Some Functional, Chemical, and Sensory Characteristics of Cactus Pear Rice-Based Extrudates♦

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ABSTRACT

Both orange-yellow and red cactus pear pulps were concentrated (to 40ºBrix), and then added to rice grits to produce a delectable product of rice-based extrudates. Both concentrated pulps were added to rice grits in five levels 0, 5, 10, 15 and 20%. The effects of added concentrated pulps on some physical (expansion ratio (ER), bulk density (BD), water absorption index (WAI), water solubility index (WSI), breaking strength (BS), and color attributes (L^*, a^* and b^*); chemical (moisture, total carbohydrate, crude protein, crude fat and ash); and sensory (taste, crispness, chewiness, odor, color, pore distribution, surface characteristics, and overall acceptability) characteristics of extruded products were evaluated. The expansion ratio (ER), water absorption index (WAI), and water soluble index (WSI) of all products decreased by increasing the added concentrated-pulp ratio, while breaking strength (BS) decreased up to 10% of the added ratio, then increased. Bulk density, ash content and color attributes (a^* and b^*) increased for all extruded products. Adding both concentrated cactus pear pulps to rice flour extremely enhanced the sensory characteristics of final extruded products, and the obtained results showed the possibility of producing a new value-added snack-type extrudate based on cactus pear pulp concentrates.

Key words: Cactus pear pulps, rice extrudates, chemical and physical characteristics

INTRODUCTION

Extrusion cooking is a high-temperature, short-time (HTST) technology applied in many food production processes and considered as a continuous cooking, mixing, and forming process with low cost and high efficiency (Ryu *et al.,* 1993; Abd El-Hady *et al.,* 1998; Ding *et al.,* 2005). Extrusion has been used in the cereal industry for several years to produce many foods and food ingredients such as breakfast cereals, snack foods, baby foods, pasta products, extruded bread, modified starches, beverages powders, meat and cheese analogues, textured vegetable protein, and blended foods such as corn starch and ground meats (Anderson *et al.,* 1969; Moore *et al.,* 1990; Abd El-Hady *et al.,* 1997; Zang and Hoseney, 1998; Rhee *et al.,* 1999). Many factors affect the quality of the final extrudate, such as extruder type, screw configuration, feed moisture, temperature profile of the barrel section, screw speed, and feed rate as well as the type of raw material and food ingredients (sugar, fiber, starch, fat, and protein) (Frazier *et al*., 1979; Noguchi *et al*., 1981 ; Holay and Harper, 1982; Moore *et al.,* 1990 ; Jin *et al*., 1994).

The main raw material for production of breakfast cereals and snack foods is the starchy component of grains, such as corn, rice, and wheat. This component is poor in sugars, fibers, vitamins, and minerals.

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Consumers are becoming more educated about the nutritional value of foods and have start changing their food consumption life style. They are now choosing foods rich in nutraceuticals, dietary fibers, natural colorants, minerals and vitamins, low in fat, and free of synthetic food additives (Saenz, 2002).

Cactus pear pulp is considered as a major source of nutraceuticals and functional components. It is a good natural source of healthy components such betalains, phenolic compounds, pectin (source of dietary fiber), vitamin C, calcium, and magnesium (Stintzing, *et al.,* 2001; Piga *et al.*, 2003; Piga, 2004). The interest of the food industry in betalains has grown since they were identified as natural antioxidants (Escribano *et al.,* 1998), which may have positive health effects in humans (Tesoriere *et al.,* 2004). Additionally, cactus pear pulp is a rich source of the amino acid proline and taurine (an end product of L-cysteine metabolism) (Stintzing *et al*., 1999, 2001). L-proline and and taurine have become common ingredients in energy drinks.

Cactus pear pulp has been processed into many different products such as juices, nectars, dehydrated sheets, marmalades, jams and jellies, natural sweeteners, wine and other alcoholic beverages, candies, and canned and frozen fruit (Barbera, 1995; Gurrieri *et al*., 2000; Saenz, 2000; Sepulveda *et al*., 2000; Saenz and Sepulveda, 2001). According to our knowledge, cactus pear pulp has not been used in the fabrication of cereal-based extrudates. Thus the aim of this study was to develop a value-added extruded snack type product with acceptable characteristics using a mixture of cactus pear pulp concentrate and rice flour.

