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Nutrient changes and functional properties of rice flakes prepared in a small scale industry

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ABSTRACT

Four varieties of paddy were soaked in hot water, drained, roasted in an industrial roaster, tempered, flaked and passed through roller. Moisture content reduced from about 35% in paddy to 11 – 13% in the flakes. Equilibrium moisture content was high (83- 85%) in roller pass flakes compared to edge runner flakes. Total amylose equivalent varied from 21 to 23% in flakes of edge runner (ER) while that of roller pass were ~22%. Soluble amylose varied from 10 to 14% in flakes of ER and 11 to 13% in flakes of ER+RP. Protein contents were high in ER flakes, but reduced to an extent of 6 to 30% in roller pass flakes. Significant changes in phosphorus, vitamins; riboflavin and niacin contents were not recorded among two types of flakes. Pasting profile parameters indicated that the initial viscosity ranged from 280 to 550 BU in all flakes. Peak viscosity was low compared to initial value in all flakes with exception in MTU 1001 variety. Swelling power remained almost same in both type of flakes, however the solubility was high in BPT 5204 variety in ER + RP flakes. In MTU 1001, the solubility in ER flakes was high compared to ER + RP flakes. Considerable nutrient losses occurred in the flakes obtained after passing through the rollers, except whitening of the flakes.

Flaked or beaten rice is a very popular traditional product in India and in other rice consuming countries. This product is consumed as snack after roasting, frying or spicing or soaking in water and seasoning with spices and vegetables as an item of breakfast. (Arya, 1990). Flaked rice (also called poha, Aval, Avalakki) is a popular whole rice product widely produced at cottage / small scale industries in India. About 10% (~ 14.4 million tons) of the paddy produced in our country is converted to rice products. Essentially the process consists of soaking paddy in warm/hot water, draining, roasting with sand in a shallow iron pan (bhatti) over a strong fire followed by flattening in an edge runner to obtain the desired thickness. (Anantachar *et al*, 1982). A continuous process for making rice flakes from paddy was developed at Central Food Technological Research, Mysore. The soaked, paddy is roasted in the continuous roaster, immediately shelled in a modified centrifugal type Sheller and gently polished in a cone type rice polisher and tempered for about 3 hours and it is flaked in a heavy duty roller flaker. Average yield of rice flakes was about 70%, which is 6-7 % higher than obtained by traditional process (Narasimha, *et al.*, 1982).

Comparative properties of rice flakes like moistness, tenderness and lumping nature were studied in rice flakes prepared by traditional (edge runner) process and the newly developed continuous (roller flaking) process. Minor differences existed in lumping and stickiness of the reconstituted flakes of varying physical properties. Roller flakes were judged to be moist, tender with a greater tendency for lumping compared to the edge runner flakes (Ekanayake and Narasimha, 1997).

A method for preparing ready to eat cereal based food in the form of flakes, was described. This consisted of steeping the raw material in warm water for shorter duration to enhance the moisture content to about 20%, tempering, flaking, and toasting to form an improved speckled RTE flake cereal (Robie and Hilgendorf, patent 2001)

Method for steam flaking of grain is described; the method involves passing grain through a steam chest at a pre determined time and pressure (Brown, patent, 2002). Phosphorus, phytin phosphorous and dietary fibre reduced with degree of flaking. The percentage of available iron ranged from 7 to 26% that of calcium 8 to 25% from thick to thin flakes (Suma *et al*, 2007).

Effect of processing on the status of starch and its in-vitro digestibility was high for roller flaker flakes. Among the rice products prepared least digestibility was seen in normal parboiled rice and among the ready to eat products popped rice showed least digestibility (about 30%), (Chitra *et al*, 2010).

MATERIALS AND METHODS

Three varieties of paddy viz; IR-64, BPT 5204 (Non pigmented) and Jyothi (pigmented) were procured from the Agricultural products marketing co-operation Bandipalaya, Mysore. These varieties were harvested and dried during December 2006, and were placed at room temperature.

