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SHORT COMMUNICATION

# Carbohydrate profile and starch digestibility of newly released high yielding moth bean (*Phaselous aconitifolius* Jacq.) varieties as affected by microwave heating and pressure cooking

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**Abstract** Seeds of 3 newly released moth bean (*Phaselous aconitifolius* Jacq.) varieties ('Jwala', 'RMO 225' and 'RMO 257') and 1 local variety of moth bean were pressure cooked and microwave oven cooked to find out the comparative effect of heating on total soluble solids (TSS), reducing sugars, non-reducing sugars and starch and starch digestibility. The TSS of raw unprocessed moth bean cultivars ranged from 6.8 to 7.7%, reducing sugars from 0.30 to 0.34.%, non-reducing sugars from 6.5 to 7.3% and starch from 47.5 to 51.3%. Both methods of cooking of unsoaked, soaked and soaked-dehulled moth bean cultivars increased the TSS (4 to 17% and 6 to 19%), reducing sugars (5 to 32% and 6 to 36%) and non-reducing sugars (4 to 16% and 6 to 18%), while decreasing the starch content (26 to 49%). Starch digestibility of unsoaked, soaked and soaked-dehulled seeds was higher ($p<0.05$) when microwave heated (88 to 129%) than pressure cooked (74–115%).

**Keywords** Moth bean · *Phaselous aconitifolius* · Total soluble solids · Reducing sugars · Non-reducing sugars · Starch · Starch digestibility · Microwave cooking · Pressure cooking

In Indian households, legumes are consumed and processed in a variety of forms according to taste and cultural practices of the population. Legumes are cooked either without soaking, prior soaking or soaking and dehulling. Cooking is generally done in covered pans or in pressure cookers. But now as the percentage of working women is increasing in India, time and energy saving cooking devices are coming in vogue. Microwave energy is a unique energy source. When microwave is used, heat is generated deep within the materials being processed mainly by the oscillation of water molecules. Thus the rate of increase in temperature is extremely rapid (Hajela et al. 1998). The microwave oven offers convenience in terms of speed, cleanliness, higher yields of finished products and better quality than that obtained by conventional heating techniques. Because of all these properties, microwave ovens are becoming very popular. Much work has been done on the effect of cooking on carbohydrate profile of legumes but no literature is documented regarding the effect of microwave cooking on carbohydrate profile and its comparison with pressure cooking. With this purpose the present paper communicates the comparative effect of microwave cooking and pressure cooking on the carbohydrate profile and starch digestibility of some high yielding varieties of moth bean, newly released by All India Coordinated Research Project on Arid Legumes, Rajasthan Agricultural University, Bikaner.

Moth bean (*Phaselous aconitifolius* Jacq.) 'Jwala', 'RMO 225', 'RMO 257' varieties (newly released high yielding varieties) and 1 local variety seeds were procured in single lot from Forage Section, Department of Plant Breeding of the university. Seeds were cleaned of dirt, dust, stones and other foreign materials prior to cooking.

The seeds were soaked for 12 h at room temperature (30±2°C) in distilled water. The soaked (12 h) seeds were dehulled manually. For microwave cooking, the seeds were cooked in open Borosil glass ovenware using distilled water. The unsoaked, soaked (12 h) and soaked (12 h)-dehulled seeds of all 4 varieties were cooked till soft in

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microwave oven (BPL-900 T, India) at high power for 3 standardized time periods. Softening of bean was determined by picking 2-3 beans at random and pressing them between thumb and finger. The seed-to-water ratio for cooking of unsoaked, soaked and soaked (12 h)-dehulled seeds was 1:3, 1:2 and 1:1 (w/v), respectively. The unsoaked, soaked (12 h) and soaked (12 h)-dehulled seeds were pressure cooked using a seed-to-water ratio of 1:3 (w/v) for unsoaked, 1:2 for soaked and 1:1 for soaked (12 h)-dehulled seeds for 15, 10 and 5 min, respectively.

