**Contratto di ricerca tra DII-UNIPR e Natura Nuova s.r.l. sul tema:**
**"Semilavorati testurizzati per nuovi prodotti a base di soia e di frutta" (marzo 2011-2013)**
Responsabile scientifico Prof. Roberto Massini

RELAZIONE SULLE ATTIVITÀ DI RICERCA
EFFETTUATE NEL PERIODO: MARZO 2011 – MARZO 2013

**Parte B. Semilavorati Testurizzati a Base di Frutta**
Gruppo di lavoro per i nuovi prodotti a base di frutta:
Prof. Davide Barbanti
Dott.ssa Beatrice Mora

# Allegato B.2 – Bibliografia estrusione frutta

sintesi della bibliografia richiamata

**Articoli su riviste**

Mary Ellen Camire, Michael P. Dougherty, Jack L. Briggs. (2007) **Functionality of fruit powders in extruded corn breakfast cereals. Food Chemistry,** 101(2):765–770 (Allegato B.2.1)
Consumer interest in naturally colored foods such as breakfast cereals is growing. Degermed white cornmeal, sucrose, citric acid and dehydrated fruit powder (blueberry, cranberry, Concord grape and raspberry) were mixed in 84.3%:14.3%:0.4%:1.0% proportions, then extruded in a laboratory-scale twin-screw extruder. Feed rate was 255 g/min; water was pumped at a rate of 12.5 g/min; screw speed was 175 rpm. Cooking temperature during extrusion was generally <130 °C. Samples were cut into small spheres and dried to 5% moisture. Cereals were stored at room temperature in opaque bags. The control samples were lighter and less red than the fruit cereals. Soluble phenolics and anthocyanins were higher in the fruit cereals. At three and six weeks of storage, fruit cereals had smaller levels of hexanal, as measured by gas chromatography of headspace of ground cereals. Although anthocyanins from fruit powders survive extrusion and retain some antioxidant activity, the levels used in this study may have been too low. Higher levels of fruit will increase production costs, but the expense may be offset by the more attractive and functional cereals that result.

N. BADRIE, W.A. MELLOWES (1992) **Cassava Starch or Amylose Effects on Characteristics of Cassava (Manihot esculenta Crantz) Extrudate**. *Journal of Food Science, 57(1):103–107*
Blends of cassava flour with cassava starch or amylose were processed on a Wenger X-5 laboratory extruder. Cassava starch added to cassava flour increased total carbohydrate in feed, reducing yellow color, water absorption and extrudate bulk density but increased expansion, product moisture, water solubility and total reducing sugars. Amylose addition increased extrudate surface regularity with reduced water solubility, total reducing sugars, and bulk density. Expansion was highest in mixtures containing 60% amylose. Textural properties of extrudate increased on addition of amylose or cassava starch. Differences in microstructures existed between cassava flour and cassava starch extrudate.

McHugh, T.H. and C.C. Huxsoll (1999). **Extrusion processing of restructured peach and peach/starch gels**. *Lebensmittel-Wissenschaft und –Technologie 32: 513-20* **(**Allegato B.2.2**)**
This study investigated the potential of twin screw extrusion technology to produce value-added, restructured peach and peach/starch gels. As water content increased, product color darkened significantly, water activity increased, and hardness and springiness values decreased significantly in both peach and peach/starch gels. Increasing melt temperatures resulted in darker products. Significant interactions between water content and temperature were observed for 100% peach gels. Starch addition resulted in significant increases in hardness, adhesiveness and cohesiveness values, as well as decreases in product springiness. Increasing melt temperatures resulted in peach/starch gels with softer, more adhesive and cohesive textures. The addition of sugar to peach gels did not significantly affect their color; however, sugar addition did significantly increase the L, a and b values of peach/starch gels. Sugar concentration did not affect peach gel texture, but sugar and starch concentration interacted significantly in peach/starch gels. As sugar concentration increased, the effect of starch concentration on the hardness and adhesiveness decreased.

HULYA AKDOGAN, TARA HABIG McHUGH (1999) **TWIN SCREW EXTRUCTION of PEACH PUREE: RHEOLOGICAL PROPERTIES and PRODUCT CHARACTERISTICS**
*Journal of Food Processing and Preservation, 23(4):285–305* (Allegato B.2.3)
A semi-empirical, nonlinear model was developed to incorporate the effects of extruder operating conditions (temperature, moisture, and shear rate) on viscosity of peach puree in a lab-size twin screw extruder. A power law dependency for shear rate, an exponential dependency for moisture, and a modified first order transform function for temperature effects were employed. the proposed model fit the experimental data well. Motor torque and Specific Mechanical Energy (SME) were

significantly affected by all extruder operating conditions. Experimental apparent viscosity varied from 40 to 130 Pass, depending on the operating conditions. Color indicatives (L, a, b) and extrudate density were mainly influenced by the moisture content. Water activity was only influenced by moisture.

Muhammad Siddiq, Ramasamy Ravi, Rabiha SuIaiman Kirk D. Dolan and Janice B. Harte. (2008) **VALUE-ADDED PROCESSING OF FRUIT-BASED EXTRUDED PORRIDGE AND SNACKS.** *Bean Improvement Cooperative. Annual report. 2008 Mar., v. 51 p. 150-151* (Allegato B.2.4)
Our main objectives were: (1) to develop fruit-based products that are tasty, shelf-stable, nutrient-rich, virtually fat-free, and convenient to consume, and (2) evaluate these products different quality characteristics. Fruits in diced/dried form were used for co-extrusion with bean flour: (i) Golden Delicious and (ii) Red Delicious apples, (iii) blueberries, (iv) cherries, (v) cranberries, and (vi) d'Anjou pears, using a lowcost twin-screw extruder (model JS30A, Qitong Chemical Industry Equipment Co, Ltd, China). Extruder screws are 30 mm in diameter and the barrel has a L/D (length/diameter) ratio of 16. Extrudates were dried overnight at 60 C and stored in sealed polyethylene bags until need for physico-chemical or sensory quality evaluation using standard lab procedures and equipment. Addition of fruits, when compared to control, had minimal effect on extrudates density (data not shown). However, hydration rate of the control extrudates was higher than those with added fruits except for one containing cranberries. Presence of pectin and sugars in the fruit tissue can affect the density of the extruded products thus resulting in lower hydration capacity.

