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RESEARCH ARTICLE

Effect of Virgin Coconut Meal (VCM) on the development of rice-based extruded snacks

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Abstract

Efforts were made to evaluate the effect of virgin coconut meal (VCM) on the rice based ready-to-eat extruded snack using twin screw extruder at preoptimised conditions. Physical parameters of extrudates, colour values (hunter colorimeter) of the blends and extrudates, pasting properties of the blends before and after extrusion were evaluated. Moisture, protein, fat, ash and fibre contents were analysed using prescribed methods. It was found that with the increase in the VCM level, there was a decrease in expansion ratio from 1.683 to 1.320, mass flow rate from 66 to 26 g/min and tap density from 0.658 to 0.602 gm/cc with the increase in bulk density from 2.29 to 4.12 g/cm^3 and water holding capacity from 12.34 to 15.64 ml. There was decrease in lightness (L) thereby increasing the redness (a) and yellowness (b) of the extrudates with the increase of VCM level. Viscosity values of extruded products were far less than those of corresponding unprocessed counterparts as evaluated. Addition of VCM resulted in increase in fibre content from 0.29 to 1.34% and protein from 6.10 to 7.20%. Sensorily extrudates with 10% VCM were found highly liked by taste panelists and it scored 8.5 on 9 point hedonic scale.

INTRODUCTION

Extrusion cooking involves a high temperature short time process whereby a single or mixed food materials is modified through the unique combination of high temperature, pressure and shear force to produce highly expanded, low density products with unique textural properties. Presently, there is a challenge in the process industry to develop convenience foods such as breakfast cereals and snacks of high nutritional value using locally available raw materials. One such versatile and efficient technology that finds application in the food process industry for the production of convenience foods is extrusion technology. It offers many advantages in terms of preparation of RTE foods of desired shape, size, texture and sensory characteristics at relatively low processing cost (Sumathi et al.,2007). It combines several unit operations including mixing, shearing, conveying, heating and process conditions. It provides the opportunity to process a variety of food products by minute changes in ingredients and processing conditions on the same machine.

Extruded snacks are being made from a variety of ingredients. In general, corn, wheat, rice, potato, tapioca and oats are used in the preparation of direct expanded snack. Rice (Oryza sativa) is a staple food crop for a large part of the world's population making it the second most consumed cereal grain. Rice as a raw material for extrusion offers a relatively good puffing quality with attractive white colour, ease of digestion bland flavour and is suitable for coating with a variety of flavouring (Yage and Gogus, 2009).

Virgin Coconut Oil (VCM) is emerging beneficial oil because of its various health benefits. Different types of extraction methods like cold and hot presses are used for its extraction from fresh coconut kernels under controlled temperature. It is not refined, bleached, deodorized or pressed in high heat during the manufacturing process. VCO has strong antimicrobial properties and helps in immune system. The whitish residue left after the extraction of oil can be milled into flour named as Virgin Coconut Meal (VCM). It is a source of dietary fibre and provides a number of health benefits in relation to coronary heart diseases, colon cancer and diabetes (Bawalan,2000). It has also been reported that consumption of high fibre coconut meal products increases facecal bulk and lowered the serum cholesterol (Arancon, 1999). Usually, meal obtained after extraction of oil found use in cattle, poultry and fish feed. However, oil extracted meal possess a good nutraecutical properties which could be utilized in the development of ready-to-eat snack foods. Earlier some workers have tried to develop foods like ladoo, halwa, biscuits using VCM (Yashi et.al., 2011 and Khan et al., 2012). But currently, no information is available on the development of extruded snacks using VCM. So attempts were made to evaluate the effect of VCM on development of rice based extruded snacks.

Materials and Methods

Rice, sugar and cardamom were procured from local market and virgin coconut meal (VCM) was supplied by Central Plantation Crops Research Institute (CPCRI), Kasargod, Kerala, India after the extraction of VCO. The Rice, sugar, cardamom and VCM were powdered in an ultra centrifugal mill using 500 mesh sieve.

Preparation of blends

Blends for the extrusion purpose was prepared using rice and VCM flour at different concentration by keeping sugar and cardamom powder concentration constant in all the blends. Blends consisted of 100% rice flour (Control) and mixtures of rice flour : VCM of 95:5; 90:10; 85:15 and 80:20. The moisture content of each blend was adjusted to 16% based on preliminary experiments. The blends were packed in polyethylene bags and equilibrated overnight at about 4-5^{o}C in a refrigerator. Before extrusion, the feed was allowed to come to ambient temperature and mixed again thoroughly for further use.