Four varieties of paddy (IR-64, BPT 5204, MTU-1001and Jyothi) after soaking in hot water over night, next day the water was decanted and allowed drain out of all the water and kept for some time, to remove all the adhering moisture. This high moisture paddy was taken to a small scale industry (Fig. 1). Individually these were used for roasting. Each of soaked paddy was dropped into the roaster, which was heated by paddy husk externally, the material traveled a distance of about 1.5 mtr. This hot paddy passed through a sieve, where the sand was separated, and hot paddy obtained was tempered by keeping in a basket by covering with paddy husk for about 5 min. and flaked in an edge runner. These flakes were named as Edge runner flakes (ER). In the next step , these flake were passed through two rollers, where polishing of the flakes takes place in addition to imparting uniform thickness to the flakes, and the resultant flakes was named as Edge runner + Roller pass flakes (ER + RP). These flakes were analyzed for their nutrient contents and some of the functional properties. Powdered flakes were defatted using a soxhlet apparatus with 85% methanol solvent for 18 hours and moisture content of defatted materials was estimated as per AOAC, 2000. Total amylose and soluble amylose equivalent were estimated as per the procedure of Sowbhagya and Bhattacharya (1971)

The moisture content of the samples was determined after drying at 105^0C until a constant weight was attained. Equilibrium moisture content (EMC) of the samples was determined by soaking the samples at room temperature as per the procedure of Indhudara Swamy *et al*, 1971. Micro kjeldal method was employed to determine total nitrogen and crude protein (N×5.95) (AOAC, 2000). Total crude carbohydrate was estimated by the phenol sulphuric acid method. (Dubois *et al*, 1956). Total phosphorus was determined spectrophotometrically at 355 nm using potassium di hydrogen orthophosphate as standard. (Singh and Ali, 1987). Riboflavin and niacin content were estimated as per AOAC method, 2000. Swelling power and solubility of flakes of IR 64, BPT 5204, Jyothi and MTU - 1001 were determined at temperature 50 ºC to 98 ºC (boiling point of water at Mysore, at 750 mm altitude), according to the modified method as described by Singh *et al*. (2000).

Brabender Viscograph, Type VSK 4 (Duisburg, FRG) fitted with a 700 cmg sensitivity cartridge was used for the experiment. Brief procedure followed was as per (Bhattacharya and Sowbhagya 1981). The following conditions were kept constant: rpm 75; rate of heating as well as cooling, 1.5^o C $min.^{-1}$; highest temperature to which heated, 95^o C and cooked at this temperature for 10 min. and temperature to which finally cooled, is to 50^o C. The following other conditions were used for the standard runs: total slurry weight, 400 g with 10 % solid content (d. b), thermo regulator setting at the beginning of heating, 60^o C; heated up to 95^o C, cooked at 95^o C for 10 min. and thermo regulator for cooling from, 70^o C and cooled to 50^o C .

Gelatinization temperature was calculated by subtracting 3^o C from the temperature of initial rise in viscosity increase, since the temperature of initial viscosity increase is about 3^o C lower with 20 % pastes than with 10% paste for the 700 cmg cartridge, (Koh and Singh 2009).

RESULTS AND DISCUSSION

Initially paddy had around 12-14% moisture. Overnight soaked paddy had around 30-35% moisture, least was in MTU 1001 variety (Table 1). At industrial level, paddy was aerated for 10-15 min, where the moisture reduced by 5-8% and the moisture content ranged from 28 to 30%. This paddy is individually dropped in the roaster, where the paddy moved for 23-25 seconds and when the paddy came out, the moisture content decreased and it varied from 16 to 19%. This paddy was tempered in that hot condition for about five minutes by covering with husk in small baskets followed by

ROASTER

EDGE RUNNER

SORTED FLAKES

ROLLER PASS

FLAKES

Fig.1. Steps involved in flaking process (Small scale industry)

flaking in an edge runner flaker. Moisture content of the flakes among the varieties was in the range of 8 to 13%, least being shown by MTU 1001 (8%). These flakes were further shade dried at room temperature, wherein the moisture content dropped down to 7 - 8%. Moisture content of powdered flakes ranged from 7 to 9%. Overall a decreasing trend in moisture content was observed during the course of flaking process, almost 25% decrease in the moisture was recorded during the process of flaking compared to the initial moisture content of soaked paddy (Table 1). In order to prolong the keeping quality of these flakes from becoming soggy it was essential to bring down its moisture content to about 7% by shade drying.