All pressure and microwave-cooked samples were dried in hot air oven at 60°C to a constant weight, ground to fine powder to pass through 0.5 mm sieve size. The powder was stored in air tight plastic containers for chemical analysis. All the samples were processed and analyzed in triplicate.

Total soluble sugars (TSS) were extracted by refluxing in 80% ethanol (Cerning and Guilhot 1973) and starch from sugar-free pellet was extracted in 52% perchloric acid at room temperature (Clegg 1956). TSS and starch were determined colorimetrically (Yemm and Willis 1954). Reducing sugars were estimated by Somogyi's modified method (Somogyi 1945). Non-reducing sugars were calculated as the difference between TSS and reducing sugars. Starch digestibility (in vitro) was assessed by employing pancreatic amylase and then measuring maltose liberated by using dinitrosalicyclic acid reagent (Singh et al. 1982).

*Statistical analysis* The data obtained were subjected to statistical analysis using completely randomized design (Panse and Sukhatme 1961).

Results are presented in Table 1.

*Pressure cooking* Pressure cooking increased the TSS, reducing and non-reducing sugars of all the cultivars but decreased the starch content. When unsoaked seeds were pressure cooked, the TSS content increased by 13 to 17% over the control. Local and 'RMO 257' experienced enhancement of 13% whereas 'RMO 225' and 'Jwala' had 16 and 17% increase over the raw unprocessed control, respectively. Soaking of seeds prior to pressure cooking resulted in less increase in TSS. The increase was 9 to 11% in soaked-pressure cooked seeds and only 4 to7% in soaked-dehulled pressure cooked seeds. The contents of TSS of soaked-pressure cooked seeds of various cultivars ranged from 9 to 11%. Pressure cooking of soaked-dehulled seeds resulted in 4% increase in TSS of Local and 'Jwala' each and 5% in 'RMO 257' and 7% in 'RMO 225' over the control.

On pressure cooking of unsoaked seeds the reducing sugar content also increased, the highest increase was in 'Jwala'. When soaked seeds were pressure cooked the reducing sugar content increased by 18% in both Local and 'RMO 257', 19% in 'RMO 225' and 15% in 'Jwala'. Further dehulling of soaked seeds before pressure cooking resulted in limited increase in reducing sugars (5 to 7%). A similar trend was observed in contents of non-reducing sugars of pressure cooked seeds of unsoaked, soaked (12 h) and soaked (12 h)-dehulled moth bean.

Starch content of cultivars decreased after pressure cooking of unsoaked, soaked (12 h) and soaked (12 h)-dehulled seeds i.e. 46 to 48, 26 to 28 and 27 to 30% over the control, respectively. The soaked-pressure cooked seeds of all the cultivars witnessed similar decline (26–28%) in starch content. The decrease in starch content as a result of pressure cooking of soaked (12 h)-dehulled seeds was maximum in 'RMO 225' (30%) followed by 'Jwala' (29%) and Local and 'RMO 257' (27%).

Pressure cooking of all the cultivars improved their starch digestibility. Pressure cooking of unsoaked moth bean seeds increased starch digestibility by 74–78% as compared to controls. Highest increment of 78% was observed in Local followed by 'Jwala' and 'RMO 225' (76%) and 'RMO 257' (74%). Soaking of seeds prior to cooking increased the starch digestibility by 88–93% with maximum increment being in 'RMO 257' and minimum in Local, 'Jwala' and 'RMO 225'. There was a further increase of 106 to 115% in starch digestibility when soaked (12 h) seeds were dehulled prior to pressure cooking. The highest increment in starch digestibility over the respective controls was seen in 'RMO 225' (115%) followed by 'Jwala' (110%) and 'RMO 257' (108%).

