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Innovation in food service technology and its strategic role

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Abstract

Innovation in food service technology offers differentiation and cost leadership in strategic terms. The majority of food service businesses do not have research and development laboratories. At present, the innovations in equipment design and layout, packaging and service techniques are of a defensive or reactive nature. Examples of defensive innovation include faster and better preparation methods, improved temperature control, even heating, energy and labour savings, less waste, better sanitation, faster service and flexibility. In contrast, developments in offensive or pro-active innovation, which can radically change current practices, are rare. Novel food service processes can evolve as a result of adoption of technological breakthroughs in "high tech" fields of the economy. This justifies investments in offensive research and highlights the importance of technical competencies for a food service professional.

Keywords: Food services; Innovation; Technology; Equipment design; Packaging

1. Introduction

Food services generate the turnover of about $360 billion (US dollars) per year in the United States (Simpson and Carevic, 2004), the global figure is $1.3 trillion (US dollars) (Webber, 2004). The dual nature of food service operations incorporating manufacturing and service commands a variety of disciplines underpinning research and innovation in this field. The front-of-house operations can be analysed from the five-aspect viewpoint: the room, the meeting, the product, the atmosphere and the management control system. It is

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informed by ethnology, sociology, anthropology, business economics, nutrition, domestic science and public health; all of these elements constitute a new discipline called Culinary Art and Meal Science (Gustafsson, 2004). It supports art, creative thinking and handicraft in delivering an extraordinary aesthetic experience. The importance of the three main consumer-focused factors of food quality (meal context, expectations and eating location) was demonstrated experimentally by the significant difference in sensory evaluation scores for the same food items in different dining settings (Meiselman, 2003).

Consumer behaviour aspects and marketing research are dominating academic literature in food service management. The back-of-house operations informed by natural science, disciplines like engineering (physics and mathematics), food science (biology, microbiology and chemistry) and operations management (Rodgers, 2005), on the other hand, are often overlooked. The only technology covered extensively in tertiary hospitality curricula is "soft" information technology. Currently, there is a dearth of analysis of developments and topology of "hard technologies" related to equipment design and packaging.

Food production, the only manufacturing function in the hospitality sector (Jones and Lockwood, 2002), is increasing in volumes and becoming more technical (Meiselman and Edwards, 2001). Alfa Flight Services (in-flight caterer based in the UK, Europe, North America, Australia and India), for example, produce 60 million meals per year. A typical modern cruise ship, such as Disney Magic (Disney Cruise Line), would have the staff of over 120 chefs preparing about 10,000 meals per day (Anon., 2004b). Institutions such as educational/health/aged care and corrective facilities, on the other hand, cannot sustain so many cooks and rely heavily on technology to enable labour efficient centralised food production (New South Wales Health Department, 1996; New South Wales Health Department, 2005). At Omeida, a central production unit of the New York State Office of General Services that supplies 70 prisons, 14 staff members produce 198,000 meals per shift to meet the budget of $2.10 (US dollars) per inmate per day (New York State Department of Correctional Services, 2003). Thus, in large volume operations, innovations in "hard" technologies offer improved solutions in order to meet consumer needs, which are typically identified by researchers in the meal science.

This paper describes possible pathways for adoption of technological developments in other "high tech" branches of economy to food services and articulates directions of strategic innovation. Two stances in innovation—offensive based on revolutionary breakthroughs and defensive based on gradual evolutionary improvements—are identified. The paper concludes that offensive inventions can lift the industry's performance.

2. Pathways in innovation

In organisational terms, innovation involves the management of ideas, the provision of funding and implementation. In manufacturing, the separation of "the laboratory", (research and development department), and the rest of the organisation has three potential problems. First, the laboratory may ignore ideas arising in operating units; second, the organisation can be too engrossed with the current consumer needs that it does not appreciate far-reaching solutions suggested by the laboratory and third, the laboratory may not know the level of technical competency of the operating units in terms of their capability to implement the invention (Christiansen, 2000).

