1. INTRODUCTION

What makes a consumer prefer one brand of coffee to another? The answer can be found in the way consumers perceive the available brands. To understand the consumer is not just "common sense" and why consumers react as they do is not always clear. It is difficult to predict consumers' actions. Moskowitz (1985) defines consumers as " *individuals who use the product, but may not know about its composition or the nuances it can assume*". Perception can be defined as "*the process by which an individual observes, selects, organises and reacts to environmental stimuli in a meaningful way*" (Schiffman & Kanuk, 1983).

Consumers are not confined to isolation, their expectations and perception of a product is susceptible to both intrinsic and extrinsic cues (Issanchou, 1996). Where intrinsic cues refer to inherent sensory qualities of the product, including appearance, taste, odour and even shape, extrinsic factors are those elements which influence the consumer from outside for example price, nutritional information, brand name as well as personal and situational variables (Acebron & Dopica, 1999).

In a survey conducted by Westenhoefer and Pudel (1993) on the sources of pleasure from eating, it was observed that the 'excellence of taste' in food was the single most important aspect of the pleasure associated with eating in the more affluent industrialised region of West Germany. In less affluent East Germany, other factors such as pleasant atmosphere played a more important role. As the economic situation of nations improves, consumers begin to place even greater influence on the sensory quality of the foods they purchase. For international food manufacturers, meeting the demand for improved sensory quality will require a better understanding of what contributes to the sensory acceptability of foods.

Cardello (1996) suggests that in order to begin to understand a consumer's food preference, two areas have to be investigated and somehow related,

- firstly, identifying factors related to preference and choice;
- secondly, pinpointing influences connected to the consumer's perception of a food product.

Using descriptive analysis methodology, trained panellists characterise and quantify the sensory qualities of food (Meilgaard, Civille & Carr, 1987). The connection between the sensory qualities and consumer reaction is often of interest. Although the human sensory system is quite sensitive, consumers often find it difficult to articulate the slight differences of products' characteristics (Steenkamp, Van Trijp & Ten Berge, 1994). Therefore while one may request consumers to provide sensory profiles of products, additional knowledge may be gained by integrating consumer response with descriptive data (Elmore, Heymann, Johnson & Hewitte, 1999).

Preference mapping supplies valuable information about each individual's reaction in a visual format (Macfie & Thomson, 1988). Preference information for each consumer participating in a study is presented within a multidimensional space representing the products evaluated. This perceptional map gives a clear presentation of the relationship among the products and the individual differences in preference by consumers for theses products (Elmore *et al*., 1999). This visual image of the products simplifies the interpretation of how product qualities affect consumer reaction.

Along with tea, coffee is the most commonly consumed beverage worldwide (International Coffee Organisation, 2001). However, it is prepared in many different way. For convenience instant coffee was developed, but for economical reasons instant coffee blends was formulated in which bulking agents like maltodextrin or coffee substitutes like chicory was incorporated. The sensory attributes of coffee have been researched rather broadly by McEwan (1996a, 1998) and Heyd & Danzart (1998), but sensory research on instant coffee blends is very limited (Zamora & Calvino, 1996).

2. MOTIVATION FOR THIS STUDY

The main goal of any business is to produce a product the consumer cannot live without, resulting in the survival and profitability of a business (Wilkie, 1994). But what does the consumer really want, and why? People generally know what they like or dislike; however, understanding why consumers prefer something is much more complex (Macfie & Thomson, 1988). If the "why" was totally understood, unnecessary expenditure on unwanted products could have been eliminated. Such understanding is vital in any 'real-life' commercial context. Marketing, advertising, new product development, product positioning and product tracking all require food manufacturers to understand their market, their product's place in that market and the characteristics that define that specific product relative to others (Hawkins, Best &Coney, 1992).

It is useful in product development, marketing and even customer service to know the relationship among the attributes of competitive products (Keane, 1992). A South African instant coffee manufacturer found it important to find out how their products were positioned with regard to the products' inherent characteristics and how it differed from other coffee products competing in the market place. It appeared to be the perfect opportunity to explore the practice of preference mapping which has been developed specifically to connect consumer preferences to physical and chemical measurements, ingredients, manufacturing processes or sensory characteristics of products (McEwan, Earthy & Ducher, 1998).