Extrusion

A Brabender laboratory twin screw co-rotating extruder (Brabendr, Germany) with 9 zones was used for the experiment purpose. The screws of the extruder were 25 mm in diameter and in 800 mm length. The extrusion temperature used throughout this paper refers to the temperature of the barrel surface in contact with food. Temperatures of the zones were maintained at 40, 50, 70, 90, 110, 130, 150, 170 and 185^{o}C for 9 zones respectively throughout the experiments. Based on preliminary experiments, the screw speed was maintained at 150 rpm with a feed screw speed of 50 rpm. The extruded products were cut with a face cutter attached at the product end which cut the product at relative cycle to equal lengths as it left the extrusion die. After stable conditions were estabilished, extrudates were collected and dried in air oven at 60°C for 2 hrs. Extruded materials were stored at refrigerator conditions for further analysis. All experiments were conducted in triplicate.

Physical parameters

Expansion ratio

The ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate (Fan et al., 1996). The diameter of extrudate was determined as the mean of 10 random measurements made with a Vernier caliper. The extrudate expansion ratio was calculated as

$$\text{Expansion ratio} : \frac{\text{Diameter of extrudate / mm}}{\text{Diameter of the die /mm}}$$

Bulk density (g/ml^{-1}) :

Bulk density was determined by filling a one litre measuring cylinder with the selected extrudates slightly above the liter mark. The cylinder was tapped 12 times till the products measured up to the liter mark. The weight of the extrudates was taken and the bulk density was calculated using

$$\text{Bulk density} : \frac{\text{Weight /g}}{\text{Volume /ml}}$$

Mass Flow Rate (MFR)

Mass flow rate was measured by collecting the extrudates in polyethylene bags for a specific period of time, as soon as it comes out of the die its weight taken instantly after its cooling to ambient temperature (Singh et al.,1996)

$$\text{MFR (gm/min)} : \frac{\text{Weight of sample collected (gms)}}{\text{Time taken to collect the samples/minute}}$$

Water Absorption Index (WAI, g/g) and Water Solubility Index (WSI, %)

WAI and WSI were determined in triplicate following the method described by Carine et al (2010). Each sample (1 g) would suspend in 20 ml of distilled water in a tared 45 ml centrifuge tube and be stirred with glass rod then put in water bath for 30 min at 30℃ temperature then centrifuge at 3,000 r min-1 for 15 min. The supernatants would pour into dry evaporator dishes of known weight and stored overnight at 120℃ for the process of evaporation. WAI and WSI would be calculating using following equations

$$\text{WAI} : \frac{\text{Weight of sediments}}{\text{Weight of dry solids}}$$

$$\text{WSI} : \frac{\text{Weight of dissolved solids in supernatant x 100}}{\text{Weight of dry solids}}$$

Hardness (N)

The hardness of the extruded samples was determined from the peak of the displacement plot of the extrudate during shearing using a Texture Analyser Plus (Model No.01/TALS/LXE/UK; LLOYD Instruments, connected to a data acquisition system Hampshire, UK) as described by Gupta et al.(2008).

Pasting properties

The changes in the apparent viscosity characteristics of the ground extruded samples were measured using Rapid Visco Analyser (RVA, New Port Scientific, Sydney, Australia) according to the method of AACC (2000).

Colour values

The colour values in terms of L ,a and b for ground extruded samples were measured using a Hunter Colour Meter (Data Lab; Silvasa, Gujarat, India) with illuminant D65 and 100 observer. A higher L value indicated a brighter or whiter sample. Values of a and b indicated the red-green and yellow-blue chromaticity respectively.

Sensory analysis of extruded snacks

Organoleptic characteristics of extrudates were determined by evaluating different attributes like colour, aroma, taste, texture and overall acceptability (OAA) by a 25 semi trained panel of the laboratory on a 9 point hedonic scale having a score of 9 for extreme liking and 1 for extreme disliking (Larmond, 1977).

Chemical analysis

Moisture, ash, protein, fat and fibre analysis of raw materials and extrudates was carried out using standard procedures of AOAC (1990). Carbohydrates were calculated by difference. All the experiments were replicated in order to express the data as the mean of ± SD of triplicate analysis.