In food services, the majority of which are small businesses in comparison to food manufacturing, there are no research and development laboratories as such. The exception would be the multinational contract catering companies such as SODEXHO, ARAMARK, COMPASS and others. As a result, suppliers often mediate between the latest developments in engineering (equipment) and food science (ingredients) by offering new or improved products to sell to the food service industry. Thus, the laboratory is not only physically removed from the actual food service operators, but it is in someone else's hands. Such a distance limits the possibilities for communication. Could this be the reason why the basic design of cooking equipment has not changed over several decades?

Commercialisation of sous vide (cooking-in-a-bag) preparation, a radical innovation proposed by a chef (Light and Walker, 1991), was driven by a packaging company, CRYOVAC, in cooperation with a kettle manufacturer, GROEN, in the 1980s. Both companies saw this development as a new market for their products. Currently, sous vide installations are often left abandoned due to lack of expertise when the chef/manager who installed them moves to another company. In April 2006, New York City Department of Heath banned sous vide cooking to reduce the risk of *Listeria* and botulism resulting from the lack of food safety expertise amongst chefs (Bowen, 2006).

The food service industry does not have a reputation for being highly innovative or for having the culture of a learning organisation (Bessant, 1999). In the United States, this has been addressed to some extent by the Research Chef Association that promotes the importance of the principles of food science in food preparation. However, the whole field of food service technology is much broader than this; it also includes equipment and facility design as well as the whole food service systems. Furthermore, the scope of innovative horizons should be expanded beyond the traditional food service disciplines to reach other industries with higher rates of technological progress such as medicine and space exploration.

Historically, many significant breakthroughs originated on the interface between different fields. Some of the examples are listed in Table 1. Hazard Analysis Critical Control Point (HACCP) principles, a common risk management technique used in non-food related fields (Lois et al., 2004), were applied to foods for the first time by NASA (National Aeronautic and Space Agency, US) to ensure the safety of astronauts' meals in the 1960s (Sumner, 1995). The new discipline, predictive microbiology, which contributes to objectivity in the selection of critical limits and corrective actions in HACCP

Table 1
Examples of technology transfer from different fields to food service applications

Innovation	Idea originated from	Relevance to food services
HACCP	NASA space programmes	Food safety assurance
Self-sterilising of materials	Medicine	Prevention of cross-contamination
Incorporation of antimicrobials into equipment	Incorporation of antimicrobials into packaging	
Predictive modelling	Statistics and computation	HACCP and risk management
2zones[2] kitchen design	Architecture	Product flow and hygiene
The design of tumble-chillers	Clothes washing machine	Better heat transfer for "cooked-in-a-bag" products
Immersion circulator	Laboratory equipment in medicine	Gentle heating of sauces
Filters for ventless hoods	Nuclear energy projects	Low cost and more flexibility in equipment layout

management (Miles and Ross, 1999), is a hybrid between food microbiology and statistics/computer modelling. The high-efficiency arrestor filters currently used for ventless deep fryers originated from the Atomic Energy Commission (US) projects on filtering radioactive particles out of the air (Sherer, 2004).

3. Innovation and strategy

Food, packaging and equipment represent the main physical resource and, thus, a core competency of tourism/hospitality organisations (Evans et al., 2003). Innovation based on these "hard core" elements offers significant competitive advantages (Table 2) in terms of Porter's generic strategy framework (Porter, 1985). This fits well with the innovation system suggested by Christiansen (2000) where the option of differentiation is articulated as a "better match with existing customer needs" and "better anticipation of future customer needs"; cost leadership as "more speed versus competitors" and "reduced costs". Unlike "soft" information technologies that are rarely exclusive to one organisation, "hard" technologies require more complex configurations of physical resources, which are unique to a particular setting and more difficult to copy or transfer (Bessant, 1999). For example, superior cooking techniques can increase product desirability and decrease price sensitivity by preventing direct comparability (Van Stamm, 2003). The reduction of a product's perishability by shelf-life extension with refrigeration not only opens up new markets and distribution channels, but it offers significant cost savings resulting from bulk buying of raw materials, bulk food production as well as waste reduction (Creed, 2001). Such centralised meal production falls under the "industrial cuisine" concept. Interestingly, innovative production technologies are recognised as one of its enablers (Hudson, 1997).