MATERIALS AND METHODS

Cactus pear pulp

Representative half-ripened orange-yellow and red cactus pear fruits were collected from a specialized cactus orchard in Al-Sharqiyah governorate, Egypt. The fruits were washed, manually peeled, and blended for 5 seconds in a blender (Moulinex, 300W, type 721, France) to facilitate seeds separation, and then were sieved to separate the seeds only from the full pulp. The extracted pulps contained all their components and were tested freshly for some technological and chemical characteristics. The pulps were concentrated by evaporation under vacuum at 60°C until they reached 40°Brix using an evaporator (Büchi Rotavapor, RE 111, Switzerland).

Rice flour

Rice was purchased from the local market, then ground to get homogenous particle size by using a laboratory mill (Brabender Automat Mill Quandrumat Senior, Germany).

Preparation of formulas

Both orange-yellow and red cactus pear pulp concentrates were used in making the formulations. Formulations consisted of 100% rice flour (control) and mixtures of rice flour: cactus pear pulp concentrate of 95:5, 90:10, 85:15, and 80:20.

Extrusion

A Brabender 20DN laboratory single-screw extruder (Brabender Co., Duisburg, Germany) with 3 zones (feeding zone, cooking zone, and die zone) and equipped with a AEV 300 feeder (Brabender Co., Duisburg, Germany) and a 3 mm round die, was used to process the different formulations. Based on preliminary experiments, the feeding, cooking, and die zones were set to 100, 140 and 160°C, respectively. Other extrusion parameters were: screw speed 250 rpm; feeding screw speed 160 rpm; screw compression 4:1 and feed moisture of 16%. The produced extrudates were directly dried in an air dryer oven (WT binder, type F115, USA) at 110°C for 5 min, and allowed to reach room temperature. Selected functional, chemical, and sensory characteristics of final fresh products were evaluated.

Functional parameters
Expansion ratio (ER), the ratio between the cross-sectional diameter of the extrudate sticks and the diameter of die exit, was measured according to Gomez and Aguilera, 1984 and Abd El-Hady *et al.,* 2002.

Bulk density (BD) was measured in (g/cm^3) by weighing the quantity of extrudates required to fill a marked volume of glass cylinder (1000 cm^3) according to (Ryu, *et al*., 1993; Jin *et al.,* 1994; Abd El-Hady *et al.,* 2002).

Breaking strength (BS) was measured (in brabender units BU) according to Abd El-Hady *et al.,* (1998, 2002) using Brabender Struct-o-graph (OHG, Duisberg, Germany). Extruded sample (50 mm) was rested on two parallel support bars attached to an elevator platen, and then moved at constant speed (135 mm/min) toward a force measuring sensor equipped with a knife edge until breaking using a calibrated spring (1000 gram-force). The Struct-o-graph is equipped with a strip chart recorder that gives a force-time plot, and the peak height of the resultant recorded curve for each sample is taken as a breaking strength (in Brabender units BU), whereas 1 BU equals 1 g-force.

Water absorption index (WAI) and water solubility index (WSI) were measured using the technique according to Anderson *et al.,* 1969. The ground extrudate was suspended in distilled water at room temperature for 30 minutes with gently intermittent stirring, and then centrifuged at 1000×g for 15 minutes (Baird & Tatlock Auto Bench Centrifuge, London, England). The WSI, the weight of dry soluble solids in the supernatant, is expressed as a percentage of the original weight of sample. The WAI, the weight of gel obtained after removal of the supernatant, is expressed as weight of obtained gel per gram of extrudate.

Assessment of chemical parameters and color attributes

Chemical analyses were carried out according to AOAC (1990). Color attributes L^*(lightness), a^*(redness) and b^*(yellowness) were evaluated using a Minolta Color Reader CR-10 (Minolta Co. Ltd.,Tokyo, Japan).

