ALTERING PASTING CHARACTERISTICS OF SELECTED DEHULLED LEGUMES INCORPORATED RICE AND MAIZE EXTRUDATES

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Altering Pasting Characteristics of Selected Dehulled Legumes incorporated Rice and Maize Extrudates

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ABSTRACT

This study assessed the effect of incorporation of selected dehulled legumes (black gram, green gram, lentil and peas) on the pasting characteristics of rice and maize based extrudates made using low cost collet extruder as compared to raw composites. Extrudates were prepared keeping constant feed rate (25 kg/h) and moisture content (14 % wb) at different legume incorporation levels (0, 5, 10 and 15 %). Pasting characteristics of porridge made of extrudate flour as well as raw composites were evaluated using Rapid Visco Analyser. There is a decreasing trend of visco parameters viz., peak viscosity (PV), minimum viscosity (MV), break down (BD) and final viscosity (FV) with increase in legume incorporation level. Thus, legume blend level (up to 15 %) of dehulled legumes shows a promising trend for the production of low cost instant flour and infant food.

INTRODUCTION

Extrusion cooking is one of the most versatile food manufacturing process owing to its capacity to convey, homogenize, gelatinize, denature, and cook and / or cool of food materials as applied in many conventional and novel food manufacturing operations, and more recently also in bio-technical and chemical processes. During extrusion cooking, raw materials undergo high shear, thus allowing partial starch hydrolysis (Colonna *et al.*, 1984). Adoption of extrusion cooking processing for instant flour production in developing countries is still limited. So, application of simple machine having small production capacity is therefore of great potential interest. The possibilities of a low cost collet extruder (about 25-35 kg/h) need to be studied for the production of snack foods and instant flours. Rice (*Oryza sativa*) and maize (*Zea Maize*) are the most frequently used cereals for making gluten-free food products and weaning foods. Legumes are a prime source of plant proteins, calories and other nutrients. Extrusion cooking of legumes increases the digestibility of legume protein. The quality of protein is related mainly to its essential amino acid composition and digestibility. While proteins of major cereals rice, maize, wheat and barley are very low in lysine and rich in methionine, and those of legumes and oilseeds are deficient in methionine and rich or adequate in lysine.

Rapid viscoanalyser can be used to investigate the pasting effects of lipids and amino acids on rice starch and flour (Liang and King, 2003, Liang *et al.*, 2002). The compact structure resulting from extrusion process can lead to a dense protein network reducing the availability of starch granules to attack by alpha-amylase (Fardet *et al.*, 1999). Moreover, the physical barrier created by the protein network limits the accessibility of starch to amylase and delays in vitro starch hydrolysis (Hoebler *et al.*, 1999). Studies have shown that proteins and added amino acids can influence the pasting characteristics of starch. The removal of proteins from starch caused the starch to have greater viscosity upon pasting because the granules without the protection of proteins were more fragile and allowed a greater amount of water to enter the granules, causing increased swelling. Various reports suggested that pasting characteristics (Lai 2001, Wiesenborn et al. 1994), rheological properties of paste and gels (Kim et al. 1995, Wiesenborn et al. 1994) and other functional properties (Wotton and Bamunuarachchi 1978, Zobel 1984) of starches vary with species and variants. The pasting properties of protein rich extrudates derived from rice and maize modified by the incorporation of legumes have not been studied so far. The objectives of the study were (1) to investigate the pasting differences between the starches from rice and maize incorporated with legumes, and (2) to determine the effect of legumes on the pasting characteristic of porridge made from raw and extrudates.

EXPERIMENTAL METHODS

Raw Materials

Different dehulled legumes (black gram, green gram, lentil and peas) and polished rice and maize were purchased from local market. After cleaning and grading, the raw materials were subjected to coarse grinding in plate mill to make grits in the particle size range of 1.65-2.36 mm. Different legume grits were blended (0, 5, 10 and 15 %) with rice grits. For making extrudates, about 2 kg of blended materials conditioned to 14 % (wb) were used. The different extrudates were prepared using a single screw food (collet) extruder of capacity 25 kg/h.

Sample Preparation for Analysis

After extrusion, extrudates were ground (< 0.85 mm) and subjected for pasting characteristics studies.