Cafes and restaurants differentiate themselves through menu choices (variation of ingredients and preparation methods), décor, theming and branding (Hudson, 1994), but rarely through novel technologies in food preparation. Even large fast-food chains and multi-national contract catering companies compete with small operators by the sheer size of their operations (economies of scale) and not with technological breakthroughs.

Gradual improvements occur as individual restaurants experiment to retain customer interest. This "innovation by trial" strategy floods the market with a wide variety of

Table 2
Strategic advantages of innovation in food preparation

Differentiation	Cost leadership
Superior food quality	Centralised production
Enhanced nutritional value	Higher yield
Unique cooking methods	Less food waste
Unique service methods	Less food cost
Maintaining the freshness of ingredients	Less energy costs
Speed and accuracy of service	Less capital cost
Cooking/service methods as attractions	Less preparation/service time
	Less workers' compensation
	Streamlined processes

product/price offerings. However, the predominance of artistic and intuitive approaches to product design and the lack of "high tech" leaders reduces the entry barrier in the industry (no scientific "know-how" is needed) and increases the rivalry among "low tech" competitors. In addition to this, the small size of food service organisations increases the power of suppliers (Porter, 1980). The United States' major meat processor, Tyson Foods (Springdale, Arkansas), for example, spent $40 million (US dollars) on its Discovery Centre. Food services can rarely match the technical expertise and resources available to food and equipment manufacturers.

4. Equipment design and layout

The main objectives for designers of food service equipment include better temperature distribution and control, faster cooking, less energy and labour costs, safer operations, better sanitation, modularity and flexibility (Table 3). For example, in a modern oven salmon fillets can be prepared in 3 min, a baked quarter chicken in 1.5 min and a pizza in 60 s (Bendall, 2004). Steam-powered cooking provides rapid heating and even temperature distribution due to the higher thermal conductivity of steam. Steamers equipped with a vacuum pump allow quick heating and gentle cooking of heat sensitive foods at temperatures below water's boiling point. This also contributes to the versatility of steamers. In addition to cooking function, steamers can be used for gentle reheating and hot storage of meals. In pressure fryers (pressure is created by escaping vapour), food can be cooked faster at higher temperatures with reduced moisture loss. Induction heating offers high energy-efficiency (95%) as well as the high speed of cooking (Anon., 2004c). In induction units such as iChef (Induced Energy, UK), altering current in the coils creates a magnetic field that excites the metal molecules in the cookware with a special coating that absorbs the magnetic waves.

The shape of the heating unit is an important design consideration. In the future, the application of sophisticated modelling techniques capable of predicting the heat flow, such as Computational Fluid Dynamics (Verboven et al., 1999) and neural networks (Xie, 2002), may result in units of unusual shapes, such as a spherical cooking chamber, for example. Currently, the Steam Vector Baffling Systems developed by ACCU Temp Products Inc. (2005) accelerates and directs the steam flow using the wall geometry without fans or other moving parts. Similarly, in convection cooking, the dual-flow-path valve alternately directs the heated and returning cooler air through the multi-ported walls of the oven cavity (Bendall, 2004).

Incorporating food safety considerations in design is driven by legislation—Chapter 4 "Equipment, Utensils and Linen" of the Food Code (US Food and Drug Administration), for example. Units combining conveniently situated refrigeration and heating (Imperial Commercial Cooking Equipment, 2003) can reduce the amount of movement at a work station and encourage temperature control. Numerous temperature-recording devices plus the incorporation of anti-bacterials in food contact surfaces support Good Manufacturing Practices.

Cleanability as a food safety feature is the universal requirement for any piece of food service equipment, while other design solutions are more specific to a particular food service setting. The desire for energy and space saving on cruise ships dictated the need for desk and wall mounted units, efficient induction cookers and blast-chillers (Anon., 2004b). Casinos, convention centres, stadiums, airlines, major hospitals and other large institutions,