Sensory evaluation
Comparison sensory test was used to evaluate the produced extrudates. The evaluation was carried out by ten trained panelists for taste (20), crispness (20), chewiness (15), odor (15), color (10), pore distribution (10), and surface characteristics (10). Overall acceptability of products was calculated from the total scores of these attributes. Grades were given according to the following scale: excellent (86 to 100), good (76 to 85), fair (61 to 75) and poor (50 to 60), according to Abd El-Hady *et al*., 1998, 2002.

Statistical analysis
The analysis of variance (ANOVA) was carried out to test the possible significance ($p \leq 0.05$) of treatment effect. Fisher's Least Significance Difference (LSD) as described by Ott (1984) was used to perform all possible pair comparisons between means of different treatments.

RESULTS AND DISCUSSION

Some technological and chemical characteristics of cactus pear pulps
Table 1. presents values of some technological and chemical characteristics of both orange-yellow and red cactus pear pulps, which agree with those recorded by Askar and El-Samahy (1981), Sawaya *et al.* (1983), Saenz-Hernandez (1995), Parish and Felker (1997), Saenz and Sepulveda (1999), Abdel-Nabey (2001), El-Samahy *et al*. (2006a, 2006b). Both pulps have high pH values, which make them suitable

food substitutions, especially with low-acid foods like cereal-based snacks. In addition to that, both pulps have good contents of sugars, crude protein, dietary fibers, pectin, and ash.

Functional characteristics of final extrudates

Results presented in Tables 2a and 2b show that the expansion ratio (ER) of final products decreased significantly ($p \leq 0.05$) with the addition of cactus pear concentrates. This decrease of ER may be due to the reduction of starch and increase of sugar and dietary-fiber contents. As reported by Anderson *et al*. (1981), Kervinen *et al*. (1981), Moore *et al*. (1990), Ryu, *et al*. (1993), Jin *et al*. (1994), Adesina *et al*. (1998), Abd El-Hady *et al*. (2002), highly expanded products are obtained with high starch content, whereas the expansion of extruded starch-based materials depends on the degree of starch gelatinization. Increasing sugar content in formula increases viscosity and reduces the availability of water (water activity), which decreases the available steam to feed expanding cells during the flashing process) and, consequently, decreases the gelatinization degree of starch and the expansion ratio of products. On the other hand, decreased expansion ratio (ER) of extruded products may be due to increased of dietary-fiber content by adding cactus concentrates. Whereas, in addition to dilution of starch content by fibers, high fiber content prevents the gas bubbles from expanding to their full potential (Moore *et al*., 1990; Williamson, 1993; Jin *et al.,* 1994; Abd El-Hady *et al.,* 1998; Onwulata *et al*., 2000). Also, as noticed by El-Samahy *et al*. (2006a,b), viscosity of cactus pear pulp increases progressively with raising of temperatures above 50ºC, and this increasing of viscosity was attributed to the influence of high temperatures on pulp components, especially pectin. Therefore, decreasing of the expansion ratio of extrudates by adding cactus pear concentrate may also be due to increasing of cactus pear concentrate viscosity by the effect of high temperatures on pulp components, especially pectin, which consequently increases dough viscosity inside the extruder.

Bulk density (BD) of extruded products had an opposite-direction trend to that for the ER, whereas the BD increased with increasing substitution levels of cactus pear concentrates. Increasing of bulk density may be due to increasing of both sugars and dietary fibers in replacing the starch content as reported by Anderson *et al*. (1981), Moore *et al.* (1990), Ryu, *et al*. (1993), Jin *et al*. (1994), Abd El-Hady *et al*. (1998), Adesina *et al*. (1998), Abd El-Hady *et al*. (2002). Also, Meuser and Wiedmann (1989) reported that the density of extrudates increases as a result of liquification of sugar via melting during extrusion cooking.