TITUS U. NWABUEZE, MADUEBIBISI O. IWE, ENOCH N.T. AKOBUNDU (2008) **PHYSICAL CHARACTERISTICS AND ACCEPTABILITY OF EXTRUDED AFRICAN BREADFRUIT-BASED SNACKS**. *Journal of Food Quality, 31(2):142–155* (Allegato B.2.5)
Five-level combinations of African breadfruit, corn and soybean, in the ratios 40:5:55; 55:5:40; 70:5:25; 85:5:10 and 100:0:0%, respectively, were hydrated to 15, 18, 21, 24 and 27% and extruded into snacks at screw speeds of 100, 120, 140, 160 and 180 rpm. Physical characteristics of snacks from blends containing 15 and 18% moisture ranged from thin-smooth to thin-fine-smooth pellets. Those containing 21 to 27% moisture were either thin-smooth or thick-smooth, fine-smooth or rough strands. Feed moisture and feed composition were the most significant process variables influencing physical and sensory characteristics. The optimum process variable combination that had maximum influence on physical and sensory characteristics of snacks was the 70:5:25 feed ratio with 21% moisture and extruded at 140 rpm. This resulted in an overall acceptability score of 8.20 on a 9-point hedonic scale.

**Create value-added extruded products from barley and fruit pomace blends.**
*Emerging Food R&D Report. 2008*
http://www.highbeam.com/doc/1G1-177987454.html.
Pomaces are low-value byproducts obtained when fruit and vegetable products are processed. Tomato, grape and pomegranate pomaces as well as barley are valuable sources of fiber and other compounds that are known to be beneficial to human health.
Scientists wanted to produce an extruded barley-based snack into which they would incorporate different types of pomace. Their findings demonstrate the feasibility of developing value-added products from fruit and vegetable pomace and barley flour blends.
In tests, the researchers determined the effects of extrusion conditions on the physical properties of the extrudate. The barley flour and pomace blends were extruded at 22% moisture content in a 30-mm commercial co-rotating twin-screw extruder with five heating zones and a slit die.
The scientists performed three-factor factorial designs for each type of pomace-barley flour blend. Analysis of variance, a collection of statistical models, was used to evaluate the effect of die

temperature, which ranged from 140°C to 160°C; screw speed, which ranged from 150 rpm to 200 rpm; and pomace ratio-2% to 10%-on the flour's physical properties.
Researchers analyzed the sectional expansion index (SEI), bulk density, peak force and color. The values for SEI ranged from 0.83 to 2.09. Increasing the die temperature and pomace ratio caused a decrease in the SEI. The response of the screw speed differed as a function of the type of pomace. Peak force values decreased as die temperature, pomace level and screw speed increased.
The bulk density ranged from 0.25 g $cm^3$ to 1.24 g $cm^3$, but differed for the different types of pomace tested. Hunter color values a and b increased, while L values decreased with an increasing pomace ratio. Some acceptable products were produced. They had bulk densities in a range of 0.35 g $cm^3$ to 0.65 g $cm^3$, and a peak force of less than 10 N.

YAĞCI, SIBEL; GÖĞÜŞ, FAHRETTIN (2009) **DEVELOPMENT OF EXTRUDED SNACK FROM FOOD BY-PRODUCTS: A RESPONSE SURFACE ANALYSIS.** *Journal of Food Process Engineering, Volume 32, Number 4, August 2009 , pp. 565-586(22)* (Allegato B.2.6)
Response surface methodology was used to investigate the effects of extrusion conditions including the moisture content of blend (12-18%), barrel temperature (150-175C), screw speed (200-280rpm) and change in feed composition on the product characteristics of the snack food developed from rice grit in combination with durum clear flour, partially defatted hazelnut flour (PDHF) and fruit wastes. The blend was made up of rice grit (67%), durum clear flour (8-20%), PDHF (5-15%) and fruit waste (3-7%). The response variables were radial expansion ratio, color, and textural and sensory properties of the extruded snacks. Increasing the PDHF content caused a decrease in the radial expansion ratio, hardness and lightness of the snacks. The textural properties and color of produced snacks were affected by the fruit waste addition. Increasing the moisture content and decreasing the temperature caused an increase in the expansion ratio for most compositions. The extruded snacks with lower PDHF content had the highest levels of overall acceptance in the sensory panel. There was no significant effect ($P<0.05$) of fruit waste addition on the sensory properties of the snacks.

Karkle, E.L., Alavi, S., Dogan, H., Jain, S., Waghray, K. (2009). **Development and evaluation of fruit and vegetable-based extruded snacks**. Online. AACC International Cereal Science Knowledge Database.
There is a global trend towards the development of healthy snacks. The incorporation of fruits and vegetables in extruded snacks represents a strategy to increase consumption of this food group while greatly increasing the nutritional value of snacks. The objective of this work was to develop and evaluate fruit and vegetable-based extruded snacks. Dehydrated powders of pumpkin (*Cucubita moschata*), lotus stems (*Nelumbo nucifera*), kulfa leaves (*Portulaca oleracea*), curry leaves (*Murraya koenigii*) or Indian gooseberry (*Emblica officinalis*) were added individually to whole cornmeal in two levels (25% and 50%). The mixes were extruded on a twin-screw lab scale extruder under typical conditions for directly expanded extruded snacks. Cornmeal was used as a control. The dietary fiber content of the dehydrated powders ranged from 14.5 g/100 g (lotus) to 51.5 g/100 g (kulfa). Increasing the powder level from 25 to 50% caused decreased radial expansion for all extrudates, except for gooseberry. Void fraction (determined by X-ray microtomography) was correlated to radial expansion ($r = 0.72$) and also to flow temperature ($r = 0.82$) of the dry mix (measured on a Phase Transition Analyzer). Both soluble and insoluble fiber had a negative correlation to radial expansion ratio ($r = –0.68$, $r = –0.60$, respectively), while only soluble fiber was negatively correlated to flow temperature ($r = –0.67$). Breaking force (3-point breaking test) of gooseberry, pumpkin and curry snacks was lower than the control. Powder level did not influence breaking force. A sensory test was conducted by 30 panelists (women, 40–50 years) using a 9-point hedonic scale. Although the control had the highest overall acceptance score (5.9), it did not differ from the snacks with lotus, kulfa or gooseberry at either powder level ($P < 0.05$). Snacks at both powder levels were equally accepted for all 8 sensory attributes and all 5 fruit and vegetable

powders. The selected fruit and vegetable powders caused great impact on physical and structural characteristics of extruded snacks; however based on equal sensory acceptance, 50% of cornmeal can be replaced by the nutrient-dense powders of lotus stems, kulfa leaves or gooseberry.