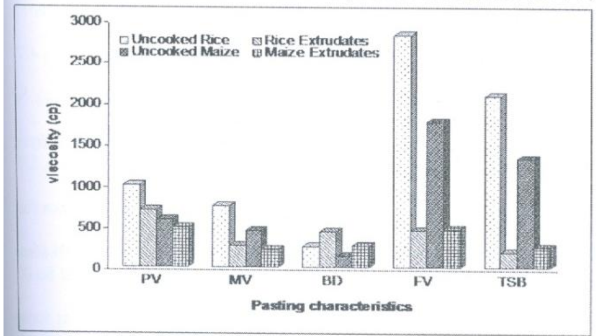
Pasting Characteristic Analysis

Pasting properties of extrudate powders were determined using a Rapid Visco Analyser (RVA) Model 3-D (Newport Scientific Pvt. Ltd, Australia) with Thermocline software (3.0 version) by ICC 1995. Sample suspension was prepared by placing extrudate powder (3g), in a canister containing (30g) distilled water. A programmed heating and cooling cycle was used. Each sample was stirred (960 rpm, 10 s) while heated at 50°C and then constant shear rate (160 rpm) was maintained for the rest of the process. Temperature was held at 50°C up to 1 min. Then the samples were heated (50-95°C, 3 min 42 s) and held at 95°C for 2 min 30 s. Subsequently samples were cooled down (95-50°C, 3 min 48 s) and then held at 50°C for 2 min. A RVA plot of viscosity (cp) versus time (s) was used to determine peak viscosity (PV), minimum viscosity (MV), breakdown viscosity (BD) and final viscosity (FV). Each analysis was done in triplicate.

RESULTS AND DISCUSSION

Comparison on Uncooked and Extrudates of Cereals

Formation of starch-fat complexes (Ho and Izzo 1992) and starch-protein complexes (Madeka and Kokini 1992, Mitchell and Areas 1992, Li and Lee 1996) may be significant during extrusion of cereal flours with complex composition. As shown in Fig. 1, for the pasting characteristics of rice and maize incorporated extrudates viz. PV,



(PV: peak viscosity, MV: Minimum viscosity, BD: Break down, FV: Final viscosity, TSB: Total set back)

Fig. 1. *Variation in viscoparameters for uncooked and extrudates.*

MV, FV, TSB were found to be decreased while BD increased almost twice as compared to rice and maize flour. The PV, MV and FV found to decrease up to 300 and 88 cp, 482 and 223 cp and 2367 cp and 1296 cp for rice and maize extrudates respectively. Also TSB has been observed to decrease by 1887 cp and 1074 cp for rice and maize extrudates. Sanni *et al.*, 2004 says that lower set back during the cooling of the paste indicates greater resistance to retrogradation. Among RVA parameters BD showed an increasing trend (180 cp and 132 cp) considerably for rice and maize based extrudates. These trend correlates well with the degree of gelatinization (Balasubramanian *et al.*, 2008). When extrudates powder suspensions are heated above a certain temperature, water penetrates into the granules and weakens the hydrogen bonds in starch segments and reflects a degradative RVA profile as compared to its corresponding raw material, due to mechanical input (Balasubramanian *et al.*, 2008). According to Lockwood *et al.*, 2008 amylose in the content of flour showed greater degree of entanglement and expressed increased viscosity level during cooling phase.

