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UTILIZING KARONDA PULP AS A NUTRIENT BOOSTER IN EXTRUDED SNACK

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ABSTRACT

Karonda (*Carissa carandas* L.) is one of the potentially underutilized fruits that have nutritional benefits that apply to the preparation of different value-added products. Extrusion processing is High-Temperature, Short Time (HTST) process whereby the food product is exposed to very high temperatures for only a few seconds. The study on the topic “Utilizing karonda pulp as a nutrient booster in extruded snacks” was conducted at the Department of Postharvest Technology, College of Horticulture, Bengaluru, in the academic year 2021-2022. Karonda pulp fortified extruded snack was developed with three variables namely karonda pulp (5, 7.5 and 10%), barrel temperature (100, 115 and 130 °C) and moisture content (16, 18 and 20%). Sensory scores (9-point hedonic scale) of extruded snacks prepared with 10% karonda pulp, 100 ! barrel temperature, and 18% moisture content recorded maximum sensory scores. The extruded snack with the same composition registered 2.88 m/m expansion ratio, 198 crispness, 10.73 kg hardness, 49.04 kg sec chewability, and 86.54 mm fracturability.

Key words : Extruded snack, Karonda pulp, Fortification, Expansion Ratio, Textural characteristics.

Introduction

Rapid urbanization has brought changes in occupation pattern, people’s life style and family structure. Urbanization usually involves varying degrees of modernization and westernization, which will have an impact on the dietary habits, traditional diets and lead to shift in the food consumption patterns. Consumer demand for convenience foods is now on the rise around the globe. Convenience has an immense impact on the food choices of today’s consumers. Today’s consumers want a lot more than merely safe and shelf-stable food. Extrusion processing is High Temperature Short Time (HTST) process whereby the food product is exposed to very high temperature for only few seconds. During which the structural change in the food is bound to occur thereby leading to expansion of the product. Extrusion cooking along with expansion also serves certain inherent benefits like increase in protein quality and digestibility and decrease in anti-nutritional factors. Huang *et al.* (2006) reported that extrusion processing has become an important food process in the production of snacks, pasta, Ready To Eat (RTE) cereals, pet foods and textured vegetable protein. Therefore, it has gained major importance in food processing. An extruder consists of a tight-fitting screw rotating within a stationary barrel. Pre-ground and conditioned ingredients enter the screw where they are conveyed, mixed and heated by a spread of processes. The product exits the extruder through a die where it usually puffs and changes texture from the discharge of steam and normal forces. Extrusion has been broadly applied in the development of nutritive foods. As extruders are being applied in many diverse food operations, they are increasingly considered as flexible process. It is a common belief that extruded products made from a single component have a poor flavour, which might be due to a lack of quality characteristic or other factors. As a result, fortification is likely to compensate for some qualities by reconnecting flavours and removing or diluting unwanted extruded product components. Fortification is used to maintain the balance of quality characters in the final product (Chakraborty *et al*., 2016). Extrusion works on the principle of gelatinization of starch, the macromolecule structure of starch molecule opens up and viscous plasticized mass is produced. Due to the lesser amount of starch content in the karonda pulp, there is a need to supplement other starchy ingredients like maize grits for development of karonda fortified extruded products. Extruded products are becoming very popular among the adolescents and elders as well. They normally called as junk foods since they contribute very less or no nutrition but they are tasty and offers convenience. Many researchers have attempted their fortification with fruit and vegetable powders to increase functionality yet retaining taste they offer. Karonda (*Carissa carandas* L.) is an underutilized minor fruit crop of India. It belongs to the family Apocynaceae. Karonda is an indigenous protective fruit used in high esteem in Indian diet. It is popularly known as "Christ's thorn". Some of the other names are karamda, karamanda, karavanda, Natal plum, Kaunda etc (Banik *et al.*, 2012). Botanically the fruit of karonda is a berry, which is produced in clusters of 3-10 numbers. Flowering starts in the month of January – February. A fruit comes to mature in May-June and are harvested at both mature and ripe stage depending on their use. Mature fruits are green in colour with sour and astringent taste (Anonymous, 2013). Nutritionally fruits are rich in protein (1.1 g/100g), vitamin C (20 mg/100g), carbohydrates (2.9 g/100g) and minerals especially iron (39 mg/100g), calcium (160 mg/100g) and 60 mg/100g of phosphorus (Hameed *et al*., 2021). The complete plant has medicinal values. Karonda flowers are used to remedy diverse diseases. Anemic disease is controlled by iron found in karonda. Vitamin C is found in high amounts in karonda. By which scurvy disease is controlled. Karonda fruit has an Anthelmintic effect with inside the Body, which expels the Parasitic Worms. It eliminates impurities from the blood. Eating Karonda mature fruit removes the disease of anorexia. Epilepsy disease is controlled by the use of karonda leaves. Abdominal pains, dysuria, menorrhagia and ulcer are controlled using the root of Karonda. It is fine in decreasing the blood sugar quantity in curing Diabetes (Singh and Singh, 2021). Owing to its perishability, the shelf life of ripe karonda is very limited due to its soft flesh and elevated amount of moisture. Under normal temperature, harvested fruits can be stored only up to two days at normal temperature. Mature fruits can be stored for five to seven days at room temperature before they began to shrivel (Peter, 2007). Response Surface Methodology (RSM) is a statistical method used to describe the link between process factors and product quality (Giovanni, 1983). The RSM is a statistical technique that investigates the links between many explanatory variables and one or more response variables. Box and Wilson (1951) first proposed the approach. The primary principle of RSM is to obtain an optimal response through a series of carefully prepared tests. Although, the RSM model provides an approximation result, it is extensively employed because it is simple to estimate and apply, even when little information about the process is available. RSM is widely utilised in food extrusion research. The main advantage of RSM is the reduced number of experimental runs needed to provide sufficient information for statistically acceptable results. Based on the above understandings, the present research was focused on the development of the fortified extruded snack using karonda pulp that is similar to commercial kurkure, as it satisfies the function of convenience food, which is a non-traditional cereal-based food product that is becoming increasingly popular around the world for its nutritional benefits, palatability and convenience.