Table 3
Innovation in food service equipment design

Benefits	Innovative approaches/principles	Examples
Reduction of cooking time	Cooking at temperatures above water's boiling point	Pressure fryers
	Combination of convection, microwave and high-intensity light wave energy	Ovens
	Short recovery time resulting from the higher heat conductivity of the copper used in the heating plates	Gas deep fryers
	Cooking both sides of a product at the same time	Clamshell griddles
Energy efficiency	Cookware rather than the heating element is the heat source	Induction stoves and reheating units
	Forced-air gas combustion	Ranges
	Solar energy powered units	Refrigerated salad bar
Labour saving	Robots (pneumatic lifts and motor driven transports)	Sushi preparation
	Ultrasonic washing system	Dishwashers
Evenness of heat distribution	Vertical double rotation system	Rotisserie
	Dual-flow-path valve	Ovens
	Seam Vector Buffing System	Steamers
	Cooking with high-pressure steam (high thermal conductivity)	Steamers, griddles/braising pans
	Solid-to-solid heat transfer	Banquet carts
Superior process control	Temperature control within one-tenth of a degree	Immersion circulator
	Time/humidity programming	Convection ovens
	Variable transmission speed of the beater shaft/rotor	Mixers and food processors
	Microprocessor-controlled heating	Grills and griddles
	Controlled beer carbonation	Low-pressure nitrogen generators
Modularity and flexibility	Cross-purpose equipment:	
	• backing, steaming and smoking	Ovens
	• griddling, roasting, warming, steaming, proofing, holding and deep-frying	Tilting skillets
	• steaming and holding	Steamers
	• a wormer and a cooking top	Cooking and holding induction units
	Portable equipment	Numerous bench-mounted units with interchangeable attachments
Superior food quality	Better penetration of marinate	Vacuum tumblers
	Lower boiling temperature for heat-sensitive items	Steamers with a vacuum pump
	Efficient freezing with liquid nitrogen	Tumble-freezer
	Limited moisture loss	Pressure fryers

Table 3 (*continued*)

Benefits	Innovative approaches/principles	Examples
HACCP and Good Manufacturing Practices	Conveniently located refrigerated units	In-built refrigerated drawers in ranges and grills
	Remote temperature control, continuous recording, integration of temperature fluctuation	Data loggers
	Anti-bacterial inorganic silver ions are incorporated into food contact materials	Benches, beverage dispensing equipment, sinks, ice machines, door handles, slicing machines, thermometer probes, cutting boards, steel or plastic shelving and gloves
	Self-cleaning with a chlorine solution	Ice machines
Improved service	Long holding time (convenience)	Banquet carts
	Coloured and anti-finger prints steel (aesthetics)	Display cooking and holding units
	Replacement of stainless steel with decorative materials (aesthetics)	
	Personalisation of service	Single portion cooking and holding units
	Flexibility (variable energy sources such as electricity and liquid fuel) and convenience (long holding time)	Banquet carts, mobile kitchens
	Technology as a feature	Futuristic robots that act like humans

on the other hand, would require high-volume industrial-type equipment such as continuous cookers/chillers/freezers, automated portioning/packaging machines, conveyer belts and folk lifts for transportation. Such complex equipment configurations can be classified as systems. The food service systems, which are traditionally associated with industrial cuisine, include cook-hot holding, cook-chill (traditional and extended shelf-life or sous vide) and cook-freeze (Creed, 2001).

The use of different energy sources and other innovative energy management strategies addresses environmental concerns reflected in the UN Framework on Climate Change (UNFCC) and Commission for Sustainable Development (UNCSD). Other examples include the European Union's Directive on Integrated Pollution Prevention and Control (IPPC) and the Dow Jones Sustainability Indexes. New design of filters reduces air pollution: grease particles can be converted to harmless carbon dust, carbon dioxide and water vapour using packed bead beds, cyclonic motion filters (water mist hoods) and the latest UV light technology. Ventless hoods, which do not require ductwork, offer more flexibility in equipment layout. Their design is based on the high efficiency arrestor filters, which can capture particles larger than 0.3 μm in size (Sherer, 2004).