Comparison among different Legumes and Incorporation Levels

Incorporation of legumes with cereals resulted in a decline in pasting characteristics viz. PV, MV, BD, FV, TSB (Table 1). Among the selected legumes black gram incorporation showed a higher PV. The PV of uncooked rice and maize at different incorporation levels were 964.5 cp, 812 cp and 595.5 cp and 547.5 cp, 505 cp and 478 cp, respectively. Similarly PV for extrudates of rice and maize were found to be 683 cp, 612.5 cp and 576.5 cp and 465.5 cp, 453.5 cp and 420.5 cp. Sathe et al. 1982 also reported a very typical visco amylograph pasting profile for black gram starch than most legume starches. In this study, for both rice and maize, black gram decreased the remaining visco parameters significantly (Table 1). Among legumes, pea showed minimum pasting characteristics for uncooked composites and extrudates. The RVA parameters of green gram and lentil incorporation also showed decreasing trend, however these values were well configured to the pasting behavior of black gram and pea. At 5% incorporation level black gram showed a decrease of PV by 29.5 cp, 27.5 cp and 13.5 cp and 22.5 cp for uncooked raw composite and rice and maize extrudates. Incorporation of pea at 5% showed a decreasing PV by 59 cp, 169.5 cp and 33.5 cp, 94.5 cp for uncooked composites and extrudates of rice and maize respectively. Similar increase was the case for other incorporation levels. Symon and Brennan 2004 confirmed this significant decreasing trend for fibre fractions from barley incorporation with wheat starch as compared to its control starch. Also reported that these altering pasting properties trends were depend on legume type and its incorporation levels. However MV found to be decreased by 49 to 138 cp and 28 to 39 cp for uncooked rice and maize composites, but for extrudates MV was not prominently pronounced. The FV of uncooked rice and maize composites at 5% incorporation level showed a reduction up to 1144.5 cp and 587.5 cp, respectively. At 10% and 15% incorporation levels, FV decreased in greater extent. Similarly FV showed a maximum decrease (77.5 cp and 96.5 cp) for 15 % legumes incorporated rice and maize extrudates, respectively. TSB also observed a decrease from 435.5 cp to 849.5 cp and 284.5 cp to 495.5 cp for uncooked rice and maize extrudates respectively. Also, BD decreased from 53 cp to 103.5 cp and 30.5 cp to 45.5 cp at 15 % incorporation level for uncooked rice and maize composites. Similarly at 15 % incorporation level BD decreased from

TABLE 1. *Pasting characteristics of uncooked Rice and Maize Flour and Extrudates*

Types of Cereals	Pasting Characteristics (cp)	Types of legumes											
		Black gram (%)			Green gram (%)			Lentil (%)			Peas (%)		
		5	10	15	5	10	15	5	10	15	5	10	15
		Uncooked											
Rice	PV	964.5	812.0	727.0	883.5	781.0	591.0	843.5	723.5	604.0	824.5	740.0	595.5
	MV	695.0	592.5	512.5	641.0	575.5	462.5	630.0	534.5	575.0	606.0	544.5	446.5
	BD	265.5	217.5	173.5	254.0	204.5	173.0	213.0	189.5	197.0	216.5	194.5	146.5
	FV	2807.0	2403.5	1835.5	2545.0	2353.5	2042.0	2416.5	2159.0	2213.0	2409.0	2235.5	1674.5
	TSB	2110.5	1806.5	1490.0	1903.5	1776.5	1522.0	1785.0	1625.0	1639.5	1803.5	1689.5	1225.5
Maize	PV	547.5	505.0	478.0	544.5	471.0	447.5	525.5	474.0	450.0	516.0	495.0	436.5
	MV	415.0	390.5	376.0	412.5	371.5	360.0	405.5	370.0	357.0	404.0	382.5	345.5
	BD	133.0	114.5	101.5	128.0	96.0	86.5	115.5	103.0	93.5	112.5	113.0	88.0
	FV	1746.5	1557.5	1415.0	1623.0	1319.5	1184.5	1603.0	1404.5	1303.0	1553.0	1494.5	1176.5
	TSB	1310.5	1167.0	1036.5	1210.0	946.0	825.5	1191.5	1032.5	946.0	1149.0	1114.5	826.5
		Extrudates											
Rice	PV	683.5	624.0	576.5	643.5	621.5	555.0	633.5	586.0	552.5	602.5	531.5	522.0
	MV	261.0	242.0	234.5	253.5	244.5	236.5	251.5	231.0	226.5	237.0	243.5	225.0
	BD	422.5	384.0	342.0	390.0	374.0	318.0	382.0	352.5	326.5	367.0	287.5	296.0
	FV	437.5	397.0	382.0	421.0	402.5	383.0	430.5	390.0	379.0	412.5	405.5	374.5
	TSB	174.0	153.5	145.5	166.0	158.0	145.0	179.0	158.5	148.0	176.0	164.0	148.5
Maize	PV	465.5	453.5	420.5	462.5	447.5	416.5	459.0	437.0	415.5	454.5	430.0	390.0
	MV	225.5	225.5	215.0	234.5	226.5	215.5	223.0	223.0	216.0	227.0	217.0	218.0
	BD	239.5	230.5	206.5	230.5	220.0	202.5	235.0	215.0	190.0	225.0	214.0	173.0
	FV	454.5	414.0	394.0	453.0	445.5	375.0	448.0	423.0	380.0	440.0	407.0	370.5
	TSB	227.5	190.5	179.5	217.0	218.0	160.5	226.0	201.0	165.0	215.5	185.0	152.5

(PV: peak viscosity, MV: Minimum viscosity, BD: Break down, FV: Final viscosity, TSB: Total set back)

89 cp to 135 cp and 61.5 cp to 95 cp for rice and maize extrudates, respectively. The decrease in BD of starch signifies that the paste will be more stable to shear during cooking (Bean 1986).