Breaking-strength (BS) values of all extruded products decreased significantly ($p \leq 0.05$) with the addition of both concentrated pulps, and it may be due to decreasing of starch content and increasing both of sugars (Adesina *et al*., 1998; Abd El-Hady *et al.,* 2002), and fibers (Abd El-Hady *et al.,* 1998). But, on the other hand, obtained results showed that breaking strength values decreased progressively with added concentrated pulp up to 10% substitution level, and then increased progressively by increasing of the substitution level up to 20%. Whereas high-fiber extrudates have high hardness and breaking-strength values (Onwulata *et al*., 2000) and increasing sugar content increases breaking strength of final extrudates (Ryu *et al*., 1993), this behavior of breaking strength values may be due to effects of high concentrations of both of sugars and fibers with additional concentrated pulp at 15% and 20% substitution levels to the formula.

Water-absorption index (WAI) decreased slightly by increasing substitution levels of both concentrates for all extruded products, which may be due to decreasing of starch and increasing of sugar level. It agrees with data reported by Adesina *et al*. (1998) which referred the reduction in WAI to increasing of sugar in the formula, whereas sugar retards the rate of hydration by competing with the starch molecule for water. Park *et al*. (1993) reported that high content of corn starch in formula resulted in high water absorption (WAI) of final extruded products.

Water-soluble index (WSI) decreased for all extruded products by increasing substitution levels of both cactus concentrates. Decreasing of WSI may be due to formation of some insoluble water compounds as a result of sugar caramelization and/or Maillard reaction.

Color attributes; $L*$ (lightness), $a*$ (redness), and $b*$ (yellowness) of the ground extruded products were measured and recorded in Tables 2a and 2b. The lightness values significantly ($p \le 0.05$) decreased, while the redness and yellowness values increased with increasing substitution levels of both of cactus pear concentrates for all extruded products. It may be due to effects of colors of cactus pulps, Maillard reaction, and/or caramelization of sugars.

Chemical composition of extrudates
Tables 3a and 3b show no significant differences between the treatments for moisture, total carbohydrates, and protein contents. Ash content increased significantly ($p \le 0.05$) for all extruded products by increasing of substitution levels of both cactus pear concentrates. The crude fat value of extruded products decreased by increasing the substitution level of both cactus pear concentrates up to 10%, but increased at high substitution levels (15% and 20%). The increase in crude fat values at 15% and 20% substitution levels may be due to rising concentration of some compounds formed by Maillard reaction and/or caramelization, which are soluble in organic solvents.

Sensory evaluation of cactus pear extrudates
Tables 4a and 4b show that poor sensory attributes of the base formula (0% cactus pulp) were extremely improved by adding both cactus pear concentrates. For all extruded products, there is clear improvement in crispness, which significantly improved by increasing the substitution level of cactus concentrates up to 10% compared with base formulae (0% cactus pulp). It agrees with results obtained above for breaking-strength values (Tables 2a and 2b) which decreased by adding 5% and 10% cactus pear concentrates, then increased at the highest levels of substitution.

CONCLUSION

This investigation shows the high potentiality of producing a new delectable product of rice-based extrudates using both red and orange-yellow concentrated cactus pear pulps (40ºBrix). Data show that 5% and 10% substitution levels of concentrated cactus pulps are the best to produce extruded products with good functional, nutritional, and sensory characteristics.

REFERENCES

A.O.A.C. (1990). Official Methods of Analysis, 15th Ed. Association of Official Analytical Chemists, Inc. USA.

Abd El-Hady, E. A.; El-Samahy, S. K.; Mostafa, G. A. and Youssef, K. M. (2002). Use of date pulp and concentrate in rice-based extrudates. Getreide Mehl und Brot, 56(3): 179-185.

Abd El-Hady, E. A.; Mostafa, G. A. and El-Samahy, S. K. (1997). Production of rice extrudates with high nutritional value. Egypt. J. Appl. Sci., 12: 172-186.

Abd El-Hady, E. A.; Mostafa, G. A.; El-Samahy, S. K. and El-Saies, I. A. (1998). Production of high fiber corn extrudates. J. Agric. Sci. Mansoura Univ., 23(3): 1231-1245.

Abdel-Nabey, A. A. (2001). Chemical and technological studies on cactus pear (*Opuntia ficus indica*) fruits. Alex. J. Agric. Res., 46(3): 61-70.