Equipment layout solutions integrate elements of food science, engineering and operations management. The novel 2zones[2] kitchen, for example, consists of a set of stainless steel modules where operations take place in "cooking canals" instead of

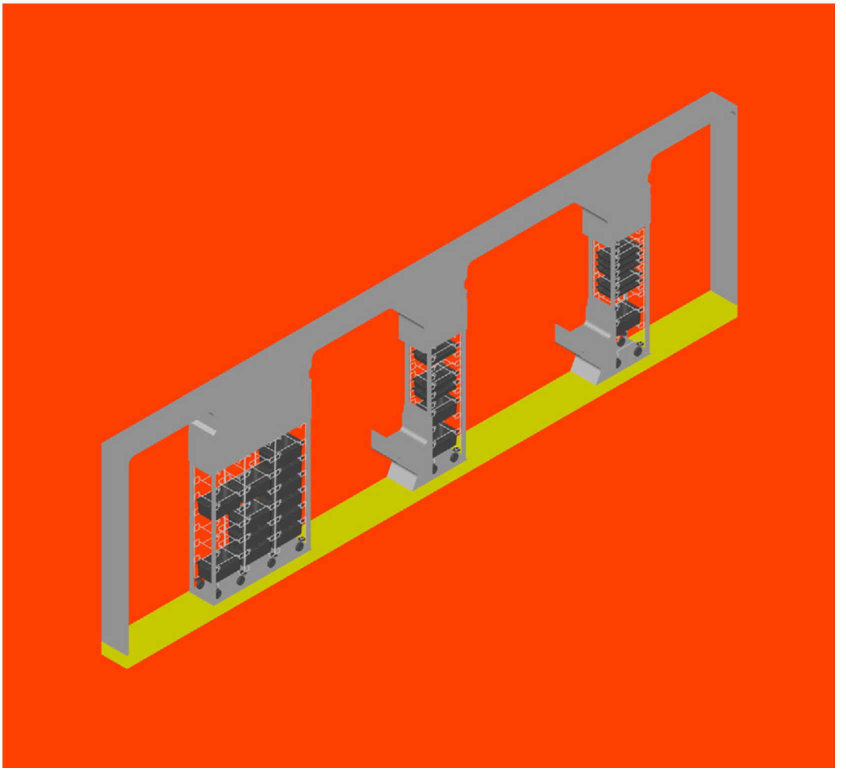

Fig. 1. Refrigerated walls separating different production areas in the novel 2zones[2] kitchen design (a virtual tour is available online http://www.2zones2.com/en).

preparation benches and food is stored in temperature controlled walls instead of coolrooms (Fig. 1). The four functional areas (cold/clean, cold/soiled, warm/clean, warm/soiled) create a series of parallel climate-controlled zones. Such design streamlines product flow from the operational and food safety perspective, which results in energy savings (lower volumes of air have to be chilled) and a 50% reduction in floor space (Anon., 2004c).

5. Innovations in packaging

There is a great variety of packaging products for cooked meals and beverages. These options include unit-portion packs, vacuum barrier bags, trays for frozen and chilled meals, flexible pouches and ‘‘bag-in-a-box’’ products (Brody, 2003), disposable heat-resistant bags for cooking and hot-holding, as well as self-heating containers (heat generating reaction of calcium oxide and water). The interaction between packaging and food is governed by reactions of sorption, permeation, crystallisation, migration, atmosphere oxidation, mechanical restraint and others (Blumenthal, 1997). Prevention of recontamination of food, convenience and minimisation of waste, more storage space and less labour costs are just some of the benefits of packaging (Olsson et al., 2004). The portioning of alcohol in a disposable recyclable drinking glass opened up new markets for serving spirits such as stadiums and vending machines (Jones, 1996). Shelf-stable packaged products are the base of military and humanitarian relief rations. Food services in general represent the growing market for retort pouches (Brody, 2006). Currently, food services of the New South Wales Health Department (Australia) are experimenting with a type of recyclable/biodegradable dishware originally developed by VISY Food Service for the Sydney Olympics 2000 (Swamy, 2005). Chilled meals can be plated at a central production unit and rethermalised at the ward level of participating hospitals. Trials were conducted to establish the water permeability of the lid during reheating process.