Results and Discussion

Effect of virgin coconut meal (VCM) on the rice based extruded snack was evaluated by incorporating VCM at different levels (0-20%). Based on preliminary experiments, feed moisture level, feed rate, zone and die temperatures, screw speed were kept constant throughout the experiment. The proximate composition of rice flour was moisture 12.10%; protein 6.10%; fat 0.17%; ash 0.39%; fibre 0.29% and total carbohydrates (by difference)

81.18%. In VCM the proximate composition was moisture 6.7%; fat 54.0%; protein 14.3%; crude fiber 2.50%; ash content 1.55% and total carbohydrates (by difference) 23.40% . Protein content of extrudates showed a marginal increase compared to their raw materials due to inherent higher protein content of VCM. Fat content of extruded products were lower than those of their corresponding unprocessed flour blends indicating that extrusion process plays a role in fat reduction. Camire (2000) also reported the formation of complexes with amylose and protein content might be responsible for lower lipid extraction. Extrusion cooking did not resulted in remarkable change in fiber and ash contents of rice based VCM extrudates compared to their corresponding unprocessed flour blends (Table 1).

Bulk density which considers expansion in all directions is a very important parameter in the production of expanded and formed food products increased significantly ($p \leq 0.05$) from 2.29 to 4.12 with the increase in VCM concentration. The increase in bulk density may be attributed to the increase in fibre content and fat content with the increase in VCM concentration which decreases the starch content hence reduces the puffing quality of extrudates and in turn increase the bulk density. (Anderson, 1981; Singh et al., 1996 and Asare et al, 2004). Increase in bulk density may also be attributed to the increase in protein content with the increase in VCM concentration which reduces the puffing quality of extrudates.

The amount of expansion in food depends on the difference between the vapour pressure of water and atmospheric pressure, as well as the ability of the existing product to sustain expansion. In extrusion cooking, expansion which is highly dependent on the chemical composition of the raw ingredients used, and the transformations of these constituents during processing are composition dependent is associated with product crispness, water absorption, water solubility and crunchiness. Results presented in Table 2 shows that the expansion ratio (ER) of final products decreased significantly from 1.683 to 1.320 with the addition of VCM concentration. Expansion ratio of extruded products had an opposite direction trend to that for the tap density decreased from 0.658 to 0.602 g/cm^3. The decrease in ER may be due to the reduction of starch and increase in fiber and fat content which prevents the gas bubbles from expanding to their full potential (Moore et al., 1990; Williamson, 1993; Jin et al., 1994).

Water absorption index which measures the water holding by the starch after swelling in excess water, which corresponds to the weight of the gel formed. Increase in the VCM content resulted in increase in water absorption index from 6.70 to 10.13 g/g. The increase in WAI can be attributed to the increase in fibre content, there will be decrease in starch content resulting in the increase in water absorption capacity. Earlier also, Badrie and Mellowes (1992) reported a similar trend when wheat bran was added to cassava flour.

Water soluble index which is used as an indicator of degradation of molecular components, measures the amount of soluble components released from the starch after extrusion was found to decrease significantly from 11.52 to 9.26 % with the increase in VCM concentration. This decrease may be due to the increase in fiber content (Badrie and Mellows, 1992). It is also may be due to the fact that, since the extrusion was done at a high temperature, resulted in decrease in water soluble index. Mass flow rate which shows the rate of exit of extrudates from the die at a particular time found to decrease significantly with the increase in VCM concentration from 66 to 26 g/min.

The hardness of rice based VCM extrudates was determined by measuring the force required to break the extrudates. With the increase in VCM concentration, the hardness of the extrudates increases significantly ($p \leq 0.05$) from 14.35 to 43.14 N. The increase in hardness may be attributed to the increase in fibre content and protein content with the increase in VCM concentration. The increase in hardness may be directly correlated with the decrease in expansion ratio and increase in bulk density significantly from 2.29 to 4.12 g/cm^3 of the extrudates with the increase in VCM concentration. Earlier also, Altan et al (2008) showed that increasing grape pomace level resulted in an increase in the hardness of extrudates.