Adesina, A. A.; Sowbhagya, C. M.; Bhattacharya, S. and Zakiuddin Ali, S. (1998). Maize-soy-based ready-to-eat extruded snack food. J. Food Sci. Technol., 35: 40-43.

Anderson, R. A.; Conway, H. F.; Pfeifer, V. F. and Griffin Jr, E. L. (1969). Gelatinization of corn grits by roll- and extrusion-cooking. Cereal Sci. Today, 14: 4-7.

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.

Askar, A. and El-Samahy, S. K. (1981). Chemical composition of cactus pear fruit. Deutsche Lebensmittel-Rundschau, 77(8): 279-281.

Barbera, G. (1995). History, Economic and Agro-ecological importance. pp.1-11. In: Agro-ecology, cultivation and uses of cactus pear. Ed. by Barbera, G.; Inglese, P. and Pimienta-Barrios, E. FAO Plant Production and Protection Paper Nº 132.

Ding, Q.; Ainsworth, P.; Tucker, G. and Marson, H. (2005). The effect of extrusion conditions on the physicochemical properties and sensory characteristics of rice-based expanded snacks. J. Food Eng. 66(3): 283-289.

El-Samahy, S; Abd El-Hady, E; Habiba, R. and Moussa, T. (2006a). Effect of ripening stage on rheological properties of cactus pear pulp. 4th International Symposium on Food Rheology and Structure, Switzerland. pp. 581-582.

El-Samahy, S; Abd El-Hady, E; Habiba, R. and Moussa, T. (2006b). Chemical and rheological characteristics of orange-yellow cactus-pear pulp from Egypt. J. Profess. Assoc. Cactus Develop., 8: 39-51.

Escribano, J.; M. A. Pedreño, F. García-Carmona, R. Muñoz (1998). Characterization of the antiradical activity of betalains from *Beta vulgaris* L. roots. Phytochem. Anal. **9**: 124–127.

Frazier, P. J.; Crawshaw, A.; Stirrup, J. E.; Daniels, N. W. and Egitt, P. W. (1979). Factors affecting texture formation during extrusion cooking. Food Process Eng. In: Food Processing System, Vol. 1. Linko, P.; Olkku, J. and Larinkari, J. (eds). Applied Sci. Puplishers LTD, London.

Gomez, M. H. and Aguilera, J. M. (1984). A physico-chemical model for extrusion of corn starch. J. Food Sci., 49: 40-43, 63.

Gurrieri, S.; Miceli, L,; Lanza, C. M.; Tomaselli, F.; Bonomo, R. P. and Rizzarelli, E. (2000). Chemical characterization of Sicilian cactus pear (*Opuntia ficus indica*) and perspectives for the storage of its juice. J. Agric. Food Chem., 48: 5424-5431.

Holay, S. H. and Harper, J. M. (1982). Influence of the extrusion shear environment on plant protein texturization. J. Food Sci. 47: 1869.

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

Kervinen, R.; Linko, P. and Olkku, J. (1981). Extrusion cooking induced changes in functional properties of wheat flour. Page 219 In: Proc. Nordic Cereal Chem. Assoc. 21st Kirjapaino Painorengas Oy Helsinki.

Meuser, F. and Wiedmann, W. (1989). Extrusion plant design. Pages 128-133. In: Extrusion Cooking. C. Mercier, P. Linko and J. M. Harper, eds. Am. Assoc. Cereal Chem.: St. Paul. MN.

Moore, D.; Sanei, E.; Vanhecke, Z. and Bouvier, J. M. (1990). Effect of ingredients on physical/ structural properties of extrudate. J. Food Sci., 55: 1383-1387, 1402.

Munos de Chavez, M.; Chavez, A.; Valles, V.; Roldan, J. A. (1995). The Nopal: A Plant of Mainfold Qualities. In World Review of Nutrition and Dietetics. 77:109-134.

Noguchi, A.; Kugimiya, W.; Haque, Z. and Saio, K. (1981). Physical and chemical characteristics of extruded rice flour and rice flour fortified with soybean protein isolate. J. Food. Sci. 46:210.