Altan A, McCarthy KL, Maskan M. (2009) **Effect of extrusion cooking on functional properties and in vitro starch digestibility of barley-based extrudates from fruit and vegetable by-products.** J Food Sci. 2009 Mar;74(2):E77-86. (Allegato B.2.7)
Barley flour and barley flour-pomace (tomato, grape) blends were extruded through a co-rotating twin-screw extruder. The aim of the present study was to investigate the effects of die temperature, screw speed, and pomace level on water absorption index (WAI), water solubility index (WSI), degree of starch gelatinization, and in vitro starch digestibility using a response surface methodology. The selected extrudate samples were examined further using differential scanning calorimetry (DSC) and polarized light microscopy, respectively. The WAI of barley-pomace extrudates was affected by increasing pomace level. Temperature had significant effect on all types of extrudate but screw speed had significant linear effect only on barley and barley-grape pomace extrudates on degree of starch gelatinization. Although no gelatinization peak was detected, an endotherm was observed on all selected extrudates. In general, extrusion cooking significantly increased in vitro starch digestibility of extrudates. However, increasing level of both tomato and grape pomace led to reduction in starch digestibility.

V. Stojceska, P. Ainsworth, A. Plunkett, Ş. İbanoğlu (2010) **The advantage of using extrusion processing for increasing dietary fibre level in gluten-free products**. *Food Chemistry 121:156–164* (Allegato B.2.8)
Gluten-free products generally are not enriched/fortified and frequently are made from refined flour and/or starch. Such products have been found to provide lower amounts of total dietary fibre than their enriched/fortified gluten-containing counterparts. The objective of this study was to increase the level of total dietary fibre in gluten-free products by using extrusion technology and by incorporating a number of different fruits and vegetables, such as apple, beetroot, carrot, cranberry and gluten-free Teff flour cereal. The materials were added at the level of 30% into the gluten-free balanced formulation (control) made from rice flour, potato starch, corn starch, milk powder and soya flour. Different process conditions, such as water feed rate 12%, solid feed rate 15–25 kg/h, screw speed 200–350 rpm, barrel temperatures: 80 °C at feed entry and 80–150 °C at die exit were used. Pressure, material temperature and torque were monitored during extrusion runs. The relationships and interactions between raw ingredients, extrusion processing parameters and resulting extrudate nutritional and textural properties were investigated. The results of this study clearly show that extrusion technology has the potential to increase the levels of total dietary fibre in gluten-free products made from vegetables, fruits and gluten-free cereals.

Preetam Sarkar, Nikhil Setia and Gour S. Choudhury (2011) **Extrusion Processing of Cactus Pear**. *Advance Journal of Food Science and Technology 3(2): 102-110, 2011* (Allegato B.2.9)
Whole fruit utilization using extrusion technology has received limited attention in the food processing industry. The objective of this study was to investigate the utilization of prickly pear fruit solids in extruded food products. Peeled prickly pear fruits were ground to form a paste. This paste was strained to remove the seeds and then mixed with rice flour in three different solid ratios. The three blends were dried to a moisture level of 13% (w/w basis) and ground to form fine flour. These feed mixes were extruded in a twin screw extruder (Clextral EV-25) at a feed rate of 15 kg/h, feed moisture content of 13% (w/w), screw speed of 400 rpm and L/D ratio of 40:1. The temperature profile from feed to die end was maintained as: 25, 30, 40, 50, 60, 70, 80, 100, 120, 140ºC. The extruded products were analyzed for physical and textural properties. Apparent density and breaking strength of the cactus pear extrudates increased from 116.07 to 229.66 kg/m$^3$ and 58.5 to 178.63 kPa, respectively with increase in fruit solid level. However, true density, porosity and

radial expansion ratio decreased from 837.89 to 775.84 kg/m$^3$, 86.12 to 70.34% and 12.37 to 6.6, respectively with increase in fruit solid level (rice flour solids: puree solids were 6:1, 8:1 and 10:1). This study demonstrated the potential of extrusion processing to utilize peeled cactus pear fruits for production of expanded food products.

Shirani Gamlath (2008) **Impact of ripening stages of banana flour on the quality of extruded products**. *International Journal of Food Science and* Technology 43:1541–1548 **(**Allegato B.2.10**)**
The study investigated the physical, nutritional and sensory properties of different ripening stages of banana during extrusion processing in combination with rice flour to develop quality snack products. Dehydrated banana flours at ripening stages 4, 5 and 6 (peel colour) were mixed separately at 40% banana to 60% rice flour levels. The mixtures were extruded through a twin-screw extruder at 120 °C barrel temperature, 220 and 260 r.p.m, screw speed and 12% feed moisture. Increase in ripeness indicated negative effect on expansion and water absorption capacity while increasing the water solubility index and moisture retention (wet basis) of the products. Protein and mineral (except for zinc and copper) content of the products were significantly different ($P < 0.05$) from 4 to 6 of the ripening stages. Most of the essential amino acids in the extruded products increased significantly ($P < 0.05$) at the ripening stage of 6. All the products were within the acceptable range in the 9-point Hedonic scale showing the best texture and flavour scores for stage 4 and 6, respectively. The extruded products show potential as snack products because of their nutritional quality and sensory acceptability.

A. CHAOVANALIKIT, M.P. DOUGHERTY, M.E. CAMIRE, AND J. BRIGGS (2003) **Ascorbic Acid Fortification Reduces Anthocyanins in Extruded Blueberry-Corn Cereals.** *JOURNAL OF FOOD SCIENCE. 68(6):2136-2140* (Allegato B.2.11)
Corn meal was mixed with ascorbic acid (0%, 0.1%, and 1%, wt/wt) and sucrose (15%) or lowbush blueberry concentrate (17%), and twin-screw extruded to produce ready-to-eat breakfast cereals. Consumers evaluated selected samples using just-right scales. Extrusion decreased anthocyanins in blueberry cereals; ascorbic acid was retained better in cereals containing blueberry concentrate than in the sweetened corn cereals.
Blueberry concentrate decreased expansion ratio and increased bulk density. Based on sensory scores, blueberry extrudates with 0.1% ascorbic acid could be acceptable if sweetness is increased.