3. OBJECTIVES OF THE STUDY

The aims of this study were

- To identify, describe and quantify the sensory profiles of 11 commercially available instant coffees, of which four were pure coffees (PC), six were coffee blends (CB) and a coffee alternative chicory instant drink (CID).
- To compare the L a b colour values, aroma profile by electronic nose and caffeine content of the 11 instant coffees.
- To determine liking for the 11 instant coffees as assessed in-home over a period of 14 days.
- To relate the consumer preferences for the instant coffees to the sensory profiles, colour values, aroma profiles and caffeine content.

4. HYPOTHESES FOR EACH OBJECTIVE

By attempting to achieve the above objectives a clearer picture can be obtained on precisely what the consumer wants in a coffee product and what factors specifically must be kept in mind when developing an instant coffee or instant coffee blend. Therefore the hypotheses are made that:

- There will be a clear differentiation between pure coffees (PC), coffee blends (CB) and the chicory instant drink (CID), because of each variants' unique composition (Briandet, Kemsley & Wilson, 1996).
- The L a b colour values, aroma profile by electronic nose and caffeine content will substantiate the findings of the descriptive panel (Sivetz & Desrosier, 1979, Briandet, Kemsley & Wilson, 1996, Hodgins, 1997).
- The taste (overall sensory experience) is the main purchase driver (McEwan, 1996a) and therefore consumer sensory preference will reflect coffee purchasing patterns.
- Consumer preference will mainly be directed towards attributes that are perceived as positive (McEwan & Thomson, 1989).

5. LITERATURE REVIEW

5.1 Modelling food choice

Food preference is of interest because of recognition of its significant role in food consumption decision-making and therefore its close association with other behaviours and attitudes associated with food habits, most notably consumption and acceptance (Shepherd & Sparks, 1994). Food consumption refers to a behavioural act involving the acquisition of food. Food acceptability has an important distinction in that it denotes "the consumption of food accompanied by pleasure" (Pilgrim, 1957). This definition emphasizes that, unlike consumption, acceptance comprises of both a behavioural and an attitudinal component, the pleasure inherent in it.

Pilgrim (1957) defined food preferences as "the degree of like or dislike for a food." Thus food preference rests predominantly in the affective domain and can exist independently of consumption (Randall & Sanjur, 1981). Food preference, like any complex human behaviour, is influenced by many interrelating factors. Many models have been put together to illustrate food choice (food acceptance or food preference). Cardello (1996) presented a model (Fig. 1) in which the basic sensory, perceptual and hedonic stages involved in the processing of information about the physicochemical structure of food and resulting in food acceptance behaviour is illustrated. Khan (1981) focused in Fig. 2 mainly on the individual factors that influence food preference, whilst Randall & Sanjur (1981) designed a similar model (Fig. 3), but simplified it by suggesting that factors influencing food preference have their origin either at the level of the consumer, environment/situation or the food product.

5.2 How consumer preference is influenced by food product intrinsics

The success of a food product in the market place is predominantly a question of 'taste' and more accurately a matter of sensory characteristics (McEwan, 1996b). Everybody has an expectation of something at times. Expectation can vary enormously from person to person and also according to different situations (Cardello, Maller, Masor, Dubose & Edelman, 1985). For food consumption, expectation plays an important role because it may improve or degrade the perception of a product, even before it is tasted. Two general types of expectation may be distinguished

(1) A sensory-based expectation. Whenever a food is presented for consumption, expectancies are generally about what the sensory qualities of the item "should" be. These expectancies are based upon information that may be as simple as the name of the item, the manner in which it is served, the utensils provided for its consumption, etc. (Cardello *et al.*, 1985). The greater the degree to which a consumer's experience with the product matches his/her pre-established expectancies of it, the greater his/her liking of the product. The larger the discrepancy between the two, the greater the disliking (Anderson, 1973).