Onwulata, C. I.; Konstance, R. P.; Strange, E. D.; Smith, P. W. and Holsinger, V. H. (2000). High-fiber snacks extruded from triticale and wheat formulations. Cereal Food World, 45 (10): 470-473.

Ott, L. (1984). An Introduction to Statistical Methods and Date Analysis. 2nd edition, PWS publisher, Boston, M. A., USA.

Parish, J. and Felker, P. (1997). Fruit quality and production of cactus pear (*Opuntia* spp.) fruit clones selected for increased frost hardiness. J. Arid Environments, 37: 123-143.

Park, J.; Rhee, K. S.; Kimm, B. K. and Rhee, K. C. (1993). Single-screw extrusion of defatted soy flour, corn starch and raw beef blends. J. Food Sci., 58(1): 9-20.

Piga, A. (2004). Cactus pear: A fruits of nutaceutical and functional importance. Journal of the Professional Asociation for Cactus Development. 9-22.

Piga, A.; Del Caro, A.; Pinna, I. and Agabbio, M. (2003). Changes in ascorbic acid, polyphenol content and antioxidant activity in minimally processed cactus pear fruits. Lebensm.-Wiss. U.-Technol. 36: 257-262.

Rhee, K.; Cho, S. and Pradahn, A. (1999). Composition, storage stability and sensory properties of expanded extrudates from blends of corn starch and goat meat, lamb, mutton, spent fowl meat, or beef. Meat Sci., 52(2): 135-141.

Ryu, G. H.; Neumann, P. E. and Walker, C. E. (1993). Effects of some baking ingredients on physical and structural properties of wheat flour extrudates. Cereal Chem. 70(3): 291-297.

Saenz, C. (2000). Processing technologies: an alternative for cactus pear (*Opuntia* spp.) fruits and cladodes. J. Arid Environments, 46: 209-225.

Saenz, C. (2002). Cactus pear fruits and cladodes: A Source of functional components for foods. Acta Hort.(Proc.4th IC on Cactus Pear and Cochineal), 581: 253-263.

Saenz, C. and Sepulveda, E. (1999). Physical, chemical and sensory characteristics of juices from pomegranate and purple cactus pear fruit. Annals of the 22nd IFU Symposium, Paris. pp. 91-100.

Saenz, C. and Sepulveda, E. (2001). Cactus-Pear Juices. Journal of the Professional Association for Cactus Development. 4: 3-10.

Saenz-Hernandez, C. (1995) Food manufacture and by-products. pp.137-143. In: Agro-ecology, cultivation and uses of cactus pear. Ed. by Barbera, G.; Inglese, P. and Pimienta-Barrios, E. FAO Plant Production and Protection Paper Nº 132.

Sawaya, W. N.; Knatchadourian, H. A.; Safi, W. N. and Al-Muhammad, H. M. (1983). Chemical characterization of cactus pear pulp, Opuntia ficus indica, and the manufacturing of cactus pear jam. J. Food Tech., 18(2): 183-193.

Sepulveda, E.; Saenz, C. and Alvarez, M. (2000). Physical, chemical and sensory characteristics of dried fruit sheets of cactus pear (*Opuntia ficus indica* (L.) MILL.) and quince (*Cydonia oblonga* MILL.). Italian J. Food Sci., 12(1): 47-54.
spent fowl meat, or beef. Meat Sci. 52(2): 135-141.

Stintzing, F. C.; Schieber, A. and Carle, R. (1999). Amino acids composition and betaxanthin formation in fruits from *Opuntia ficus-indica.* Planta Medica, 65: 632-635.

Stintzing, F. C.; Schieber, A. and Carle, R. (2001). Phytochemical and nutritional significance of cactus pear. Eur Food Res Technol, 212: 396-407.

Tesoriere, L.; Allegra, M.; Butera, D. and Livrea, M. A. (2004). Absorption, excretion, and distribution of dietary antioxidant betalains in LDLs: potential health effects of betalains in humans. American Journal of Clinical Nutrition, 80 (4): 941-945.