Materials and Methods

The raw materials used for the development of extruded snack products were maize grits and karonda pulp, both procured from a local market in Bengaluru, Karnataka. The snack development process was carried out using a twin-screw extruder, which is a widely used machine in food processing, known for its ability to mix and shape ingredients through a high-temperature, high-shear cooking process.

Formulation and Parameters of extruded Snack

The development of the extruded snack product involved experimenting with several key variables to optimize the product's quality, including maize grits: Constituting from 92.5 to 100%; Proportion of karonda pulp: Three levels were tested were 5.0%, 7.5% and 10%; Barrel temperature: The extrusion was conducted at three different temperatures were 100°C, 115°C, and 130°C; Moisture content: The initial moisture content of the blend was varied between 16%, 18% and 20%.

Evaluation of the extruded snacks

Expansion ratio : Measures how much the snack "puffs" during extrusion. A higher ratio gives a lighter, crispier texture.

Colour value : Assessed the snack's visual appeal, influenced by cooking temperature and natural pigments from the karonda pulp.

Textural characteristics are : Crispness: Desirable light, airy texture; Hardness: Force needed to break the snack, balanced for optimal satisfaction; Chewability: Ease and comfort in chewing; Fracturability: Snack's ability to break easily, enhancing mouthfeel.

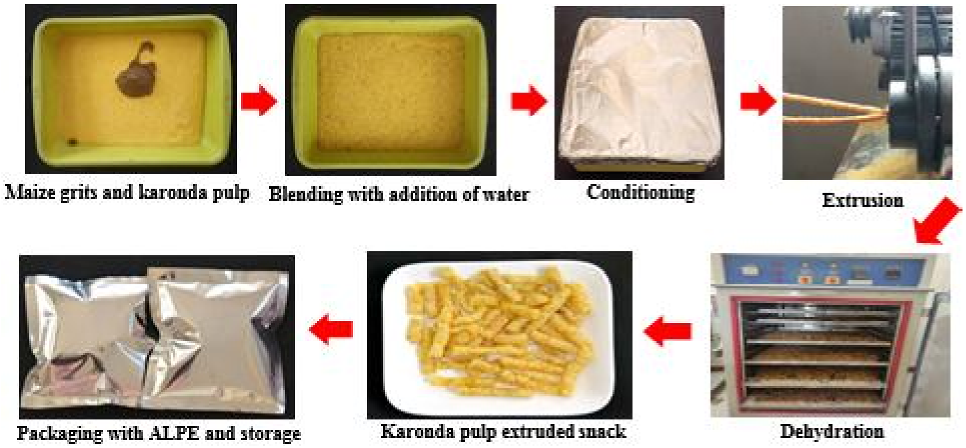

Fig. 1 : Process flow chart for production of fortified RTE extruded snack.