Table 1. Moisture content of different paddy varieties while processing into flakes

Sample	Paddy	Soaked paddy	Paddy before roaster	Paddy after roasting	Edge runner flakes	Flakes after drying	Powdered flakes
IR-64	12.0 ± 0.0	34.3 ± 0.1	29.5 ± 0.2	17.4 ± 0.1	11.4 ± 0.2	7.0 ± 0.9	7.1 ± 1.0
BPT 5204	12.8 ± 0.2	35.4 ± 0.2	29.0 ± 0.1	17.1 ± 0.4	13.3 ± 0.1	7.2 ± 0.1	7.1 ± 0.2
MTU1001	13.7 ± 0.5	30.7 ± 0.1	28.6 ± 0.2	18.6 ± 0.1	7.9 ± 0.1	7.9 ±0.3	8.6 ± 0.1
JYOTHI	12.4 ± 0.1	34.6 ± 0.2	28.1 ± 0.1	16.6 ± 0.3	13.2 ± 0.2	7.2 ± 0.1	6.9 ± 0.5

The edge runner flakes showed around 78-81% equilibrium moisture content (EMC) at room temperature (Table 2) least being shown by IR-64, indicating the fact that comparatively IR-64 had undergone less degree of gelatinization. However, other 3 varieties had shown almost same EMC indicating they have undergone gelatinization to same extent. These flakes after passing through the roller pass, the EMC values increased to an extent of 2-4% (82-85%). While passing through the roller adhering bran gets detached and becomes starchy. Endosperm portion absorbs higher quantity of water and hence the EMC values may be high in these flakes. Higher EMC also indicates that the gelatinized starch was not allowed to dry (not to undergo retrogradation) instead it was flaked from roasting step, where precipitation of linear molecules in the starch granules had been delayed; hence the EMC values may be high.

Table 2. Equilibrium moisture content of flakes

Variety	Flakes ER	Flakes ER+RP
IR-64	77.8 ± 0.2*	82.8 ±0.1*
BPT 5204	81.0 ± 0.2*	84.8 ±0.1*
MTU - 1001	80.8± 1.4^{ns}	82.3 ± 0.1^{ns}
JYOTHI	81.1 ± 0.6*	83.7 ±0.1*

Mean ± SD (n=3), means are significantly different (P d” 0.05) ns, means are not significantly different (P e” 0.05); ER-edge runner, RP= roller pass

Carbohydrate content in edge runner flakes (ERF)(Table 3) varied from 71 to 75%. Among the varieties, jyothi showed highest value of 75% and least by IR-64 and BPT 5204. These values indicate that in bolder grains impact between the idle roller and outer ring of edge runner was less (Jyothi and MTU 1001) compared to IR-64 and BPT 5204 which were medium and fine grain varieties. The carbohydrate content in edge runner followed by roller pass flakes varied from 67-72%, where again the impact was similar as observed above, but with 2 to 4% loss of carbohydrates during roller pass operation. Protein content varied from 6 to 7% in the edge runner flakes and the highest retention was seen in IR-64 followed by Jyothi, BPT 5204 and MTU 1001, where highest loss appeared in MTU 1001, similar trend was observed in flakes after passing through the rollers. Among the varieties an increasing order in retention of protein was noted, MTU 1001< BPT 5204 <Jyothi<IR-64 in case of edge runner flakes. However, in edge runner + roller pass flakes the pattern differed as MTU 1001<Jyothi<BPT 5204<IR-64.