Aylin Altan,1 Kathryn L. McCarthy2 & Medeni Maskan (2009) Effect of **extrusion process on antioxidant activity, total phenolics and b-glucan content of extrudates developed from barley-fruit and vegetable by-products**. *International Journal of Food Science and Technology, 44:1263–1271* **(**Allegato B.2.12**)**
The aim of this study was to determine the effects of extrusion processing variables on antioxidant activity (AA), total phenolic content (TP) and b-glucan content (BG) of extrudates. Products were prepared by extrusion cooking of barley flour, barley flour–tomato pomace and barley flour–grape pomace blends.
Antioxidant activity as measured by the DPPH method was 43.17 ± 0.362, 27.57 ± 0.120 and 82.23 ± 0.785% while TPs, expressed as ferulic acid equivalents, were 5.29 ± 0.126, 4.66 ± 0.023 and 9.15 ± 0.015 mg g)1 dry sample in the extracts obtained from barley flour, tomato and grape pomaces, respectively. Extrusion cooking decreased AA and TP of barley, barley–tomato pomace and barley–grape pomace extrudates. Temperature and screw speed had significant ($P < 0.05$) effect on BGs of barley flour and barley–grape pomace extrudates. However, BG of tomato pomace blend extrudates had significantly ($P < 0.05$) influenced from pomace level only. Results indicated that the content of b-glucan is higher in barley flour than in extrudates of barley flour and pomace blends.

Ruth Potter, Valentina Stojceska, Andrew Plunkett (2012) **The use of fruit powders in extruded snacks suitable for Children's diets.** *Food Science and Technology xxx (2012) 1-8* **(**Allegato B.2.13**)**
This study considered whether different fruit powders could be successfully incorporated into extruded snack products to improve the nutritional profile.
The study investigated the interactions between fruit powders, extrusion process and physical properties and nutritional qualities of the resulting product. Five different samples were extruded using the same process conditions including a solid feed rate of 20 kg/h, moisture of 13% and barrel temperatures of 80 and 120 °C. Nutritional properties (soluble and insoluble fibre and total antioxidant content) and physical properties (including bulk density, lateral expansion, and hardness) were evaluated. The addition of fruit powder has significant ($P < 0.05$) effect on expansion and density of the extrudates. Both soluble and insoluble fibre increased substantially after extrusion process while antioxidant levels significantly ($P < 0.05$) decreased.
The resulting products had an improved nutritional profile compared with other extruded snack products being low in fat and sugar and a good source of fibre. Further work would investigate the effect of varying the levels of fruit powder and the process conditions and considering how nutritional qualities could be further improved (in particular protecting antioxidants during the extrusion process and fortification with vitamins and minerals).

**C. E. ORREGO, N. SALGADO, C. A. BOTERO.** (2012) **Developments and Trends in Fruit Bar Production and Characterization.** *Critical Reviews in Food Science and Nutrition, Accepted author version posted online: 24 Feb 2012* (Allegato B.2.14)
Overall, fruit bars have a far greater nutritional value than the fresh fruits because all nutrients are concentrated and, therefore, would be a convenience food assortment to benefit from the health benefits of fruits. The consumers prefer fruit bars that are more tasted followed by proper textural features that could be obtained by establishing the equilibrium of ingredients, the proper choosing of manufacturing stages and the control of the product final moisture content. Fruit bar preparations may include a mixture of pulps, fresh or dried fruit, sugar, binders and a variety of minor ingredients. Additionally to the conventional steps of manufacturing (pulping, homogenizing, heating, concentrating and drying) there have been proposed the use of gelled fruit matrices, dried gels or sponges and extruders as new trends for processing fruit bars. Different single type dehydration or combined methods include, in order of increasing process time, air-infrared, vacuum and vacuum-microwave drying convective-solar drying, convective drying and freeze drying are also suggested as alternative to solar traditional drying stage. The dehydration methods that use vacuum exhibited not only higher retention of antioxidants but also better color, texture, and rehydration capacity.

**Brevetti**

**Restructured fruit and vegetable products and processing methods**
United States Patent 6027758 (Allegato B.2.15)
Value-added, restructured fruit and vegetable products made from bulk-processed ingredients are taught. The restructured fruit and vegetable products are to be eaten out-of-hand as confectionery items or incorporated into baked, canned and/or frozen foods, such as cereals, cookies, cakes, fruit cocktails and ice creams. Processing methods involving twin-screw extrusion used to obtain the restructured fruit and vegetable products are also taught.
Rivendicazioni
1. A restructured fruit, vegetable or fruit and vegetable product, which product consists essentially of 70-100% of a dried bulk processed fruit, vegetable, or fruit and vegetable ingredient selected from the group consisting of drum dried puree, spray dried puree, and piece formed dried pieces, wherein said product has a water activity of 0.58 to 0.78.
2. The restructured product of claim 1 which further includes a gelling agent selected from the group consisting of starch, gelatin, alginate, pectin, and gellan gum.
3. The restructured product of claim 1, which product consists essentially of 100% of a dried bulk processed fruit, vegetable, or fruit and vegetable ingredient selected from the group consisting of drum dried puree, spray dried puree, and piece formed dried pieces.
4. A process for preparing a restructured fruit, vegetable, or fruit and vegetable product, which consists essentially of,
(1) combining in a twin screw extruder,
(a) a dried bulk processed fruit, vegetable, or fruit and vegetable ingredient comprising 70-100% fruit, vegetable, or mixtures thereof, said ingredient selected from the group consisting of drum dried puree, spray dried puree, and piece formed dried pieces, and
(b) a liquid ingredient, and
(2) extruding a combined product having 70-100% fruit, vegetable, or mixtures thereof, wherein said product has a water activity of 0.58 to 0.78.
5. The process of claim 4 wherein said liquid ingredient is water, sugar solution, juice concentrate, liquid puree, or clarified syrup.
6. The process of claim 4 wherein said liquid ingredient is in an amount to provide a combined extruded product having a water activity of 0.58 to 0.78.
A Haake-Leistritz co-rotating, twin screw extruder rheometer was used for the continuous production of restructured fruit. The temperature profile within the extruder barrel was manipulated and monitored to achieve the desired results. The characteristics of the final product can be manipulated by varying the temperature of the extrudate. At lower temperatures, added starch remains ungelatinized, resulting in a more dense product. As the temperature increases, adhesiveness and cohesiveness of the product increases. As the product temperature increases, the texture changes from soft and dense to a light, puffed state. Product temperatures above 100° C. result in crisp, puffed restructured fruit and vegetable products, whereas product temperatures below 100° C. result in softer, denser products.