(2) An hedonic-expectation that is related to like/dislike to a certain degree (Cardello, 1993). According to Bryan & Lowenberg (1958) it was found that for childrens' food preferences taste, texture and temperature of foods are critical. Van Riter (1956) indicated that for adults preference are influenced by odour, appearance, method of preparation, ease of eating, digestibility, frequency of exposure to the food, familiarity of the food product and association with other foods.

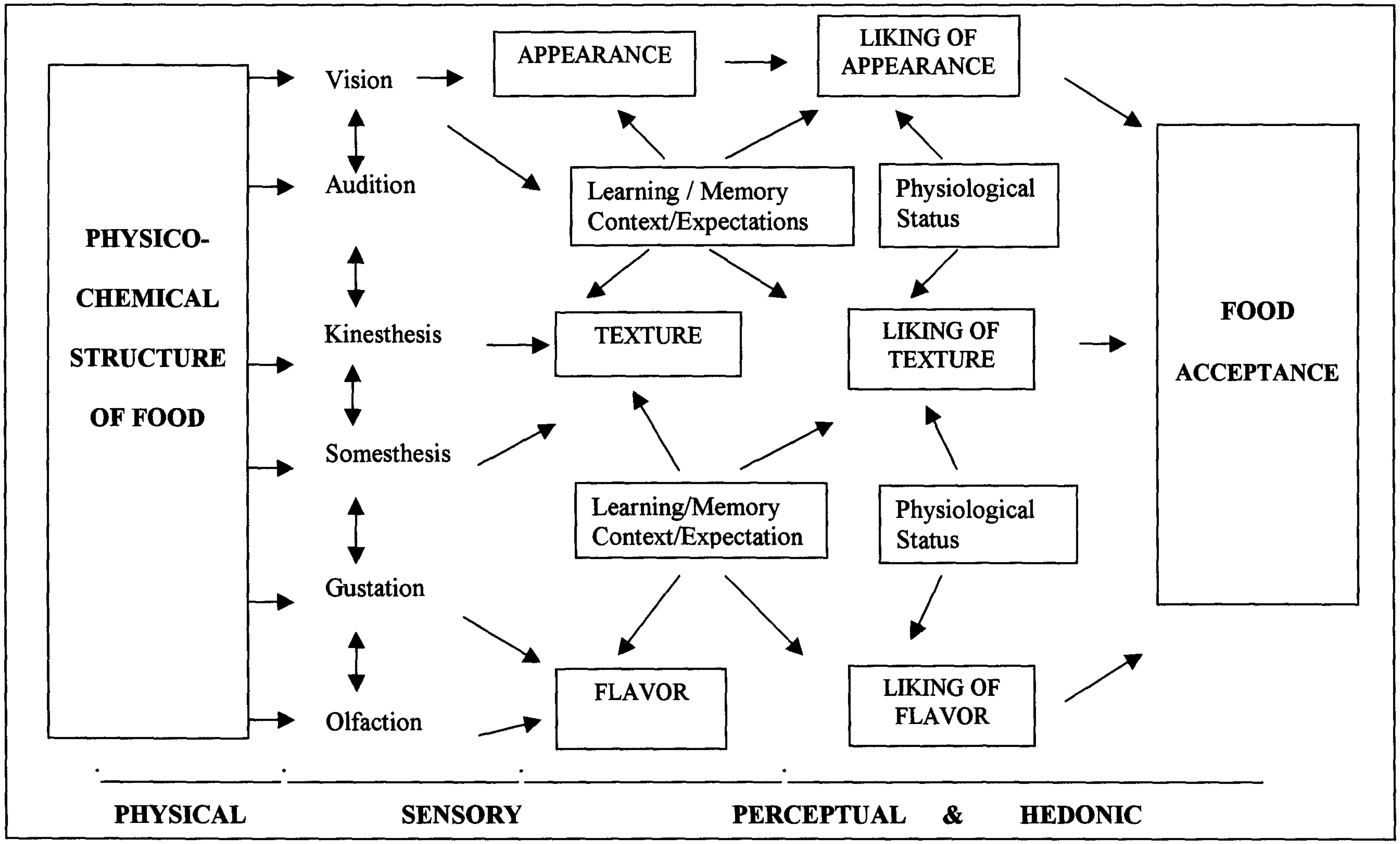


Fig. 1: Schematic diagram showing the basic sensory, perceptual and hedonic stages involved in the processing of information about the physicochemical structure of food and resulting in food acceptance behaviour (Cardello, 1996)