Packaging is a critical element of the sous vide food service system. Historically, this method was first adopted for bulk food production by institutions (health services, nursing homes, retirement villages, schools, correction facilities, the army, etc.) and later by commercial organisations (independent restaurants, restaurant chains, hotels, resorts, clubs, casinos, convention centres, stadiums, cruise ships, airlines, railways, etc). This technology results in reduced energy consumption (the cooking/chilling of packaged product can be accomplished in water which has higher heat conductivity than air) and superior product quality (the retention of juices during cooking). This allows further experimentation with new types of dishes such as sous vide small green eggplant (Duecy, 2003) or the "salmon shank" made of the tail portion of the fish that contains the bone (Wilkes, 2006). Low-quality cuts of meat (high content of connective tissue) can be tenderised during extended cooking at lower temperatures without excessive evaporation.

In packaging, inhibiting chemical deterioration and microbial growth during storage are typical objectives of product development. Modified atmosphere packaging (Simpson and Carevic, 2004), vacuum packaging and oxygen scavenging (Dobias et al., 1999) prevent the growth of aerobic microflora, which have a high spoilage potential. Anti-bacterials, such as organic acids, fungicides, bacteriocins, lysozyme, ethanol, silver ions, grapefruit seed extract and others, can be incorporated into the packaging material (Han, 2000).

The availability of biodegradable materials such as biopolymers and bio-plastics made of starch, foam and limestone is also a result of innovations in packaging technologies. Event organisers have the option of packing lunch/dinner meals in recyclable bags made of vegetable starches. The multi-layer films developed by the Polymer Process Department of the Royal Melbourne Institute of Technology (2005) contain barrier layers that decompose in conventional recycling equipment. This technology is suitable for the cross-linked types of films that are currently dumped in landfills. Another way to address environmental concerns is to reduce the need for packaging in the first place. Such options include single portion hot-holding units, re-sealable bags and stainless steel containers, such as GREENVAC (Kuchenberater, 2005) that imitate the effect of vacuum packaging.

It can be concluded that the majority of innovations in this field fall under the "high tech" category. Packaging is becoming more important in the design of new food service systems. Consumers can benefit from improved food safety, labelling and the ability to eat in less formal settings. Tourism-oriented businesses can produce packaged meals for external markets such as the local food retail sector during a slow season or periods of tourism downturn.

6. Innovations in service

Advances in the design of reheating and holding equipment address the ease of temperature control, aesthetics and personalisation of service (Table 3). There are numerous types of units for holding, displaying, reheating, portioning and cooking food in front of consumers. Equipment for display cooking, such as clamshell and griddles (Anon., 2004a), single-serve pasta cookers and high-speed broilers (Lawn, 2004) provide speed of service in fast-food and personalised service in upscale establishments. The combination of induction cooking and a vacuum-powered air cleaner is used for ''sizzling on-the-spot'' preparation in front of the customer. It offers quick and efficient preparation with minimum escaping odours and heat.

The solid-to-solid phase heat exchange used in EnduraHeat™ banquet carts manufactured by Carter-Hoffmann (US) achieves even temperature distribution and long-lasting heat retention (up to 2 h). The variable energy sources (electricity plus fuel cans) of the carts provide the additional flexibility. Induction heating can be used in meal rethermalisation carts; the crockery designated for hot items has the special electro-magnetic coating.

In health care, patients can choose food from dishes kept hot and displayed in bulk on a ''hostess trolley'' (a heated delivery cart) in a cafeteria-type setting. This menu-less operation reduces the potential error in meal assembly and the misunderstanding of menu selections. Apart form waste reduction, it also offers the possibility for social interactions during mealtime, improves the perception of freshness and the level of satisfaction in general (Hartwell and Edwards, 2003). The combination of novel food service equipment and production management software reduces the gap in service quality between the commercial and institutional sectors. It also allows for a room service with a restaurant-style menu in an institution. In the Robert Wood Johnson University Hospital (Hamilton, US), for example, the combination of holding units and electronic ordering made it possible to deliver Kosher, ''kids'' and ''cold cuisine'' meals to rooms on request to the 46 different locations across the seven-building campus.