Colour is an important quality parameter since it reflects the extent of chemical reactions and degree of cooking or degradation that take place during extrusion cooking (Ilo and Berghofer, 1999). It also directly related to the acceptability of food products. The colour of extruded samples determined by L, a and b values are shown in Fig1. It is clear from the graph/ Fig1 that with the increase in VCM content, the lightness (L) of extrudates decreases from 82.31 to 69.51 (R^2 =0.972) with the increase in redness (a) and yellowness (b) from 1.56 to 3.12 (R^2 =0.972) and from 7.98 to 10.98 (R^2 =0.945) respectively. The decrease in lightness may be due to the increase in VCM content in the flour blends used for extrusion. The changes in redness and yellowness may be due to the shear forces generated during extrusion which accelerated the chemical reactions between amino acids and reducing sugars (maillard reaction) that takes place during extrusion (Guy, 2001).

Table -1. Proximate composition of unprocessed rice : VCM blends and their corresponding extrudates

	Fat (%)		Protein (%)		Ash (%)		Fibre (%)	
	BE	AE	BE	AE	BE	AE	BE	AE
Control (Rice flour)	0.18[ax]	0.10[a]	6.10[ax]	6.12[ax]	0.39[ax]	0.40[ax]	0.29[ax]	0.30[ax]
VCM (5%)	1.89[bx]	1.24[b]	6.39[bx]	6.46[bx]	0.42[bx]	0.44[bx]	0.39[bx]	0.40[bx]
VCM (10%)	4.35[cx]	2.52[c]	6.69[cx]	6.89[cx]	0.46[cx]	0.45[cx]	0.48[cx]	0.51[cx]
VCM (15%)	7.42[dx]	3.71[d]	7.15[dx]	7.27[dx]	0.52[dx]	0.49[dx]	0.57[dx]	0.59[dx]
VCM (20%)	8.91[ex]	6.12[e]	7.36[ex]	7.41[ex]	0.58[ex]	0.55[ex]	0.71[ex]	0.75[ex]

BE : Before Extrusion ; AE : After Extrusion
*Mean ± SD (n = 3)
[a-e] : values within the same column with different superscripts differ significantly ($p \leq 0.05$);
[x] :significantly different from their corresponding extruded samples ($p \leq 0.05$).

Table -2. Physical characteristics of Rice based VCM extrudates

Composition	Expansion ratio	Bulk density (g/ml^{-1})	WSI (%)	WAI (g/g)	Mass flow rate (g/min)	Hardness (N)
Rice flour	1.683[a]	2.29[a]	11.52[a]	6.70[a]	66[a]	14.35[a]
5%	1.490[b]	2.43[b]	11.04[b]	7.31[b]	61[b]	16.26[b]
10%	1.450[c]	2.65[c]	10.45[c]	8.53[c]	50[c]	25.14[c]
15%	1.400[d]	3.44[d]	9.95[d]	9.41[d]	38[d]	36.98[d]
20%	1.320[e]	4.12[e]	9.26[e]	10.13[e]	26[e]	43.14[e]

*Mean ± SD (n = 3);
[a-e] : values within the same column with different superscripts differ significantly ($p \leq 0.05$);

Table -3. Pasting characteristics of unprocessed and their corresponding rice based VCM extrudates

	Final Viscosity (RVU)		Break down (RVU)		Set Back (RVU)		Pasting Temp (°C)	
	BE	AE	BE	AE	BE	AE	BE	AE
Control (Rice flour)	245.0[ax]	45.92[a]	25.15[ax]	37.25[a]	143.00[ax]	15.08[a]	85.55[ax]	50.40[a]
VCM (5%)	234.0[bx]	40.28[b]	20.32[bx]	34.10[b]	131.75[bx]	14.23[b]	85.60[ax]	51.80[b]
VCM (10%)	210.0[cx]	29.25[cx]	17.58[cx]	28.23[c]	115.08[cx]	10.32[c]	87.10[bx]	65.45[c]
VCM (15%)	182.0[dx]	21.11[d]	13.22[dx]	25.12[d]	96.75[dx]	9.12[d]	88.80[cx]	68.23[d]
VCM (20%)	132.0[ex]	11.33[e]	10.11[ex]	18.17[e]	70.00[ex]	8.33[e]	88.90[cx]	70.14[e]

BE : Before Extrusion ; AE : After Extrusion
*Mean ± SD (n = 3);
[a-e] : values within the same column with different superscripts differ significantly ($p \leq 0.01$);
[x] :significantly different from their corresponding extruded samples ($p \leq 0.01$).