Results and Discussion

Effect of process conditions on the physical and textural properties of extruded snacks

Expansion Ratio (ER) : The expansion ratio (ER) values of the extruded products exhibited variability, ranging from 3.06 to 4.31 m/m, as delineated in Table 1. Notably, the lowest expansion of extrudate occurred at a heightened karonda pulp fortification (T_{10}), while the highest expansion was observed at a lower level of karonda fortification (T_{16}). This phenomenon underscores a significant dependence of the expansion ratio on the starch content within the raw materials. As the level of karonda pulp fortification increased, there was a concomitant reduction in starch content, consequently diminishing the expansion ratio of the products. This reduction in ER with elevated Karonda pulp levels can be attributed to the concomitant decrease in starch gelatinisation. This observed trend aligns with prior findings in analogous studies. Perez Navarrete *et al.* (2005) reported similar outcomes regarding the expansion ratio in lima bean-fortified extruded snacks, while Bisharat *et al.* (2013) documented comparable trends in dehydrated vegetables fortified extruded snacks. Such congruent results further underscore the intricate interplay between fortification levels and the resultant expansion characteristics in extruded products.

Crispness (No of peaks) : The crispness values of the extruded products demonstrated variability ranging number of peaks from 128 to 279, as delineated in Table 1. Notably, the minimum crispness of the extrudate was observed at a higher level of karonda pulp (10%) and moisture (20%) in the blend at T_6, while the maximum crispness was recorded at a lower level of karonda pulp (0%) and moisture (18%) in the blend at T_{16}. This variance in crispness underscores a significant dependency on the starch content within the raw materials. The crispness of the products is predominantly influenced by the starch content in the raw materials. As the level of karonda pulp increased, there was a corresponding reduction in starch content, thereby decreasing the crispness of the products. This decrease in crispness with elevated levels of Karonda pulp can be attributed to the presence of a lesser number of thin walls in the microstructure and larger air pockets within the product. Sahu and Patel (2020) reported similar trends in crispness in defatted soy-incorporated maize-millet-based extruded products, while Dar *et al.* (2014) documented analogous results in carrot pomace-based extrudates. Such congruence in results highlights the intricate relationship between formulation parameters and the resultant crispness characteristics of extruded products, emphasizing the need for meticulous consideration of ingredient composition in product development and optimization endeavours.

Hardness (Kg) : The hardness values of the extruded products displayed variability ranging from 8.43 to 15.80 Kg, as outlined in Table 1. Notably, the minimum hardness of the extrudate was observed at a lower level of karonda pulp (0%) and moisture (18%) in the blend at T_{16}, while the maximum hardness was recorded at a higher level of karonda pulp (10%) and moisture (16%) in the blend at T_1. This variation in hardness underscores a significant dependence on the content of raw materials and moisture levels. The hardness of the products is primarily influenced by the composition of raw materials and moisture content. As the levels of karonda pulp and moisture increased, there was a corresponding reduction in starch content, leading to an increase in product hardness. This increase in hardness with elevated levels of karonda pulp and moisture can be attributed to several factors. Firstly, there is a reduction in starch gelatinization, thereby affecting the structural integrity of the product. Additionally, the increase in fibre content contributes to higher cell wall thickness, consequently reducing the size of air pockets within the product. Moreover, the presence of a denser mass in the microstructure of the product

Table 1 : Effect of different levels of karonda pulp (K), barrel temperature (BT) and moisture (M) on karonda pulp extruded snack responses of textural properties

