability was determined as%DPPH versus a blank.

2.6 Determination of kodo millet flour rheological (pasting) properties

Pasting properties of kodo millet flour were determined according to the method of Sharanagat (2019) [18] by using Rheometer instrument (MCR 52, Anton Paar Co. Ltd). A Kodo flour samples (3g) was mixed with 25ml of water Stirred in the sample container and stirred mix at 50°C for 1 min. After equilibration, as per temperature protocol the mix was heated from 50 to 95 °C at the rate of 6 °C per min. Then, the blend was keep warm at 95 °C for 5 min, cool to 50 °C at the rate of 6 °C per min and finally keep warm again at 50 °C for 2 min.

2.7 Statistical analysis

Statistical analysis was carried out by using one-way analysis of variance (ANOVA), MINITAB-17 was used as a statistical tool to perform Tukey honest significance difference for comparing means at a 95% significance level and all analysis done in triplicates.

3. Results and Discussion

3.1 Effect of Microwave treatment on Kodo millet colour characteristics

The effect of microwave heating changes the colour characteristics kodo millet flour given in the table (1). The colour characteristics values among all control and treated samples showed a significant difference at 95%. The L* value rise 77.12 (control) to 79.32 at (540 W3 for 210 sec). This may be due to the reduction in moisture content and after grinding of grains development of the glazed of flour. During mild heat treatment lightness of the flour due to the denaturation of protein and oil concentrate attached to protein matrix this may be one of the reason for increase in lightness of flour for the sesame seed and hazelnut given by Kahyaoglu & Kaya, (2006) [12] and Özdemir & Devres, (2000) [16] respectively. On other hand decrease in L* value at power level 720 W for time duration 210 and 270 sec. compare to control are 75.22 and 67.93 respectively. The change in the power level and increase time roasting will accurse in grain due to higher temperature. The change in L* value is inversely proportional to degree of roasting and the result data supported by the data of (Corrales *et al*., 2017) [6] in sesame seed.

In the values of the a* and b* found early decrease in lower time and lower power level compare to control value and further increase in the higher time and power level increase given in the table 1. The* value indicate redness and b* value indicates yellowness of the color characteristics and among all microwave power level kodo millet flour shows increase from control a* value 2.47 to 5.84 on 720 W for 270 sec treated sample and b* values of control 15.89 to 20.66 on 720 W for 270 sec treated sample. This may be due to maillard reaction, caramelization and related to heating oxidation of polyphenols (Sharanagat *et al*., 2019) [18]. ΔE values are also increase with respect to the increase in time and power level. The ΔE values lowest 1.4 sample treated at 360 W for 150 sec and highest at sample treated at 720 W for 270 sec. Present study data on effect of microwave treatment on kodo millet flour colour characteristic is supported by microwave roasting of the sorghum millet (Sharanagat *et al*., 2019) [18].

3.2 Effect of Microwave treatment on phytochemical properties

Total phenolic content of microwave treated millet is found to be increase in the present study among all treated sample kodo millet treated at 720 W power showed a significant difference at 95%. TPC from 3.26 to 4.32 mg GAE/100g similarly microwave roasting of sorghum millet in TPC was increase from 2.64 to 4.67 mg GAE /100g and also heat treatment of chestnut flour increase in TPC content observed they concluded that protein – phenolic component alter chemical structure and degraded hydrolysable tannins smaller phenolic compound the by heat and increase the TPC. On other hand Antioxidant activity (AOA) found highest in the control sample (92.12%) compare treated decrease in treated sample AOA in range of (91.12 -87.94%) similar results was found in the microwave treated sorghum sample flour (Sharanagat *et al*., 2019) [18].

3.3 Effect of Effect Microwave treatment on functional properties

Water/ oil absorption capacity are important for flour sample this parameter are important for defining mouth sensation and flavor holding in food applications related to it. In current study kodo sample treated at 540 W and 720 W for higher time showed a significant difference at 95%. Highest Water absorption capacity (1.12 g/g) at 720 W for 270 sec was observed for flour prepared from kodo millet. and lowest at in control (0.98 g/g) this may be due to formation of porous structure and damage of the grain starch (Khan *et al*., 2016) WAC show the greater affinity for water and structural loss of starch polymer (Adebiyi *et al*., 2016) [1].

Oil absorbance capacity in all among microwave treated kodo millet flour showed a significant difference at 95%. OAC in the present study show the lowest (0.78 g/g) at 720 W, for 270 sec. and in control observed highest (0.84 g/g) the lower OAC may be due to the reduction in apolar amino acid, degradation or dissociation of protein and protein constitute or change in polarity (Obasi *et al*., 2014) [14].

3.4 Effect Microwave treatment on rheological properties

Rheological properties like pasting properties of kodo flour represents the texture profile of and cooking nature of grain flour and its products. Pasting properties include pasting temperature, peak viscosity, breakdown viscosity, holding viscosity, final viscosity and setback from trough. The result of control and microwave treated kodo millet flour are shown in table (4) all properties of flour sample microwave treated at 300 W, 540 W and 720 W continues decrease with increase in time all properties of the flour In control sample flour all values of Breakdown viscosity (1409.5cP), Peak viscosity (2856cP), Holding viscosity (1355cP), Final viscosity (4721cP), Setback from trough (3365cP) and sample treated at (360W For 150sec) is 75.14 Pasting temperature (°C) found highest.

The flour viscosity depends on the functioning of protein degradation, starch swelling, gluten content, gelatinization etc. may be due to kodo millet is gluten free or may disulphide –link aggregates in the present study reduction in the pasting and viscosity at higher power and higher time this may be due to MW lower content of starch, degradation of starch, amylose lipid complex formation (Shah *et al*., 2016) [17] up on microwave heating with respect to time and power level present study supported by the microwave roasting of sorghum (Sharanagat *et al*., 2019) [18] at different power level and time similar trend in present study observed.