Fat content varied from 1.4 to 1.7% in edge runner flakes and 1.1 to 1.4% in edge runner + roller pass flakes. Loss of fat in the varieties followed an increasing order, BPT 5204d” Jyothi<MTU 1001 < IR -64 in edge runner flakes and BPT 5204<MTU 1001d” Jyothi<IR-64, in ER + RP. Ash content remained almost same, which ranged from 1.3 to 1.4% in ER and 1.1 to 1.3% in ER +RP indicating some amount of loss of bran while passing through the rollers.

Table 3. Nutritional composition changes after flaking

Parameters	IR -64		BPT 5204		Jyothi		MTU - 1001	
	ER	ER+RP	ER	ER+RP	ER	ER+RP	ER	ER+RP
Carbohydrate (gm/100g)	71.27±0.62*	66.85±1.26*	70.98±0.40*	68.23±1.20*	75.4±0.63*	72.41±1.12*	73.23±0.78^{ns}	71.28±1.00^{ns}
Protein (%)	7.22±0.10^{ns}	06.79±0.20^{ns}	06.33±0.03*	05.63±0.24*	6.86±0.26*	4.74±0.06*	06.10±0.24*	4.34±0.16*
Fat (%)	1.7±0.86 ^{ns}	01.32±0.12 ^{ns}	01.4±0.41^{ns}	01.14±0.22 ^{ns}	1.50±0.08 ^{ns}	1.30±0.10 ^{ns}	1.5±0.28 ^{ns}	1.33±0.16 ^{ns}
Ash (%)	1.30±0.08 ^{ns}	1.18±0.05 ^{ns}	1.10±0.03 ^{ns}	1.08±0.12	1.37±0.09*	1.14±0.07*	1.40±0.05 ^{ns}	1.30±0.08 ^{ns}

Mean ± SD (n=3), *means are significantly different (P d” 0.05) ns, means are not significantly different (P e” 0.05)
ER - edge runner, RP - roller pass

Riboflavin content of ER flakes varied from 36 to 57µg% (Table 4). Retention was high in BPT 5204 and least in Jyothi. Hence increasing order of retention for these varied and followed the pattern as Jyothi< MTU 1001 < IR-64 < BPT 5204 (ER). In ER + RP, the range was 28 to 38 µg%. Thus about 8 to 25 µg of riboflavin loss occurred in the ER + RP flakes, that is Jyothi< IR – 64 <BPT 5204< MTU 1001. Niacin content varied from 2 to 2.95 mg% in ER, loss was less in MTU 1001 and high in the case of Jyothi variety flakes. When these flakes were passed through rollers, losses occurred and the values ranged from 0.2 to 1.66 mg%. Highest loss was noticed in flakes of BPT 5204 variety and least in IR-64 flakes, indicating the loss of vitamins were to a greater extent in ER +RP flakes.

Phosphorus content varied from 209 to 195 mg% in ER; least was noticed in BPT 5204 flakes followed by IR-64. The phosphorus content after roller pass ranged from 162 to 200 mg%. Highest loss was noticed in the case of Jyothi flakes (~ 40 mg %). In undefatted form, the total amylose equivalent varied from 17 to 18.8% in ER flakes, 18 to 18.5 % in ER

Table 4. Changes in vitamins and phosphorus content after flaking

Parameters	IR-64		BPT 5204		Jyothi		MTU - 1001	
	ER	ER+RP	ER	ER+RP	ER	ER+RP	ER	ER+RP
Riboflavin (µg/100g)	53.0±0.26*	30.0±6.0*	57.0±1.23*	32.0±1.84*	36.0±1.0^{ns}	28.0±2.36^{ns}	50.0±0.52*	38.0±1.47*
Niacin (mg/100g)	2.73±0.29^{ns}	2.07±0.8^{ns}	2.26±1.0^{ns}	2.00±0.89^{ns}	2.0±0.45^{ns}	0.77±0.30^{ns}	2.95±0.53^{ns}	2.0±0.65^{ns}
Phosphorus (mg/100g)	208.5±0.8*	200.27±1.00*	195.71±0.14^{ns}	186.73±1.21^{ns}	202.8±0.10*	162.3±2.21*	208.81±1.46*	195.07±1.68*