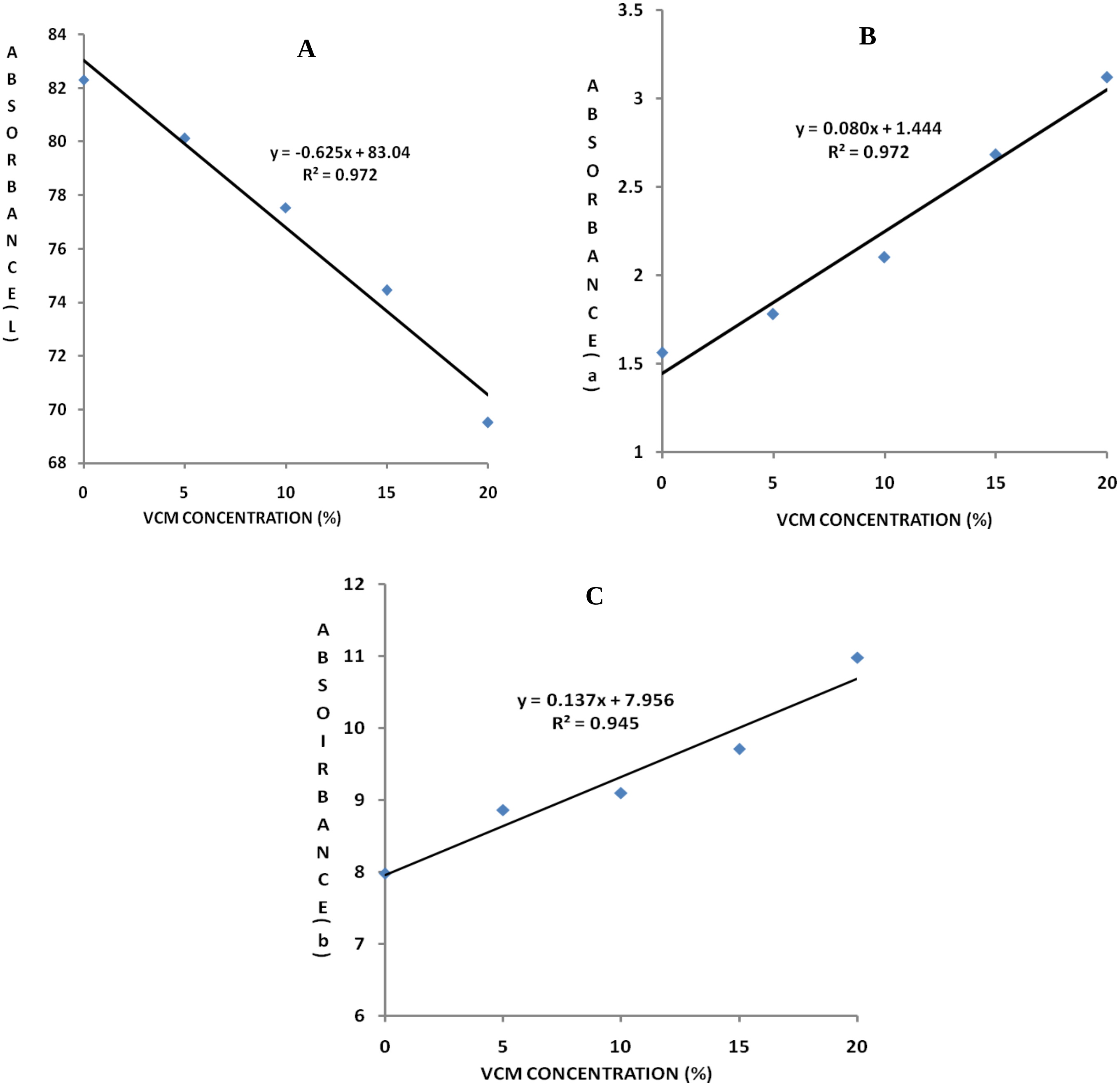

Fig -1. Effect of VCM concentration on the A) lightness, B) redness and C) Yellowness of rice based VCM extruded snacks

Reference :