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

Zhang, W. and Hoseney, R. C. (1998). Factors affecting expansion of corn meals with poor and good expansion properties. Cereal Chem. 75(5): 639-643.

Table 1. Some technological and chemical characteristics of cactus pear pulps

Characteristic	Cactus Pear Pulps	
	Orange-yellow Pulp	Red Pulp
pH	6.20[a]	6.14[a]
T.S.S (°Brix)	13.5[a]	11.25[b]
Color Attributes, *L**	30.60[a]	25.00[b]
*A**	1.60[b]	6.90[a]
*B**	10.90[a]	2.10 [b]
Moisture %	86.27[b]	87.10[a]
Total Sugars %*	88.02[a]	86.85[a]
Reducing Sugars %*	85.24[a]	82.98[a]
Crude Protein %*	4.59[b]	5.26[a]
Pectin %*	2.39[a]	2.44[a]
Crude Fibers %*	1.40[a]	1.44[a]
Ash %*	2.39[a]	2.27[b]

* Calculated on dry-weight basis

- Means of triplicates

- Means having the same letter within each property are not significantly different at $p \leq 0.05$.

Table 2a. Functional characteristics of orange-yellow cactus pear-rice based extrudates

Concentrated Pulp Level	ER*	BD** (g/100 cc)	BS * (BU)	WAI**	WSI** %	Color Attributes*		
						*L**	*A**	*B**
0%	3.21^{a}	77.31^{c}	500^{a}	9.73^{a}	$33.04^{a,b}$	84.7^{a}	3.0^{c}	12.1^{d}
5%	3.22^{a}	$78.79^{b,c}$	420^{c}	9.83^{a}	33.56^{a}	79.2^{b}	7.0^{b}	18.7^{c}
10%	2.95^{b}	79.42^{b}	390^{d}	9.69^{a}	$31.65^{a,b,c}$	$78.0^{b,c}$	7.4^{b}	21.1^{b}
15%	2.78^{c}	88.18^{a}	430^{c}	8.90^{a}	$30.85^{b,c}$	$77.3^{c,d}$	7.9^{a}	23.0^{a}
20%	2.72^{c}	88.32^{a}	450^{b}	8.63^{a}	29.71^{c}	76.3^{d}	8.1^{a}	23.6^{a}

1 BU (Brabender unit) = 1 gram-force
* Means of ten readings ** Means of triplicates
There is no significant difference between means (within the same property) designated by the same letter at $p \leq 0.05$.

Table 2b. Functional characteristics of red cactus pear-rice based extrudates

Concentrated Pulp Level	ER*	BD** (g/100 cc)	BS* (BU)	WAI**	WSI** %	Color Attributes*		
						*L**	*A**	*B**
0%	3.21^{a}	77.31^{c}	500^{a}	9.73^{a}	$33.04^{a,b}$	84.7^{a}	3.0^{c}	12.1^{d}
5%	3.15^{a}	82.75^{c}	440^{c}	9.19^{a}	33.75^{a}	82.8^{b}	4.9^{d}	19.8^{c}
10%	3.07^{b}	83.11^{c}	400^{e}	8.97^{a}	$30.81^{b,c}$	76.8^{c}	7.6^{c}	20.1^{c}
15%	2.95^{c}	84.87^{b}	420^{d}	8.95^{a}	29.84^{c}	75.6^{d}	8.2^{b}	21.7^{b}
20%	2.76^{d}	87.91^{a}	465^{b}	8.88^{a}	29.37^{c}	74.9^{d}	8.8^{a}	24.0^{a}

1 BU (Brabender unit) = 1 gram-force
* Means of ten readings ** Means of triplicates
There is no significant difference between means (within the same property) designated by the same letter at $p \leq 0.05$.