Means±SD (n=3), * Means are significantly different (P d” 0.05), ns means are not significantly different (P e” 0.05)
ER - edge runner, RP - roller pass

Table 5. Total and Soluble Amylose content (d.b) in flakes of different rice varieties in their undefatted and defatted forms

Variety	Total amylose		Soluble amylose	
	Edge roller flakes	Edge roller flakes+roller pass	Edge roller flakes	Edge roller flakes+roller pass
IR - 64				
Un defatted	17.37±0.12*	18.43±0.24*	08.42 ±0.18^{ns}	08.34±0.12^{ns}
Defatted	22.95±0.05*	21.58±0.15*	13.72 ±0.10*	11.60±0.04*
BPT 5204				
Un defatted	17.48±0.23*	18.50±0.12*	08.08 ±0.04	10.60±0.10
Defatted	22.75±0.14*	21.58±0.03*	12.17 ±0.07	13.10±0.03
MTU - 1001				
Un defatted	17.35±0.1*	18.20±0.04*	07.80±0.90*	09.45±0.12*
Defatted	22.94±0.2*	21.77±0.11*	10.40±0.10*	11.62 ±0.04*
Jyothi				
Un defatted	18.80±0.28*	18.09±0.36*	09.12±0.05*	07.56±0.21*
Defatted	21.55±0.12^{ns}	21.80±0.30^{ns}	11.27±0.31^{ns}	11.51±0.08^{ns}

Mean ± SD (n=3) ,* means are significantly different (P d” 0.05) ns, means are not significantly different (P e” 0.05)

+RP flakes. In defatted form it varied from 21.6 to 23% in ER flakes and ~22% in ER + RP flakes (Table 5). The total amylose content was almost same in undefatted form (17%) except in Jyothi where it was ~ 19% in ER flakes, similarly in defatted form it was around 23% in all the three varieties except in Jyothi (~22%). In ER +RP, in undefatted form it was around18% in all varieties and in defatted form it was around 22%. Higher total amylose equivalent in flakes passed through ER +RP flakes was because of bran falling through the roller and increase in brightness of endosperm, where starch content happens to be high. In addition to these changes, the thickness of flakes reduces which could be named as paper thin flakes. Soluble amylose ranged from 7.8 to 9.1% in undefatted ER flakes: 7.6 to 10.6% in ER +RP flakes. In defatted form least soluble amylose was seen in MTU 1001 (10.4%) and highest in IR-64 (~14%). In ER +RP flakes, in undefatted form soluble amylose content ranged from 8 to 11%, however, on defatting, the value was almost same in 3 varieties except BPT 5204 where the values were ~13%. Thus the soluble amylose equivalents are of mixed nature, which were not following a particular pattern, among the four varieties.

When the viscosity was initiated all varieties of flakes have undergone cooking followed by minimum retrogradation, as they were not dried after roasting in the roaster. Among the flakes only BPT 5204 registered highest viscosity of 550 BU followed by Jyothi(400 BU) IR-64(350 BU) and least by MTU 1001 (280 BU) (Table 6). These values indicate that these flakes were cooked to different extent in their grain form during the course of preparation of flakes. The Peak viscosity of all these decreased after initial viscosity except in MTU 1001 flakes where it increased by 30 BU, indicating further swelling of starch granules have taken place. These values indicate the swelling of starch granules were least during heating phase, as these flakes were already gelatinized and had lost shape by losing the birefringence. Hence instead of swelling, the granule shapes were lost and hence the peak viscosity reduced in almost all the varieties of flakes. Granules which were swollen to lesser extent attempts to break down after reaching peak viscosity and hence the viscosity falls down while cooking the slurry dispersion. This fall down in viscosity, at the end of cooking phase is termed as hot paste viscosity. Irrespective of the initial viscosity and peak viscosity, the HPV values were almost same in case of IR-64, BPT 5204 and MTU 1001 with respect to jyothi the value was low (210 BU). When this cooked paste was cooled at the rate of 1.5ºC min^{-1}, in these broken granules linear molecules will try to precipitate and because of aggregation the viscosity rises and this was termed as cold paste viscosity(CPV).