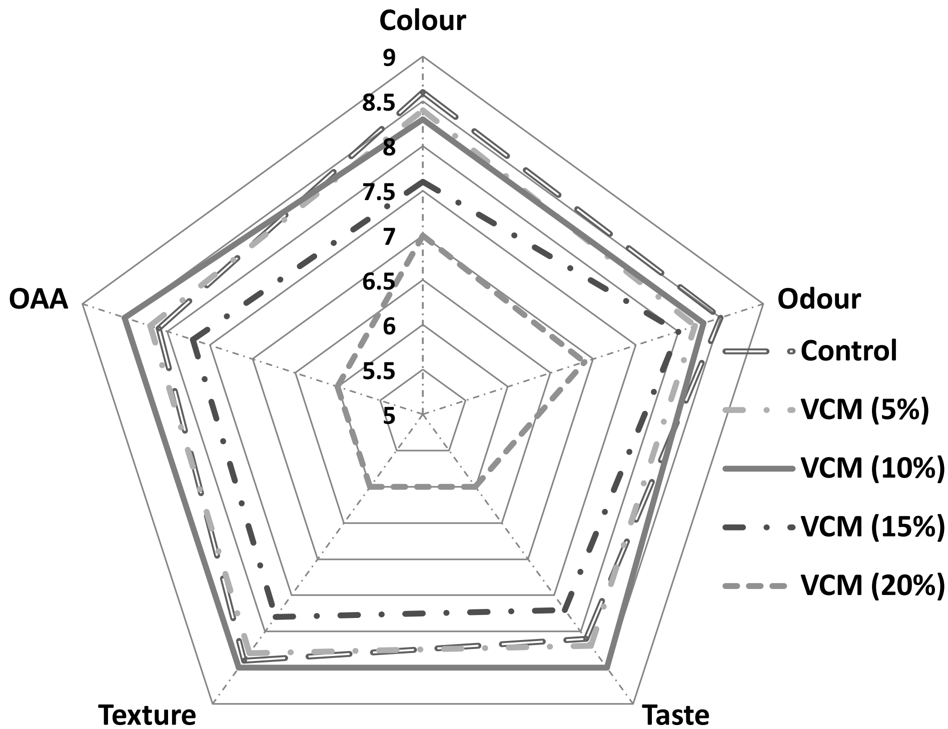

Fig -2. Sensory evaluation of rice based VCM extrudates

Pasting characteristics

The viscosity of a paste to a large extent depends on the degree of gelatinization of the starch granules and the extent of the molecular break down. From the table 3, it is evident that all the viscosity values of extruded products were significantly lower than those of their corresponding unprocessed flour blends indicating greater degradation and gelatinization of starch. The reduction in viscosity of extruded samples compared with the raw material has already been reported (Mercier and Fiellet 1975; Doublier et al., 1986). It is observed that increase in the amount of VCM results in the decrease in Final viscosity, which relates to the ability of starch granules to swell freely before their physical break down decreases from 45.92 to 11.33 RVU. The break down which is highly influenced by the amylose content and a measure of susceptibility of cooked starch granules to disintegration decreased significantly ($p \leq 0.05$) from 37.25 to 18.17. The set back viscosity which is a measure of recrystallisation of gelatinized starch during cooking and also represents the effect of cooking and tendency to retrograde decreases with the increase in VCM content from 15.08 to 8.33.

Sensory evaluation

Rice based extrudated prepared using different concentration of VCM were subjected for the attributes of colour, taste, texture, mouthfeel and overall acceptability by a panel of 15 semi trained judges. The graphical representation of the same is given in Figure 2. The graph of sensory evaluation revealed that extrudates prepared using 10% had the highest ranking scores in all the 5 attributes-colur, taste, texture, mouthfeel and overall acceptability. Extrudates prepared using 20% VCM received the lowest score in all the attributes. Extrudates with 10% incorporation of VCM were rated more acceptable than 5%, 15% and 20% VCM incorporated extrudates.

Conclusions

With the ongoing discussion, it can be concluded that highly acceptable ready-to-eat extruded snack can be developed using virgin coconut meal by preoptimising the twin screw extruder conditions. Addition of more than 10% will result in hard and unacceptable extrudates. Changes were observed w.r.t. physical properties, sensory, pasting properties and colour values with the increase in VCM content.

References

AACC(2000). Approved methods of the Association of Cereal Chemists International (10th Ed.) St. Paul, Minnesota, USA

Altan A, McCarthy K.L and Maskan, M. (2008). Twin-screw extrusion of barley-grape pomace blends: Extrudate characteristics and determination of optimum processing conditions. J of Food Engineering 89: 24-32.