**Process for making simulated fruit pieces**
United States Patent 5084296 (Allegato B.2.16)
The present invention is concerned with a simulated fruit piece suitable for combination with a dry food product having a moisture typically of from 2-3% and wherein the fruit piece maintains its softness and the food product maintains its crispness after various storage conditions, said fruit consisting of fruit solids, a fruit concentrate, a thickening agent, edible food grade acid, sweeteners, coloring, and glycerol. The glycerol/sweetener combination functions as a humectant system which produces a fruit product with an Aw of between about 0.2 to 0.50. A process for preparing said fruit

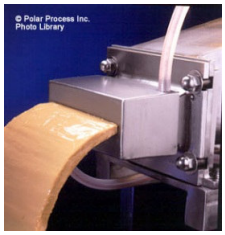
piece is also disclosed wherein a solid phase comprising a fruit solids is combined with a hot liquid phase and the mixture extruded into fruit ropes or strands and cut into the desired shape or form.

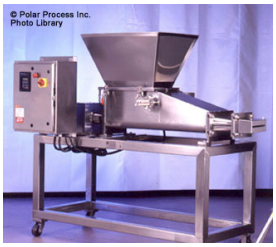
**Simulated soft fruits**
United States Patent 3922360 (Allegato B.2.17)
In an encapsulation process, particularly for preparing simulated soft fruit, drops are formed by extrusion and simultaneously coated with alginate or pectate sol. The coated drops are treated in a setting bath of calcium ions. Calcium ions inside the drops also aid setting of the coating. Better defined skins and less tendency to stick together are found than with other known processes of coating drops using calcium ions both inside and outside to set the coating gel.

**Ready-to-eat dry fruit products and process**
United States Patent 7569244 (Allegato B.2.18)
The present disclosure provides ready-to-eat (RTE), shelf-stable processed foods composed of up to 100% fruit and the system and process for their manufacture. The product, system, and process uses dried fruit in some form as an in-feed material, having a higher moisture content than heretofore has been suitable for extruder in-feed ingredients, thus retaining at least a portion of the natural volatile materials that contribute to taste and aromas. Further, the dried fruit is extruded and can be dried into crispy, crunchy, chewy, or hard particles or pieces high in fruit content that heretofore have been unavailable, and the products and process can be independent of starch and grain based prior technology. The products of the present disclosure can be eaten as healthy snacks or used as high-fruit-content additives in RTE cereals, baking mixes, toppings, and other food products. The process provides a high degree of efficiency and reduced costs.
Pectin, carrageenan help increase hardness, springiness, gumminess of extruded fruit.
Although extrusion technology has been used extensively to create carbohydrate-based snack foods, the use of extrusion to create a fruit-based snack product is a relatively new area of research. The benefits of an extruded fruit product include the health appeal of a fruit-based snack, the convenience of a ready-to-eat product and the ease of production which extrusion provides. Extruded fruit pieces can be used in ready-to-eat cereals. Extruded fruit purees can enhance the nutritional quality of candies, baked goods and frozen treats.
University of Missouri scientists investigated the moisture content, water activity, texture profile and shelf life of an extruded strawberry-based snack. The snack contained 27% strawberry puree, strawberry powder in a range of 37.25% to 39.25%, 31% glycerol, up to 2% pectin, up to 2% carrageenan, up to 1% citric acid and up to 1% potassium sorbate. The formulations were produced using a twin-screw extruder.
The ingredients were mixed together and heated to 80 C in a heating kettle-mixer before they were manually transported to the extruder. Researchers kept the processing conditions constant for all formulations--25 rpm and 65 C to 149 C in five of the nine zones. The researchers found that as the concentrations of pectin and carrageenan increased, the values for hardness, springiness and gumminess increased significantly, and the values for adhesiveness and moisture content decreased significantly.
The values for cohesiveness and water activity did not significantly change. High levels of pectin and carrageenan, combined with high levels of citric acid and potassium sorbate, yielded the highest values for hardness, springiness and gumminess and the lowest values for water activity (0.500 $a_W$), adhesiveness and cohesiveness.
Over the five-month shelf life of the product, all formulations showed a significant increase in hardness, springiness and gumminess as well as a decrease in moisture content of 5% to 7%, water activity from 0.556 Aw to 0.490 Aw, adhesiveness and cohesiveness.

**Documentazione commerciale**

**Fruit puree extrusion**
**PolarProcess**
http://www.youtube.com/watch?v=pohIjyCfhMU&feature=related
**PolarProcess** | 15 luglio 2009
Polar Process extrusion systems can receive masses of ground apple puree, add colour, flavour and acid and extrude this material as a blanket, to move down a conveyor belt for ultrasonic slitting and guillotining in the manufacture of fruit bars and fruit leather.
http://www.polarprocess.com/history.htm
Jacketed extrusions





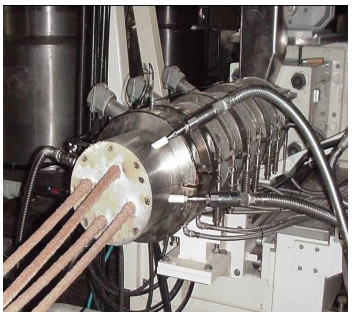

Extrusions can be done through heating or cooling dies to enhance surface texture.