Treatments	**Expansion Ratio (m/m)**	**Crispness (Number of peaks)**	**Hardness (Kg)**	**Chewability (Kg sec)**	**Fracturability (mm)**
$\mathbf{T}_{1}$ (K10:BT115:M16)	3.21	137	14.95	72.83	67.80
$\mathbf{T}_{2}$ (K05:BT100:M18)	4.02	220	09.32	47.51	71.45
$\mathbf{T}_{3}$ (K7.5:BT115:M18)	3.92	209	12.20	53.81	69.54
$\mathbf{T}_{4}$ (K10:BT100:M18)	2.88	198	10.73	49.04	86.54
$\mathbf{T}_{5}$ (K05:BT115:M16)	4.12	201	09.60	46.69	70.89
$\mathbf{T}_{5}$ (K10:BT115:M20)	2.86	128	15.73	88.10	68.83
$\mathbf{T}_{7}$ (K7.5:BT130:M20)	3.54	152	13.97	75.69	73.54
$\mathbf{T}_{8}$ (K7.5:BT100:M16)	3.73	193	11.24	59.66	71.40
$\mathbf{T}_{9}$ (K7.5:BT115:M18)	3.96	211	12.32	54.42	68.73
$\mathbf{T}_{10}$ (K10:BT130:M18)	3.06	162	13.42	78.05	68.76
$\mathbf{T}_{11}$ (K7.5:BT115:M18)	3.89	208	12.80	54.27	69.65
$\mathbf{T}_{12}$ (K7.5:BT100:M20)	3.46	139	15.80	84.21	66.81
$\mathbf{T}_{13}$ (K05:BT130:M18)	4.06	197	09.64	62.29	72.06
$\mathbf{T}_{14}$ (K05:BT115:M20)	3.98	143	13.28	102.72	72.12
$\mathbf{T}_{15}$ (K7.5:BT130:M16)	3.62	182	10.03	76.43	74.78
$\mathbf{T}_{16}$ (K0:BT115:M18)	4.31	279	08.43	47.98	70.62

K- Karonda pulp (%), BT- Barrel temperature (^{0}C), Moisture- (%).

further contributes to increased hardness. Singh *et al.* (2018) reported similar significance regarding hardness in brown seaweed extruded products, while Pensamiento-Nino *et al.* (2018) documented analogous trends in mango pulp-enriched taro flour extruded snacks. Such alignment in results underscores the complex interplay of formulation and processing parameters in determining the hardness characteristics of extruded products.

Chewability (Kg sec) : The chewability values of the extruded products exhibited a range from 46.69 to 102.72 Kg sec, as illustrated in Table 1. Remarkably, the minimum chewability of the extrudate was observed at a lower level of moisture in the blend, specifically at T_5, while the maximum chewability was recorded at a higher level of moisture in the blend, notably at T_{14}. Chewability, in this context, can be understood as the energy required to chew solid food. The observed increase in chewability with elevated moisture levels can be attributed to the concurrent increase in hardness. As moisture content increases, there is a corresponding increase in product hardness, necessitating more energy for effective mastication. This relationship underscores the influence of moisture content on the textural properties of the extruded products, particularly in terms of chewability. These findings align with prior research. Lin *et al.* (2000) reported similar significant differences in chewability in soy protein meat analogue extruded products. Such consistency in results highlights the importance of moisture content in determining the chewability characteristics of extruded products, emphasizing the need for careful consideration of processing parameters to achieve desired textural properties.

Fractuability (mm) : The fracturability values of the extruded products exhibited a range from 66.81 to 86.54 mm, as detailed in Table 1. Notably, the minimum fracturability of the extrudate was observed at a higher level of moisture (10%) in the blend at T_1, while the maximum fracturability was recorded at a lower level of moisture (7.5%) in the blend at T_{14}. Fracturability, in essence, refers to the force required for the sample to crumble and crack. It is noteworthy that fracturability varied among treatments, but not in a linear fashion as observed in other characteristics. Notably, no linear terms exhibited a significant effect on fracturability. This observation highlights the nuanced nature of fracturability as a textural attribute, which may be influenced by complex interactions among various factors. These findings are consistent with prior research. Rodriguez Vidal *et al.* (2017) reported similar significance regarding fracturability in extruded snacks from whole wheat supplemented with textured soy flour. Such alignment underscores the multifaceted nature of textural attributes in extruded products and emphasizes the importance of comprehensive analysis to understand the underlying factors governing product characteristics.