Table 1: Effect of microwave colour characteristics

Microwave power (W)	Time (seconds)	L*	a*	b*	ΔE
control	0	77.12±0.11^{c}	2.93±0.02^{d}	15.89±0.17^{d}	-
360	150	78.25±0.13^{b}	2.69±0.02^{e}	15.17±0.01^{e}	1.4±0.23^{d}
	210	78.86±0.07^{ab}	2.61±0.01^{ef}	15.22±0.07^{c}	1.92±0.08^{cd}
	270	79.01±0.18^{ab}	2.53±0.01^{fg}	15.07±0.02^{ef}	2.11±0.23^{cd}
540	150	79.11±0.07^{a}	2.48±0.01^{g}	14.77±0.02^{g}	2.36±0.12^{bc}
	210	79.32±0.5^{a}	2.48±0.02^{g}	14.9±0.05^{fg}	2.36±0.12^{bc}
	270	74.68±0.16^{d}	3.92±0.04^{b}	17.09±0.12^{b}	2.88±0.2^{b}
720	150	78.94±0.55^{ab}	2.47±0.06^{g}	15.04±0.04^{ef}	2.09±0.61^{cd}

	210	75.22±0.13^{d}	3.21±0.07^{g}	16.8±0.09^{c}	2.11±0.15^{cd}
	270	67.93±0.17^{e}	5.84±0.04^{b}	20.66±0.1^{a}	10.55±0.21^{a}

Table 2: Phytochemical analysis of microwave treated kodo millet grain flour

Microwave power	Time (seconds)	TPC	AOA
control	0	3.26±0.09^{b}	92.12±0.5^{a}
360	150	3.29±0.07^{b}	91.22±1.21^{ad}
	210	3.31±0.07^{b}	90.11±0.2^{abc}
	270	3.42±0.09^{b}	89.7±0.7^{bcd}
540	150	3.33±0.07b	89.68±1.2^{bcd}
	210	3.42±0.12^{b}	89.74±0.43^{bcd}
	270	3.46±0.12^{b}	88.13±0.59^{cd}
720	150	3.53±0.05^{ab}	89.17±0.65^{bcd}
	210	3.65±0.2^{ab}	88.79±0.5^{cd}
	270	4.23±0.71^{a}	87.94±0.3^{d}

(Where, TPC= Total phenolic content (mg GAE/100g), AOA-Antioxidant activity (% DPPH))

Table 3: Effect of microwave treatment on functional property of kodo millet flour.

Microwave power (W)	Time (seconds)	WAC	OAC
control	0	0.98±0.01^{b}	0.84±0^{a}
360	150	0.99±0.01^{b}	0.81±0.01^{ab}
	210	1.01±0.01^{b}	0.8±0.01^{b}
	270	1.03±0.03^{b}	0.79±0.01^{b}
540	150	1.01±0.01^{b}	0.8±0.01^{b}
	210	1.02±0.02^{b}	0.79±0.01^{b}
	270	1.05±0.03^{ab}	0.79±0^{b}
720	150	1.02±0.02^{b}	0.8±0.01^{b}
	210	1.06±0.05^{ab}	0.79±0.01^{b}
	270	1.12±0.05^{a}	0.78±0.03^{b}

WAC = Water absorption capacity (g/g), OAC= Oil absorption capacity (g/g)

Table 4: Effect of microwave treatment on pasting property

Microwave power (W)	Time minute	Pasting temperature (°C)	Peak viscosity(cP)	Holding viscosity (cP)	Breakdown viscosity (cP)	Final viscosity(cP)	Setback from trough (cP)
control	0	74.04^{a}	2856^{a}	1355^{a}	1409.5^{a}	4721^{a}	3365^{ab}
360	150	75.14^{ab}	2285^{b}	1184^{ab}	1086^{ab}	4360^{ab}	3176^{ab}
	210	68.14^{ab}	2124^{bc}	1151^{ab}	975.45^{b}	4293^{ab}	3142^{ab}
	270	66.59^{a}	2146^{b}	1173^{ab}	1036.65 ^{ab}	4467^{a}	3294^{ab}
540	150	63.5^{ab}	2083^{bc}	1206^{d}	942.8^{b}	4417^{ab}	3210^{ab}
	210	71.53^{ab}	1910^{cd}	914.2^{bc}	863.05^{b}	4322^{ab}	3308^{ab}
	270	73.29^{c}	1264^{e}	558.8^{d}	761.2^{bc}	3396^{c}	2837^{ab}
720	150	73.91^{b}	1657^{d}	909^{c}	851.55^{b}	4014^{b}	3105^{ab}
	210	73.35^{c}	1189^{e}	517.5^{d}	755.75^{bc}	3188^{c}	2670^{b}
	270	71.92^{d}	609.5^{f}	255.5^{d}	365.7^{c}	1501^{d}	1245^{c}

4. Conclusion

Present study on kodo millet aim to evaluate effect of microwave treatment on the phytochemical, fictional property and rheological property have been investigate for development of kodo millet based product. The microwave treatment shows the significant changes in the colour characteristic, functional property, and rheological property. The characteristic shows the changes in colour of the flour to light brown colour. In microwave treated sample total phenolic content was higher compare to untreated. The heat treatment of microwave had prominent effect on the WAC and OAC, Peak viscosity, pasting temperature, Breakdown viscosity, Final viscosity and Holding viscosity of kodo millet flour. During microwave treatment changes occur in kodo while heating of kodo millet. Present study can be referred for effective utilization of microwave treatment on kodo millet flour and improvement in the process before development of kodo based functional food products.

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