Table 6. Viscography (viscosity in brabender units, at 10% (d.b) concentration) of flakes ER+RP

Variety Flakes ER+RP	Initial viscosity	Peak viscosity	Hot paste viscocity	Cold paste viscosity	BD	SB
IR-64	350 ± 4	325 ± 10	260 ± 10	380 ± 12	65 ± 10	55 ± 10
BPT 5204	550 ± 5	350 ± 30	265 ± 35	385 ± 30	85 ± 5	35 ± 5
MTU1001	280 ± 4	310 ± 12	275 ± 15	430 ± 20	35 ± 5	120 ± 20
Jyoti	400 ± 6	225 ± 15	210 ± 20	280 ± 15	15 ± 10	55 ± 8

Means±SD (n=2), ER - edge runner, RP - roller pass

As expected CPV will be greater than PV, sometimes greater than or less than initial viscosity, which was observed only in the case of rice flakes prepared in ER.

BD values were high in the case of IR – 64 and BPT 5204, but low in the case of MTU 1001 and Jyothi. Higher BD values indicate higher swelling of starch granules, where there was no space while cooking in a given place or volume, they try to breakdown and viscosity comes down, hence the difference between PV and HPV values works out to be high. On the other hand when the BD values were low, the reverse phenomenon takes place (less swelling of starch granules). SB indicates the precipitation of linear molecules while cooling the gel or sol in the system. From the data it was observed that MTU 1001 had shown highest value indicating that this variety had higher amount of linear portions which may be from their linear molecules and their lengthiest chain of the branched molecule of the starch granules. Other three varieties showed almost same values indicating the retrogradation phenomenon in these were almost same.

The swelling power of edge runner flakes (Fig 1) at various temperatures, were almost same for IR-64, BPT 5204 and jyothi flakes, except MTU 1001 where the swelling power was slightly high. In the swelling power pattern of the edge runner followed by roller pass flakes (Fig 2.) a gradual increase in the values were observed with the increase in cooking temperature. There was slight increase in the swelling

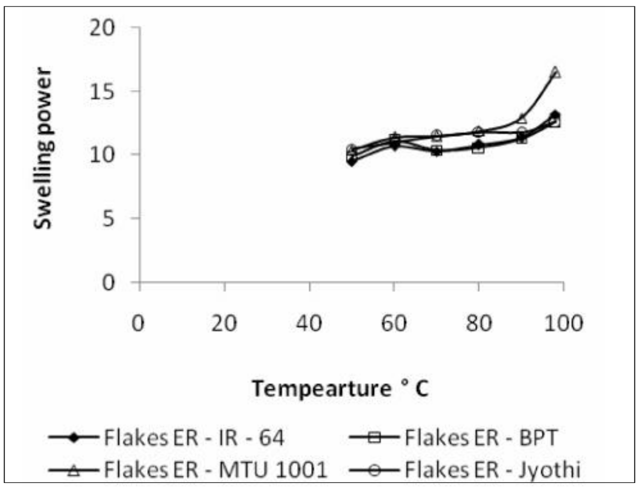

Fig.2. Swelling power of edge roller flakes

power MTU 1001 flakes at 90 and 98°C by about 1% comparatively as there was fall of bran and exposure of endosperm to a greater extent.