**Co-extruded breakfast cereals**
**Clextral** (http://www.clextral.com/) **expertise in co-extrusion processing and creativity in die design yields distinct advantages in the development and production of co-extruded products**
The **sweetened co-extruded breakfast cereals and bars** can be filled with cream, jelly, fruit paste, etc. to adapt to regional tastes and to healthy food requests, Clextral develops new co-extruded products: date filling, new fruit fillings, etc.
The raw material of the outer part is generally wheat but a variety of other cereal grains can also be processed such as rice, corn, barley, rye, oats.
A wide variety of shapes (Pillows, Tubes, Bars, Triangles, Trapeze, Stripped products), surface structures, colours, and textures are possible.
**Advantages of Clextral process:**
- Production-proven processing techniques and scale-up expertise
- Expertly crafted co-extrusion dies with superior flow design
- Pre-engineered dies for many shapes such as bars, pillows, nuts, balls, long and short ovals and specialty profiles.
- Ingredient flexibility to process a variety of cereal grains and granulations
- Processing ability to manage a variety of filling recipes

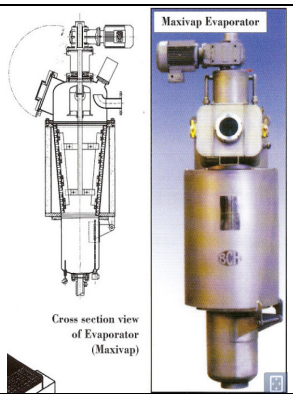
A typical **co-extrusion processing line** includes mixing and feeding vessels for both cereal shell and soft filling, **twin screw extruder** and forming equipment. Belt dryers and coating drums are offered for specific applications.


**Co-extruded breakfast cerals**


**Co-extrusion line**


**Co-extrusion die outlet**

BCH new **100% Fruit Cooking and Extrusion System** (Allegati B.2.19-20-21-22-23-24)
BCH LIMITED (BCH Ltd. is a subsidiary of Coates Engineering Group)
Spring Place, Millfold, Whitworth, Lanes. England 0L12 8DN
Tel: +44 (0) 1706 852122 Fax: +44 (0) 1706 853010
Email: info@bchltd.com Web Site: http://vww.bchltd.com
The system is a combination of BCH's large surface area MaxiVap Evaporator technology which is used for long running caramel plants combined with BCH's liquorice extrusion technology. The fruit cooking and extrusion system has enabled BCH to achieve evaporation of high moisture fruit mixes to typically **85% solids**, at which point they have a consistency of a soft dough which can be extruded using BCH extrusion technology (*side flow extruder*).
This then enables the production of a healthy snack bar using 100% organic fruit ingredients which can be co-extruded in a variety of colours, shapes and different flavours.
BCH also manufacture a range of extruders for the confectionery industry, including side flow, twin screw, continuous or batch fed. The extruders are primarily designed to handle hot, dough textures and have been used to extrude caramel, cheese, fudge, fruit paste and liquorice.



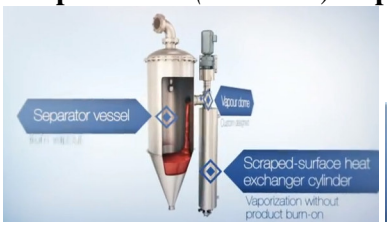
MaxiVap Evaporator


Economical Confectionery Micro Extrusion Line


The 4 Colour Twist

BCH have recently launched a new economical confectionery extrusion line which is a cost-effective solution for new start-up companies as well as certain developing markets within the Middle East, Africa and Asia who wish to gain a foothold in the sector, without committing huge initial outlay. BCH Ltd expects its new user-friendly and easy-to-install solution to be of interest to those niche companies serving smaller segments of the confectionery industry. The new extrusion line presents a viable option as users invariably lack the large sales volumes to warrant investment in larger, more expensive production lines and may also offer advantages to test kitchens environments.
In addition to its ability to extrude traditional confectionery products, BCH's new extrusion line has also been designed in tune with the continued move towards more responsible, healthy-eating attitudes. As a result, the new line offers the capability for 100% fruit and vegetable extrusion to suit the latest consumer trends for natural, organic and clean ingredient labels on snack products.
Matthew Cottam, Technical Director, BCH Ltd, explains, "Increasingly within the confectionery industry, there are niche providers, striving to differentiate themselves by offering something more special and exquisite than the mass producers. By offering an economical confectionery extrusion line, we are enabling this 'retro' market to operate in this smaller-run market segment."
BCH now have the capacity to produce 4 channels of viscous product eg) liquorice / licorice and caramel, from a single source including any colour and flavour. The product can then be combined into a single rope with up to 20 ropes extruding onto a BCH cooling tunnel. The product can be extruded in many different shapes from squares and stars to hollow, filled centres and twisted.

**Scraped-surface *(continuous)* evaporator for food products from Alfa Laval**





**Taura Natural Ingredients**

http://www.tauraurc.com/our-products/applications/fruit-snacks.html?a=#/userfiles/image/school-bar310.jpg

URC® Technology

At the heart of Taura Natural Ingredients' success is the **Ultra Rapid Concentration or URC® process technology.** Concentrating the taste, texture and natural goodness of fruit, the URC® process creates the most functionally advanced fruit pieces, flakes and pastes in the global market. Originally developed in 1991 in response to market requirements for fruit snacks and functional whole fruit ingredients, the URC® process is able to concentrate blends of heat sensitive, viscous fruit or vegetable purees to less than 10% moisture in 60 seconds. The rapid continuous processing provides consistent product quality and ensures the raw ingredients retain their primary flavour, colour and nutritional characteristics.

Ingredient profiles and product formats are easily adapted to suit a range of new product developments including water activity, bake stability and texture. Flavour blends, natural and herbal extracts and fortification options are possible, allowing manufacturers to quickly respond to consumer trends. URC® products are designed to meet the needs of today's manufacturing processes while delivering great tasting, good-for-you products that consumers love.

For Fruit Snacks

The new generation range of URC® ingredients are designed as clean label, nutritious building blocks for innovative, value-added real fruit snacks.

URC® ingredient formats are proven to be an excellent source of antioxidants, and can be formulated to contain up to seven times their own weight in real fruit content with no added sugars. From strawberry fruit snacks to cherry & pomegranate blends, increase your product appeal with real fruit ingredients.

URC® Pastes

URC® blending pastes can be incorporated into a range of formed fruit snacks and softer textures can be used for centre filling. The healthy profile can be further enhanced with vitamins, calcium or other functional ingredients. Deposited and formed fruit snacks can be made using conventional confectionery processes with URC® blending pastes that are all natural and contain no added sugar. URC® pastes are also a natural fruit base for extruded fruit bars and shapes.