*Microwave cooking* Microwave cooking of unsoaked seeds increased ($p<0.05$) the content of TSS over the control (raw unprocessed sample) in all varieties. Maximum increase was in 'Jwala' (19%) followed by Local (17%), 'RMO 225' (17%) and 'RMO 257' (15%). Soaking of seeds prior to cooking resulted in less increase in TSS of all varieties. An enhancement of 12% was noticed in 'Jwala' and 'RMO 257' whereas it was 11% in Local and 'RMO 225'. Microwave cooking of soaked (12 h)-dehulled seeds witnessed very slight increase in TSS from 6 to 8%, in all cultivars, maximum increase of 8% was observed in 'RMO 225' followed by 'RMO 257' (7%), 'Jwala' (7%) and Local (6%) varieties.

The reducing sugar content of raw-unprocessed seeds (control) of all varieties varied from 0.30 to 0.34%. On microwave cooking of unsoaked seeds, the reducing sugar content rose to 0.41–0.45% in all cultivars. Highest rise (35%) was observed in Local and 'Jwala' and the lowest (33%) in 'RMO 257'. The soaked and soaked-dehulled microwave cooked samples contained lower ($p \leq 0.05$) amounts of reducing sugars as compared to unsoaked microwave cooked samples. The soaked and soaked-dehulled microwave cooked samples of all varieties contained 0.35 to 0.41 and 0.32 to 0.37 g reducing sugars

**Table 1** Effect of pressure and microwave cooking on sugars, starch and starch digestibility of moth bean (on dry matter basis)