Table 3a. Chemical composition* of orange-yellow cactus pear-rice based extrudates (dry weight basis)

Concentrated Pulp Level	Moisture %	Crude Protein %	Crude Fat %	Ash %	Total Carbohydrate** %
0%	8.62[a]	6.56[a]	2.26[a]	0.31[c]	90.87[a]
5%	8.56[a]	6.52[a]	1.65[b]	0.38[b,c]	91.54[a]
10%	8.63[a]	6.50[a]	1.59[b]	0.43[a,b,c]	91.48[a]
15%	8.71[a]	6.45[a]	2.22[a]	0.52[a,b]	90.81[a]
20%	7.96[a]	6.31[a]	2.28[a]	0.54[a]	90.87[a]

* Means of triplicates
** Calculated by difference
There is no significant difference between means (within the same property) designated by the same letter at $p \leq 0.05$.

Table 3b. Chemical composition* of red cactus pear-rice based extrudates (dry weight basis)

Concentrated Pulp Level	Moisture %	Crude Protein %	Crude Fat %	Ash %	Total Carbohydrate** %
0%	8.62[a]	6.56[a]	2.26[a]	0.31[c]	90.87[a]
5%	8.60[a]	6.52[a]	1.66[b]	0.39[b,c]	90.69[a]
10%	8.19[a]	6.47[a]	1.72[b]	0.45[a,b,c]	91.42[a]
15%	8.03[a]	6.42[a]	2.29[a]	0.50[a,b]	91.36[a]
20%	7.94[a]	6.40[a]	2.40[a]	0.55[a]	90.76[a]

* Means of triplicates
** Calculated by difference
There is no significant difference between means (within the same property) designated by the same letter at $p \leq 0.05$.

Table 4a. Sensory characteristics of orange-yellow cactus pear rice-based extrudates

Concentrated Pulp Level	Taste (20)	Odor (15)	Crispness (20)	Chewiness (15)	Color (10)	Surface Characteristics (10)	Pore Distribution (10)	Overall Acceptability (100)	
0%	10.0^{c}	12.8^{d}	8.6^{d}	9.8^{d}	5.2^{d}	4.8^{d}	5.4^{c}	56.6^{d}	Poor
5%	13.8^{a}	13.2^{a}	15.4^{a}	$12.8^{a,b}$	8.4^{a}	6.6^{c}	7.0^{b}	77.2^{a}	Good
10%	13.4^{a}	13.4^{a}	14.0^{b}	13.0^{a}	8.6^{a}	7.0^{b}	7.0^{b}	$76.6^{a,b}$	Good
15%	12.2^{b}	13.4^{a}	12.8^{c}	12.4^{b}	7.2^{b}	$7.4^{a,b}$	7.8^{a}	$73.2^{b,c}$	Fair
20%	11.8^{b}	13.2^{a}	12.2^{c}	11.8^{c}	6.0^{c}	7.8^{a}	7.2^{b}	70.0^{c}	Fair

There is no significant difference between means (within the same property) designated by the same letter at $p \leq 0.05$.

Table 4b. Sensory characteristics of red cactus pear rice-based extrudates

Concentrated Pulp Level	Taste (20)	Odor (15)	Crispness (20)	Chewiness (15)	Color (10)	Surface Characteristics (10)	Pore Distribution (10)	Overall Acceptability (100)	
0%	10.0^{c}	12.8^{d}	8.6^{d}	9.8^{d}	5.2^{d}	4.8^{d}	5.4^{c}	56.6^{d}	Poor
5%	14.8^{c}	13.4^{a}	$14.2^{b,c}$	12.6^{a}	8.4^{a}	6.6^{c}	6.2^{b}	74.2^{a}	Fair
10%	14.2^{a}	13.2^{a}	$14.8^{a,b}$	12.4^{a}	8.0^{a}	7.2^{b}	7.6^{a}	77.4^{a}	Good
15%	13.2^{b}	13.0^{a}	13.4^{a}	12.6^{a}	7.4^{b}	8.0^{a}	7.4^{a}	75.0^{a}	Fair
20%	12.2^{c}	13.2^{a}	11.8^{c}	11.8^{b}	6.0^{c}	8.0^{a}	7.6^{a}	70.6^{b}	Fair

There is no significant difference between means (within the same property) designated by the same letter at $p \leq 0.05$.