Novel approaches to dining area layouts represent another aspect of innovation in service. Despite the growth in the size of food service operations in general, service areas are becoming more intimate and interchangeable. The chameleon-like dining facility on the Queen Mary 2 (Curnard Cruise Line, UK), for example, has a self-service café setting during breakfast and then becomes a café-bar during lunch and a waiter-served bistro in the evening. Unique themes and food concepts coupled with the ''a la minute'' cooking equipment (Anon., 2004b) offer a variety of personalised choices in food and service styles. It is conceivable that a futuristic ''high tech'' service method, such as the human-like robots (Fig. 2) capable of communication by speaking and gesturing (National Aeronautic and Space Agency (NASA), 2005), can create an attraction and become a tourist destination in and of itself.

7. Two stances in food service innovation

Currently, innovations in marketing concepts dominate the food service sector. The concentrated efforts of marketing departments in research and development are usually associated with less technologically sophisticated organisations (Souder, 1997). Equipment suppliers are pursuing incremental improvements as a reaction to customer complaints,

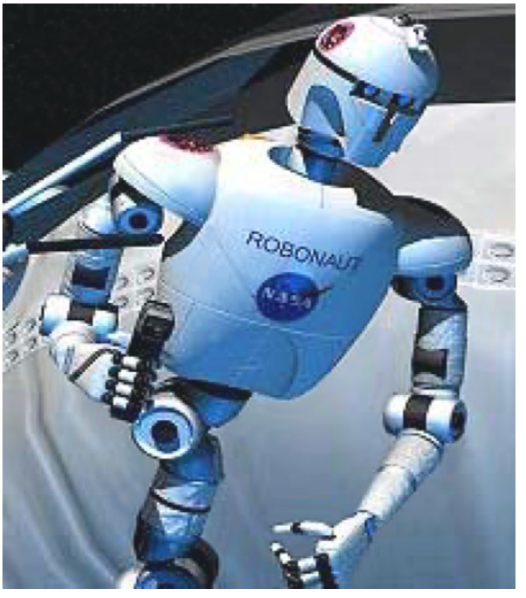

Fig. 2. Human-like robot (NASA, 2005).

Table 4
The examples of the two stances in food service innovation

Defensive	Offensive
Meeting legislative requirements to monitor and record temperatures	Unusual shapes accommodating optimum air flow patterns derived by modelling
Even air flow	
Better process control Improved cleaning/sanitation Improved aesthetics Energy saving	Radically new preparation methods (injecting hot oil into food, localised cooking, cooking by extrusion, etc.)
Labour cost reduction Waste reduction Modularity and flexibility	Controlled cooking by detecting desired flavour
Reduction in cooking time Speed of service Personalised service	Robotisation of food preparation and service
Minimising nutrients loss	New food service systems (sous vide, freeze-chilling, aseptic packaging, etc.)
	Continuous product flow (2zones[2]) kitchen design

legislative requirements or operational problems. This represents a defensive stance in innovation (Table 4). Radically new ideas such as the 2zones[2] kitchen design described earlier are examples of offensive innovation. Creative evaluation of developments in "cutting edge" manufacturing industries can result in their adaptation to food services of the future. Gas detectors (Madsen and Grypa, 2000) can be "trained" to recognise the "cooked" aroma and switch a unit from cooking to holding mode when food is ready in terms of its culinary quality. Fire-resistant materials developed for applications in space may replace expensive stainless steel in production and service equipment. In tourism, sophisticated dishes and creative technology-driven serving methods can complement futuristic developments such as hotel Burj Al Arab or the underwater luxury resort Hydropolis ("Sunken City") in Dubai (Saudi Arabia). The technical competency of operators is an essential "ingredient" in the shift to offensive "high tech" revolutionary developments.

8. Conclusion

The wide scope of disciplines encompassing food service ranges from natural science to the humanities. Research and development in equipment, food, packaging and service techniques has the potential to increase efficiency of operations (energy, food and labour costs) as well as improve food quality and safety. The latter represents the strategic option of differentiation. Often, novel solutions result from the interrelation between different fields or technical disciplines. Innovation options range from a single piece of equipment to a whole package supporting a food production system and are often based on culinary art, the science of cooking, food microbiology, engineering, packaging technology and computer modelling. The lack of scientific expertise and research laboratories in the majority of food service establishments impedes the increase in sophistication of this industry.

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