| Variety (V) | Raw unprocessed (Control) | Treatment (T) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Pressure cooking | | | Microwave cooking | | |
| | | Unsoaked | Soaked | Soaked dehulled | Unsoaked | Soaked | Soaked dehulled |
| Total soluble sugars,% | | | | | | | |
| Local | 6.8±0.01 | 7.7±0.01 | 7.7±0.02 | 7.1±0.01 | 8.0±0.01 | 7.6±0.03 | 7.3±0.05 |
| 'Jwala' | 7.2±0.01 | 8.4±0.07 | 8.0±0.01 | 7.5±0.01 | 8.6±0.01 | 8.1±0.01 | 7.7±0.02 |
| 'RMO 225' | 7.5±0.01 | 8.7±0.01 | 8.2±0.01 | 8.0±0.01 | 8.8±0.01 | 8.3±0.03 | 8.1±0.02 |
| 'RMO 257' | 7.7±0.09 | 8.7±0.01 | 8.4±0.01 | 8.1±0.01 | 8.8±0.01 | 8.6±0.08 | 8.2±0.01 |
| CD ($p$<0.05) ($n$=3) | | V=0.04, T=0.04, V×T=0.08 | | | V=0.05, T=0.05, V×T=0.07 | | |
| Reducing sugars,% | | | | | | | |
| Local | 0.30±0.14 | 0.40±0.05 | 0.36±0.47 | 0.32±0.19 | 0.41±0.10 | 0.37±0.12 | 0.32±0.08 |
| 'Jwala' | 0.32±0.04 | 0.43±0.02 | 0.37±0.02 | 0.34±0.16 | 0.44±0.14 | 0.35±0.08 | 0.34±0.10 |
| 'RMO 225' | 0.33±0.23 | 0.44±0.09 | 0.40±0.07 | 0.36±0.25 | 0.45±0.17 | 0.41±0.20 | 0.37±0.01 |
| 'RMO 257' | 0.34±0.18 | 0.44±0.15 | 0.40±0.10 | 0.36±0.20 | 0.45±0.12 | 0.41±0.17 | 0.37±0.19 |
| CD ($p$<0.05) ($n$=3) | | V=0.02, T=0.03, V×T=0.05 | | | V=0.01, T=0.02,V×T=0.05 | | |
| Non-reducing sugars,% | | | | | | | |
| Local | 6.53±0.01 | 7.4±0.02 | 7.1±0.02 | 6.8±0.01 | 7.6±0.01 | 7.2±0.02 | 6.9±0.01 |
| 'Jwala' | 6.9±0.01 | 8.0±0.01 | 7.6±0.01 | 7.2±0.01 | 8.1±0.01 | 7.7±0.02 | 7.3±0.01 |
| 'RMO 225' | 7.2±0.01 | 8.3±0.01 | 7.8±0.01 | 7.7±0.1 | 8.2±0.08 | 7.9±0.02 | 7.7±0.01 |
| 'RMO 257' | 7.3±0.03 | 8.3±0.01 | 8.0±0.01 | 7.7±0.01 | 8.4±0.01 | 8.2±0.08 | 7.8±0.01 |
| CD ($p$<0.05) ($n$=3) | | V=0.05, T=0.05 V×T=0.08 | | | V=0.06, T=0.07, V×T=0.09 | | |
| Starch,% | | | | | | | |
| Local | 51.3±0.11 | 27.7±0.14 | 37.0±0.03 | 37.5±0.08 | 27.3±0.26 | 37.2±0.17 | 37.5±0.14 |
| 'Jwala' | 48.5±0.04 | 25.7±0.02 | 35.4±0.06 | 34.4±0.07 | 25.3±0.10 | 35.1±0.04 | 33.8±0.18 |
| 'RMO 225' | 47.5±0.17 | 25.7±0.18 | 34.4±0.18 | 35.2±0.18 | 25.3±0.11 | 33.6±0.11 | 35.4±0.26 |
| 'RMO 257' | 49.6±0.15 | 25.9±0.04 | 36.8±0.15 | 36.4±0.06 | 25.2±0.06 | 36.5±0.25 | 36.2±0.03 |
| CD ($p$<0.05) ($n$=3) | | V=0.19, T=0.19,V×T=0.35 | | | V=0.05,T=0.05, V×T=0.07 | | |
| Starch digestibility *(in vitro)*, mg maltose released/g flour | | | | | | | |
| Local | 26.3±0.06 | 46.8±0.09 | 49.5±0.08 | 54.2±0.05 | 49.4±0.08 | 52.2±0.03 | 59.5±0.01 |
| 'Jwala' | 27.3±0.03 | 48.1±0.03 | 51.4±0.07 | 57.2±0.12 | 51.3±0.02 | 54.7±0.04 | 62.6±0.04 |
| 'RMO 225' | 25.3±0.03 | 44.7±0.16 | 47.7±0.09 | 54.6±0.06 | 48.1±0.04 | 51.4±0.02 | 57.1±0.03 |
| 'RMO 257' | 28.2±0.02 | 49.2±0.01 | 54.5±0.02 | 58.5±0.12 | 53.2±0.01 | 56.7±0.01 | 63.2±0.02 |
| CD ($p$<0.05) ($n$=3) | | V=0.12, T=0.11, V×T=0.41 | | | V=0.01, T=0.02, V×T=0.05 | | |

per 100 g. 'RMO 225' and 'RMO 257' contained higher amounts of reducing sugars than the other 2 varieties.

The non-reducing sugar content of raw unprocessed (control) moth bean seeds of all the varieties varied from 6.5 to 7.3%. Microwave cooking of unsoaked, soaked and soaked-dehulled seeds considerably raised the level of non-reducing sugar in all the cultivars. The unsoaked microwave cooked seeds contained higher amount of non-reducing sugars when compared to soaked and soaked-dehulled microwave cooked samples. 'RMO 257' contained significantly higher amount of non-reducing sugars as compared to other 3 varieties.

Starch content decreased significantly after microwave cooking in all the varieties. Unsoaked microwave cooked samples of all the varieties had the lowest starch content as compared to soaked and soaked-dehulled microwave cooked samples. Microwave cooking of unsoaked, soaked and soaked-dehulled samples decreased the starch content by 47 to 49, 27 to 29 and 26 to 30%, respectively. Among the varieties, the unsoaked, soaked and soaked-dehulled microwave cooked seeds of Local variety contained the highest starch content.