Lightness (colour *L value) :** The lightness values of the extruded products range from 52.4 to 63.2, as presented in Table 1. Notably, the minimum lightness of the extrudate was observed at elevated levels of karonda pulp (T_6) and moisture (T_6) in the blend. In contrast, the maximum lightness was recorded at lower levels of karonda (T_{16}) in the blend. This variance in lightness underscores a significant influence on both the colour of the raw materials and moisture content. Specifically, as the level of karonda pulp increased, there was a corresponding decrease in lightness due to the inherently darker colour of karonda pulp. Additionally, higher moisture content contributed to decreased lightness. This relationship can be further attributed to the lower levels of expansion, as reported in prior studies (Liu *et al*., 2011; Stojceska *et al*., 2009). Furthermore, non-enzymatic browning processes likely contributed to the observed decrease in lightness. Cortes *et al*. (2014) reported similar significance regarding the lightness value in passionfruit pulp extruded snacks. Such congruence in results underscores the multifaceted factors influencing the lightness of extruded products and emphasizes the need for comprehensive consideration of raw material composition and processing parameters in product formulation and optimization.

Sensory quality : The extruded products were subjected to sensory evaluation to select the best acceptable blend composition. The quality parameters included in the sensory evaluation of extruded products obtained from a series of experiments were colour/ appearance, texture/mouth feel, taste, after taste and overall acceptability. The sensory scores assigned by the panellists are given in Fig. 2. Treatment K10:BT100:M18 (karonda pulp 10% + barrel temperature 100^0C + moisture 18%) showed highest sensory scores with 8.90, 8.60, 8.50, 8.80 and 8.70 for colour/appearance, texture /mouth feel, taste, after taste and overall acceptability. The overall acceptability of the fortified RTE extruded snack varied from 6.97 to 8.84. It might be due to the colour of the product by addition of karonda pulp and textural characteristics which were well accepted by the consumers. Altan *et al*. (2008) reported similar findings where grape pomace level decreased the sensory score but it was well accepted by the panel and also by Kothakota *et al*. (2013).

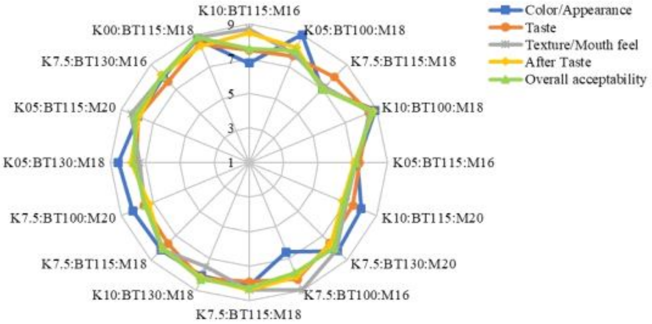

Fig. 2 :

Conclusion

The extruded products developed composite blends of karonda pulp and maize were evaluated for their physical and textural characteristics like expansion ratio, lightness, crispness, hardness, chewability, fracturability. Treatment, K10:BT100:M18 (karonda pulp 10% + barrel temperature 100°C + moisture 18%) had the best score in acceptance test (9-point Hedonic scale) by the panellists other than control sample. The successful utilization of these commodities for development of extruded products and many tropical and subtropical fruits and vegetables, which are commonly available during the season can be utilized for production of extruded products after standardizing different variables.

Authors' contribution

Supervision: Suresh G J- Associate Professor, Department of Postharvest Management, College of Horticulture, Bengaluru, UHS Bagalkot, Karnataka, India (to review article)

Co-author: Venugopalan R- Principal Scientist, IIHR, Hessarghatta, Bengaluru, Karnataka, India (to review related statistical analysis)

Conceptualization of research given by Suresh G J; Designing of the experiments done by Suresh G J; Contribution of experimental materials given by Suresh G J; Execution of field/lab experiments and data collection helped by Venugopalan R; Analysis of data and interpretation suggested by Venugopalan R; Preparation of the manuscript helped by Suresh G J.

Declaration of competing interest

The study titled " Utilizing karonda pulp as a nutrient booster in extruded snack" submitted to the Journal of Horticultural Sciences, declares that I have no competing interests associated with this research.

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