Innovative product concepts such as bite-sized pieces, formed shapes, bars or logs can be acheived with URC® pastes. The high fruit content enables nutritional on pack labelling and brings interest and variety to the healthy snack market.

URC® Pieces & Flakes

URC® fruit pieces and flakes make a great all natural fruit snack meeting the needs of today's time poor, health conscience consumer. Delicious and nutritious, they're ready to eat straight from the

packet as a real fruit snack. Added value options include chocolate, yoghurt or sugar coatings to enhance their appeal to different target markets.

**Casual Fruit**
Snack Saludable S.L. Sant Cugat del Vallès España
http://www.casualfruit.com/

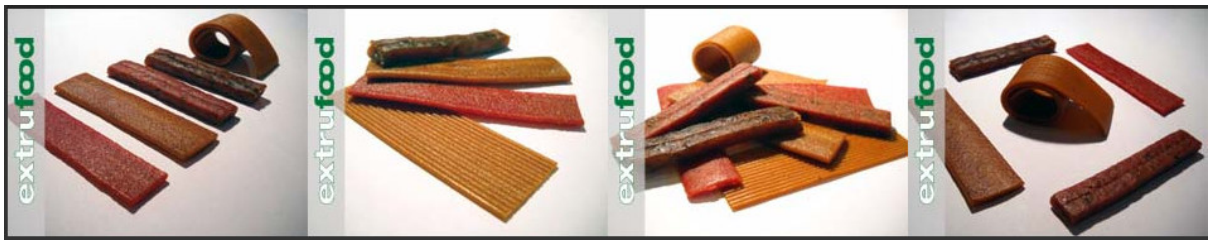

| Información Nutricional | 100 g | 1 | GDA* |
|---|---|---|---|
| Energía (Kcal) | 379,0 | 102,3 | 5% |
| Carbohidratos (g) | 90,9 | 24,5 | 8% |
| de los cuales azúcares (g) | 34,5 | 9,13 | 3% |
| Proteínas (g) | 1,3 | 0,4 | 1% |
| Grasas (g) | 0,0 | 0,0 | 0% |
| Fibra alimentaria (g) | 4,8 | 1,3 | 5% |
| Vitamina C (mg) | 18,0 | 4,9 | 5% |

Cada bolsa de 30 g equivale a **una pieza de fruta natural**.

Casual Fruit ha encontrado en el **maíz** el complemento ideal a la fruta. Además, le permite obtener una textura crujiente. Este cereal, considerado sagrado por los Incas y Mayas, se digiere fácilmente, y no contiene gluten por lo que también es apto para celíacos. Al contener maltodextrina permite también que el cuerpo metabolice rápidamente el azúcar de la fruta y libere la energía lentamente, lo que redunda en una adecuada eliminación de la glucosa en la sangre.
Casual Fruit utiliza la técnica de la **liofilización** para garantizar la total conservación de los nutrientes de la fruta fresca.
En el proceso de investigación y creación del producto, se han descartado otros proveedores especialistas en liofilización, ubicados en China, Polonia y Colombia, y se ha escogido una empresa española para producirlo.
La liofilización es un proceso que extrae el agua por sublimación, a base de combinar altas presiones (**SIC !!**) y bajas temperaturas. Durante este proceso, se elimina el agua que pasa de estado sólido al gaseoso, sin pasar por el estado líquido.
Así, la liofilización preserva la estructura molecular de la fruta garantizando su total asimilación por el organismo, a la diferencia de la fruta deshidratada.
Esta tecnología, además, permite obtener una textura crujiente y un sabor delicioso sin necesidad de aceites, azúcares añadidos, gluten o conservantes de ningún tipo.
La liofilización se utiliza actualmente tanto en la industria de alimentación como en la farmacéutica para conservar todas las propiedades de los alimentos y medicamentos.

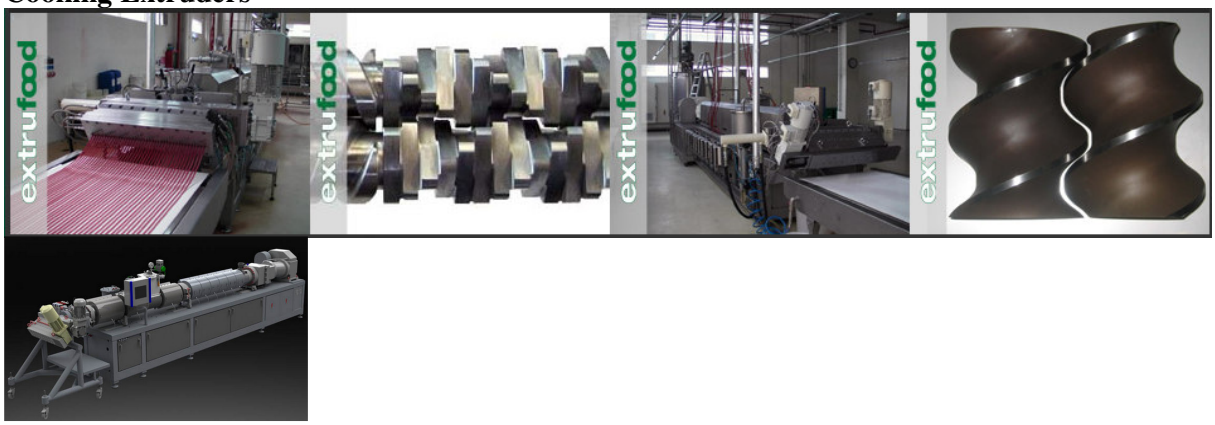
EXTRUGROUP
http://www.extrugroup.com/extruded-products/fruit-snacks