Solubility is the leach out from the flakes when cooked or soaked in water. Soluble are generally linear components of starch granules or cooked or disrupted

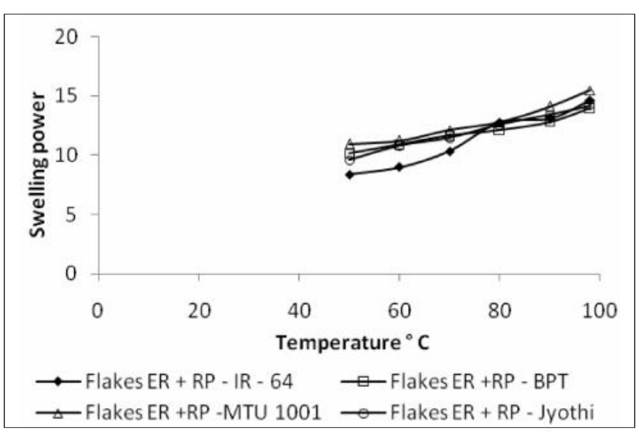

Fig.3. Swelling power of edge roller + roller pass flakes

starch granules. The solubility of flakes at lower temperature (Fig 3.) were almost same and low in the case of IR-64 and jyothi (~11-12 %), but in the case of BPT 5204 and MTU 1001 the values were in the range of 15-16%, 11-16%. Similar pattern was observed at higher temperatures (80, 90, 98° C) highest values were shown by MTU 1001 (23 to 24%) and least in BPT 5204. At 98°C, highest solubility occurred in BPT 5204.

In ER +RP flakes at initial stages, the values were 11 to 15% (Fig 4) at 80°C BPT 5204 and jyothi

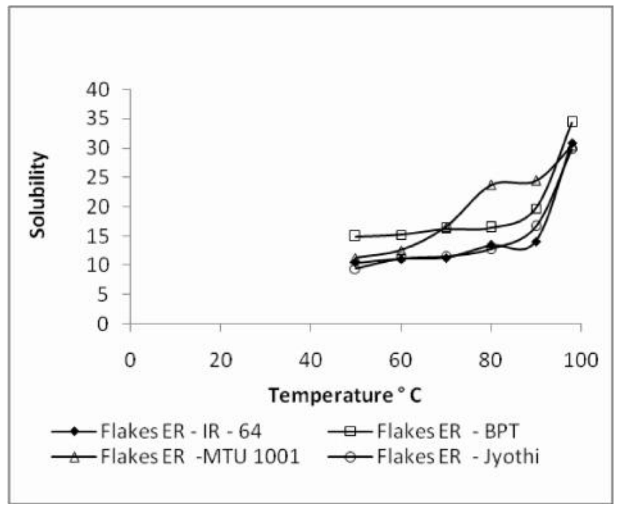

Fig.4. Solubility of edge roller flakes

showed almost same values, but MTU 1001 registered highest ~17 %. Again the differences were noticed at 90°C and at boiling water temperature. The leach out was high in ER+RP flakes, surprisingly in both type of flakes, at boiling temperature BPT 5204 behaved almost same.

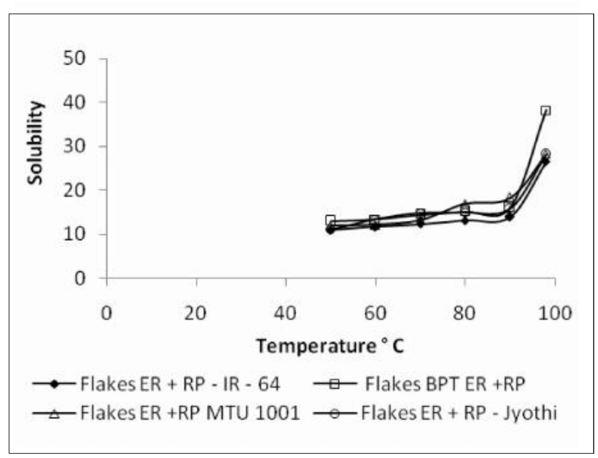

Fig.5. Solubility of edge roller+roller pass flakes

There was a drastic reduction in moisture content from the raw material to flakes; there was a significant loss in the nutrients after passing through from ER to roller pass.

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