Hydrolysis of starch to oligosaccharides and that of oligosaccharides to monosaccharides, mainly reducing sugars, resulting from cooking, may be responsible for increased concentration of sugars in pulses. As there was no scope of leaching out of sugars from unsoaked seeds, the resulting concentration of sugars in cooked samples of unsoaked seeds was ultimately higher than the samples of soaked seeds. Significant decrease in starch content of seeds as a result of cooking may result from amylolysis and it may also explain the observed increase in the concentration of sugars during cooking. Cooking may cause rupturing of starch granules followed by hydrolysis of the starch. This may explain the decreased starch content during cooking process. An increase in sugars after pressure cooking has been observed by earlier workers in amphidiloids of mung bean and black gram (Kataria et al. 1990).

Overall, it was observed that microwave cooking of unsoaked, soaked (12 h) and soaked (12 h)-dehulled seeds increased the TSS, reducing sugar and non-reducing sugar contents of all the cultivars tested to a greater extent as compared to pressure cooking. While starch content was decreased to a larger extent in microwave cooked as compared to pressure cooked moth bean cultivars.

Starch digestibility (in vitro), expressed as mg maltose released/g flour, was 25.4 to 28.2 in raw unprocessed seeds of all cultivars. The starch digestibility increased markedly on microwave cooking of unsoaked, soaked and soaked-dehulled seeds of all the varieties. The unsoaked microwave cooked samples of all the varieties had 48.1 to 53.2 starch digestibility (mg maltose released/g flour), with 'RMO 257' having maximum starch digestibility followed by 'Jwala', Local and 'RMO 225'.

The starch digestibility of soaked microwave cooked seeds was almost double than the raw unprocessed seeds of all the varieties. The soaked microwave cooked seeds of 'RMO 257' had maximum starch digestibility (mg maltose released/g flour) (56.6) followed by 'Jwala' (54.7), Local (52.2) and 'RMO 225' (51.4). A similar trend was observed in starch digestibility of soaked-dehulled microwave cooked samples of all the varieties. The starch digestibility was more than double in the soaked-dehulled microwave cooked seeds of all cultivars.

Starch in raw legumes is contained within granules that are poorly affected by hydrolytic enzymes and it is, therefore, mostly indigestible (Colonna et al. 1992). During cooking, starch granules are gelatinized and partly solubilized becoming available to digestive enzymes. This may explain the great improvement of starch digestibility attained after cooking. Starch digestibility is also influenced by presence of certain antinutrients and enzyme inhibitor particularly α–amylase inhibitor. However, during cooking these heat labile inhibitors are inactivated (Mulimani et al. 1994) and the starch digestibility thus also improved. The enhancement in starch digestibility due to heat treatment is also reported by other workers in peas (Bishnoi and Khetarpaul 1993), red gram, Bengal gram and black gram (Kelkar et al. 1996) and moth bean (Bravo et al. 1998). Enhancement in starch digestibility in soaked and cooked moth bean may also be due to reduction in phytic acid and tannins (Chopra and Sankhala 2004) with otherwise adversely affect the starch digestibility.

The starch digestibility of unsoaked, soaked (12 h) and soaked (12 h)-dehulled microwave cooked seeds of moth bean was higher as compared to pressure cooked seeds.

## Conclusion

Microwave cooking (15 to 25 min) irrespective of unsoaked, soaked and soaked-dehulled seeds, resulted in hydrolysis of polysaccharides and hence increased the concentration of total soluble, reducing and non-reducing sugars in the 4 moth bean cultivars. An improvement also occurred in starch digestibility of moth bean (88 to 129%) due to amylolysis. Moth bean in India is used mainly for making *dhal*-a legume preparation and for preparation of sprouted chat which is a spicy recipe containing sprouted and steamed moth bean, small cut pieces of onions, tomato, cucumber, salt, red chilly powder and mango powder. Microwave oven can easily be used for the preparation of *dhal* as spices and other condiments can be added during cooking. Hence it is a potential cooking method for improving the nutritional quality of food legumes.

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