**Fruits Snacks**



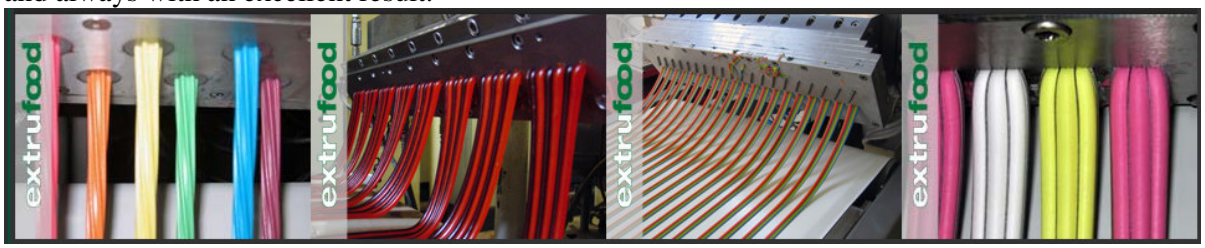

A Fruit snack is processed fruit that eats like a traditional snack food. It can be deposited, freeze dried, or air dried and may be called Fruit Leather, Fruit Bars, Freeze Dried Fruit, or most commonly, is simply known as "Fruit Snacks". The fruit snack most familiar to consumers are commercial products that are produced by combining fruit juices and fruit purees with colors and flavors. They may contain other ingredients including starches, gelatin, sugar and corn syrups. Typically they contain between 15-20% moisture to give the product a desirable soft chewy texture. An innovative range of 100% fruit snacks and bars can now be made on the Extrufood cooking and/or forming
extruders. The cooking process allows you to produce a broad spectrum of tasty, healthy products. Extrufood has gained a tot of expierience during the past few years by testing different recipes of fruit snacks in
their Extrucenter. A tot of different shapes have been produced like bars, strips, bites, belts and even hollow fruit
cables.

**Cooking Extruders**




The Extrufood cooking extruder is a twin-screw, counter-rotating extruder, especially designed for the production of low shear confectionery recipes, like licorice, fruit gums, fruits snacks, caramels, hard candy...etc.
The machine consists of a stainless steel base frame, supporting the gearbox, the electrical drive, the extruder, the de-areation, the tempering, the color and flavor dosing, and the screen changer. The cylinder consists of two components, a cooking zone and a vacuum/cooling zone, and is tempered by means of water.
During start up, the extruder is heated electrically. After the temperature set point is reached, the slurry is fed into the extruder for cooking. The internal friction in the pre-mix slurry, caused by the extruder screws, actually generates heat by itself, causing the need for additional electrical energy to drop to 30 - 40 % of the initial level!
The combination of the external energy and the internal friction inside the cylinder makes for the most efficient and effective cooking process, and is the main reason for the superior quality of the end product of a typical Extrufood line.

The barrel and screws can be dismounted and taken away for inspection and maintenance without having to move the extruder out of the line.
The control system is based on a Siemens or optionally an Allan Bradley control unit,. Our extruder is completely wired to a single connection point, which makes for an easy and very fast installation. We have supplied more than 50 cooking extruders to many leading confectionery manufacturers, and always with an excellent result.




Diemixes
The unique Extrufood Diemix® enables the production of licorice/fruit gum with up to 6 different colors and flavors while using only one extruder. The Diemix® splits the mass, coming from the extruder, into individual equal streams. Color and flavor is added to each individual flow. A dynamic mixing stage assures a homogeneous mix of each flow. A dosing skid can be fitted to the Diemix® to ensure accurate dosing of each color and flavor.
The Diemix® has a compact design and can be adapted to many different mass types and is easy accessible for maintenance. Usually with help of a small modification it will fit into your production system. A Diemix® can be fitted onto all Extrufood extruder types. This means that with co-extrusion it is possible to make 6 single colored products (licorice) on one cooking extruder with a Diemix® combined with different colored fillings (sugar paste) coming from one forming extruder with Diemix® in one production run.

Baker Perkins **Extruded Fruit Filled Snacks** (Allegato B.2.25)
http://www.bakerperkinsgroup.com/product/347/253/white-paper---extruded-fruit-filled-snacks.html

Co-extruded fruit filled snacks are a new concept introduced by Baker Perkins to support snack manufacturers facing the challenge of a rapidly changing commercial environment. Fruit-filled snacks can be marketed to both children and adults as 'good for you' while still offering the taste and convenience that consumers demand in a snack product.
They take the concept of healthy snacks beyond simply reducing fat and salt into the realm of positive nutrition.
The concept involves the replacement of conventional savoury fillings in co-extruded snacks with a fruit filling. These use highly concentrated fruit pastes from Taura Natural Ingredients, who have worked closely with Baker Perkins on the development of these products. The key to their appeal is the combination if an intense fruit flavour with a crunchy cereal. The low moisture activity of the Taura pastes ensures that the crispness of the shell is maintained so the products can be packed and distributed in a conventional, convenient format.
A new concept in co-extrusion is the 'credit card' – a thin, fruit-filled wafer type product that opens up a whole new area of marketing opportunities including dips and countlines.
As a development of well proven extrusion technology, these products can be made with minimal capital outlay on existing systems. Process technology, equipment, and customer support are all available from Baker Perkins and Taura as a complete solution.

Jinan Shengrun Extrusion Machinery Co., Ltd.
http://www.made-in-china.com/showroom/sumring/product-detailWobEvrRHZXYN/China-Snacks-Machine-TSE70-II-.html

Co extruded snack machine

1. Description: A typical co-extrusion snacks line includes batch mixer and screw feeder, twin screw extruder and forming equipment, filling stuff equipment, Belt dryers and coating drum.
2. Raw materials: The soft filling materials include chocolate, cream, jelly, fruit paste, date paste. The ingredients of the outer part is generally wheat, a variety of other cereal grains can also be progressed such as rice, corn, barley, rye, oats, sorghum, etc.
3. Products: Variety shapes are available for the core-filled food, including pillows, tubes, bars, long and short ovals, heart shape by adjusting the roller in the shaper
Also can produce snacks cereals ect by adjusting the mould from extruder
4. Capacity: 150kg/h, 240kg/h
5. Flow chart: Mixing system---Extrusion system----Core filling and shaping system---Drying system----Flavoring system---Packing system
6. Voltage in China: Three phases: 380V/50Hz, Single phase: 220V/50Hz, we can make it according to customers' Local voltage according to different countries
7. Machines Materials: All the machines are made by stainless steel

**Snack Machinery (TSE65/70/85)**
http://shengrun.en.made-in-china.com/product/LoCQRYSdCKUr/China-Snack-Machinery-TSE65-70-85-.html

| | |
|---|---|
| Price: | **US $ 1.0-9000.0/ Set** |
| Trade Terms: | **FOB, CFR, EXW, CIF, FCA** |
| Payment Terms: | **L/C, T/T** |
| Price Valid Time: | **From Nov 27, 2012 To Feb 23, 2013** |