Comparison among Legumes incorporated Rice and Maize Extrudates

Incorporation of legumes (5%) with rice decreased PV by 13.5 cp, 53.5 cp, 63.5 cp, and 94.5 cp for black gram, green gram, lentil and peas, respectively. As compared to rice and maize at same levels showed lower values. Thus PV continues to decrease by maximum of 175 cp and 98 cp for rice and maize extrudate up to 15% incorporation levels. MV and BD of rice based extrudates are comparatively higher as compared to maize based extrudate flour. At 5% incorporation level MV of rice with different legumes decreases by 5 cp, 12.5 cp, 14.5 cp and 29 cp; while for maize increased by 5.5 cp, 14.5 cp, 3 cp and 7 cp for black gram, green gram, lentil and peas, respectively. However at 15% incorporation level MV of maize decreased by 5 cp, 4.5 cp, 4 cp and 2 cp for black gram, green gram, lentil and peas, respectively. BD of rice and maize with different legumes at 5% incorporation level found to decreased by 8.5 cp, 41 cp, 49 cp and 64 cp and 28.5 cp , 37.5 cp, 33 cp and 43cp for black gram, green gram, lentil and peas incorporation, respectively. At 15% legumes incorporation level, BD decreased by 89 cp, 113 cp, 104.5 cp and 135 cp for black gram, green gram, lentil and peas with rice and by 61.5 cp, 65.5 cp, 78 cp and 95 cp for black gram, green gram, lentil and peas with maize extrudates. Protein inhibits retrogradation and hydrogen bond formation, requiring more energy in cooling i.e. BD (Ding and Wang 2004). A higher level of protein content in rice is helpful to increase heat resistance capacity and keep the hardness and stickiness of the gel when the temperature is changed (Jiamping *et al.*, 2008). At 5% incorporation level, TSB for rice is comparatively lower for rice extrudates (12 cp, 20 cp, 7 cp and 10 cp) as compared to maize (19.5 cp, 30 cp, 21 cp and 31.5 cp) for black gram, green gram, lentil and peas incorporation, respectively. Maximum decrease of TSB observed to be 41 cp and 94.5 cp for rice and maize respectively at 15% incorporation level, which signifies a lower extent of decrease in TSB for rice as compared to that of maize based extrudates. During retrogradation, glucan chains of starch become entangle with each other, which increases its viscosity. Thus the extrudates with lower TSB and pasting time implies better cooking and palatability. Thus, FV and TSB for rice and maize based extrudates decreased increased in protein content. Similarly 5% incorporation of black gram, green gram, lentil and peas decreases the FV by 14.5 cp, 31 cp, 21.5 cp and 39.5 cp for rice and by 12.5 cp, 14 cp, 19 cp and 27 cp for maize, respectively. Incorporation of 10% legumes showed much decrease between 46.5 cp and 62 cp for rice and 21, 5 cp and 60 cp for maize extrudates, which attains a maximum extent of decrease by 77.5 cp and 96.5 cp for rice and maize extrudates at 15% incorporation. It was observed that rice based extrudates had higher BD and lower TSB as compared to maize extrudates. High-amylose (linear) starches re-associate more readily than high amylopectin (branched) starches (Bultosa *et al.*, 2002). This trend was well correlated with starch amylase. Thus, it was positively correlated with pasting temperature and TSB and negatively correlated with BD (Juliano *et al.*, 1964; Noda *et al.*, 2004).

CONCLUSION

All pasting characteristics viz., PV, MV and FV for pregelatinized extrudates are lower than uncooked raw composites, with a significantly higher BD. As rice based extrudates have higher BD and lower SB as compared to maize and non-allergic would be preferable for enriched foods especially for infants. Legume incorporation further enhances the decrease in all pasting parameters probably due to variation in starch to protein fraction. Extrudates which are partially dextrinised and gelatinized during the treatment, yielding instant flour showed the scope for preparation of higher energy density gruels, especially diet and weaning foods. These results suggested that RVA pasting profile can potentially be applied in evaluating the extrudates quality of legumes incorporated rice and maize.

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