Anderson, Y., Hedlund, B., Jonsson, L. and Svesson, S. (1981). Extrusion cooking of high-fiber cereal product with crispbread character. Cereal Chem 58:370-374.

AOAC (1990). Official Methods of Analysis, 15th Edn. Association of Official Analytical Chemists, Washington.

Arancon, R.N. (1999). Coconut Flour," Cocoinfo International 6 (1): 8-10.

Asare, E.K, S., Sefa-Dedeh, E., Sakyi-Dawson. and Afoakwa, E.O. (2004). Application of response surface methodology for studying the product characteristics of extruded rice –cowpea-groundnut blends. Int.J.Food Sci.Nutri 55: 431-439.

Badrie, N. and Mellowes, W. A. 1992. Soybean flour/oil and wheat bran effects on characteristics of cassava (Manihot esculenta Crantz) flour extrudate. Journal of Food Science 57(1): 108-111.

Bawalan D.D. (2000). The Economics of Production, Utilization and Marketing of Coconut Flour from Coconut Milk Residue," Center for Occupational Research and Development 16 (1): 1-13.

Camire, M. E. (2000). Chemical and nutritional changes in food during extrusion. In: Extruders in Food Applications (edited by M.N. Riaz). Pp 127-147. Boca Raton, FL: CRC Press

Carine, S., Kong, X. and Hua, Y. (2010). Optimization of Extrusion Flour Composed of Corn, Millet and Soybean. Pakistan Journal of Nutrition 9 (3): 291-297.

Doublier J.L., Colonna, P. and Mercier, C. (1986). Extrusion cooking and drum drying of wheat starch. 11, Rheological characterisation of wheat starch pastes. Cereal Chem 63: 242-246.

Fan, J., Mitchel J.R. and Blanchard, J.M.V (1996). The effect of sugars on the extrusion of maize grits: II. Starch conversion. Int J of Food Sci 31:67-76

Gupta M, Bawa AS and Semwal AD (2008). Effect of barley flour on development of rice based extruded snacks. Cereal Chem, 85 (2) : 115-122

Guy, R., 2001. Extrusion cooking: technology and applications. Woodhead publishing limited, Cambridge, England.

Ilo, S. and E. Berghofer, 1999. Kinetics of color changes during extrusion cooking of maize grits. J. Food Eng., 39: 73-80.

Jin, Z., Hsieh, F. and Huff, H. E. (1994). Extrusion cooking of corn meal with soy fiber, salt and sugar. Cereal Chemistry 71(3):227-234.

Khan M.A., Mahesh, C, Semwal, A.D. Sharma, G.K. (2012). Optimization and Storage Stability of Virgin Coconut Meal Incorporated Instant Sooji Halwa Mix. Food & Nutrition Science 3 :1092-1099.

Larmond, E (1997). Laboratory Methods for Sensory Evaluation of Food," Canada Department of Agriculture Publication, Ottawa, pp,1637-1662.

Mercier, C and Fillet P (1975). Modification of carbohydrates components by extrusion-cooking of cereal products. Cereal Chem, 52: 283-297.

Moore, D., Sanei, E., Vanhecke, Z. and Bouvier, J. M. (1990). Effect of ingredients on physical/ structural properties of extrudate. Journal of Food Science 55: 1383-1387.

Singh, N., Singh, B., Sandhu, K.S., Bawa, A.S. and Sekhon, K.S. (1996). Extrusion behaviour of wheat, rice and potato blends. J Food Science and Technol 3 (4): 291-294.

Sumathi, A., Ushakumari, R., Malleshi, N.G. (2007). Physicochemical characteristics, nutritional quality and shelf – life of pearl millet based extrusion cooked supplementary foods. Int J. Food Science and Nutrition 58(5), 350 – 362.

Williamson, D. D. (1993). Benefits from fiber in extrusion systems. Ingredients Extra 2(3): 9.

Yage, S., and F. Gogus.(2009). Effect of incorporation of various food by-products on some nutritional properties of rice-based extruded foods. Food Science and Technology International 15 (6): 571-581.

Yashi, S., Semwal, A.D., Sharma, G.K., Bawa, A.S. (2011). Utilization of Virgin Coconut Meal (VCM) in the Production of Ready-to-Eat Indian Traditional Sweet Meat Using Response Surface Methodology, Food and Nutrition Sciences 2 :214-221.