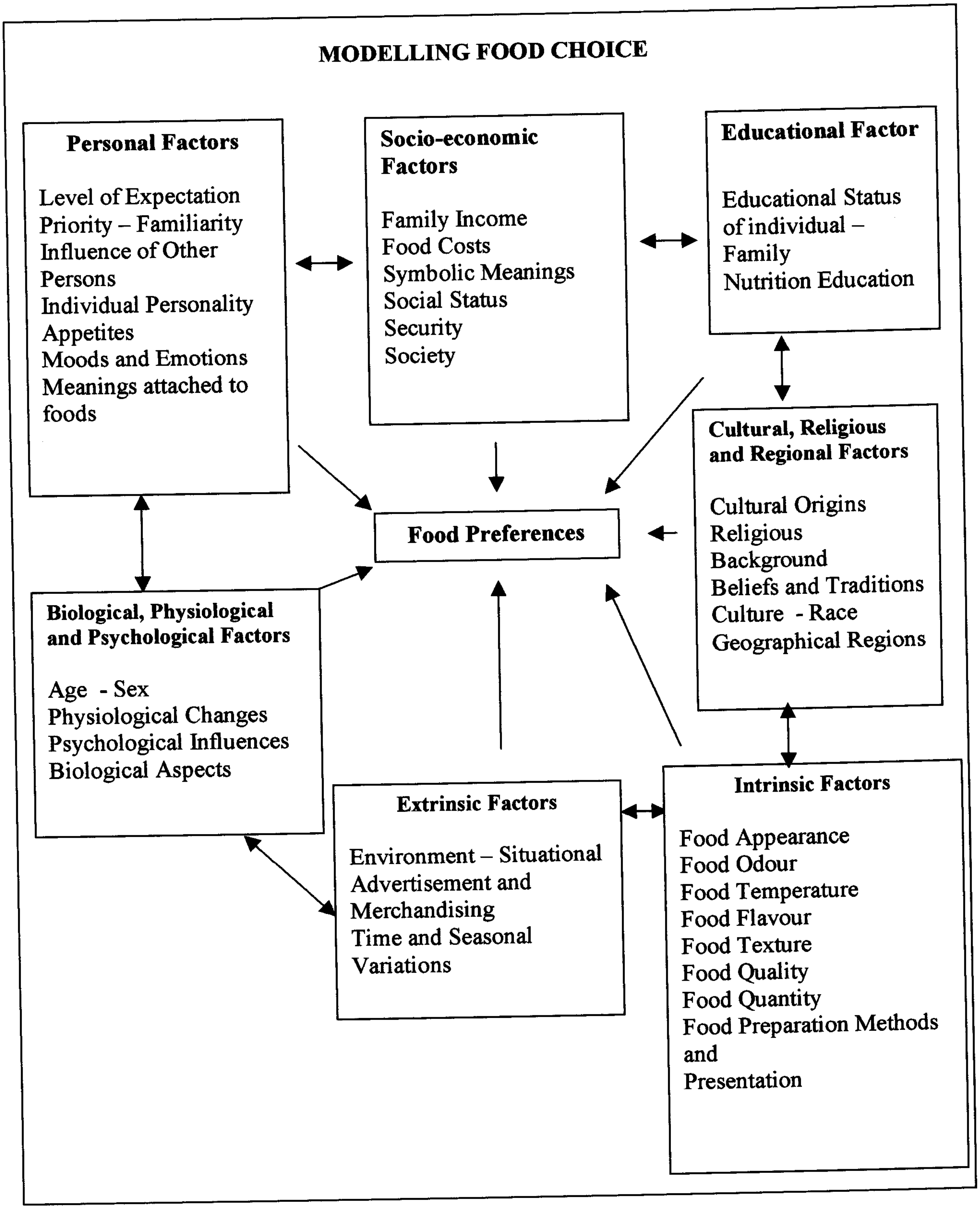


Fig. 2: Factors influencing food preferences (Khan, 1981)

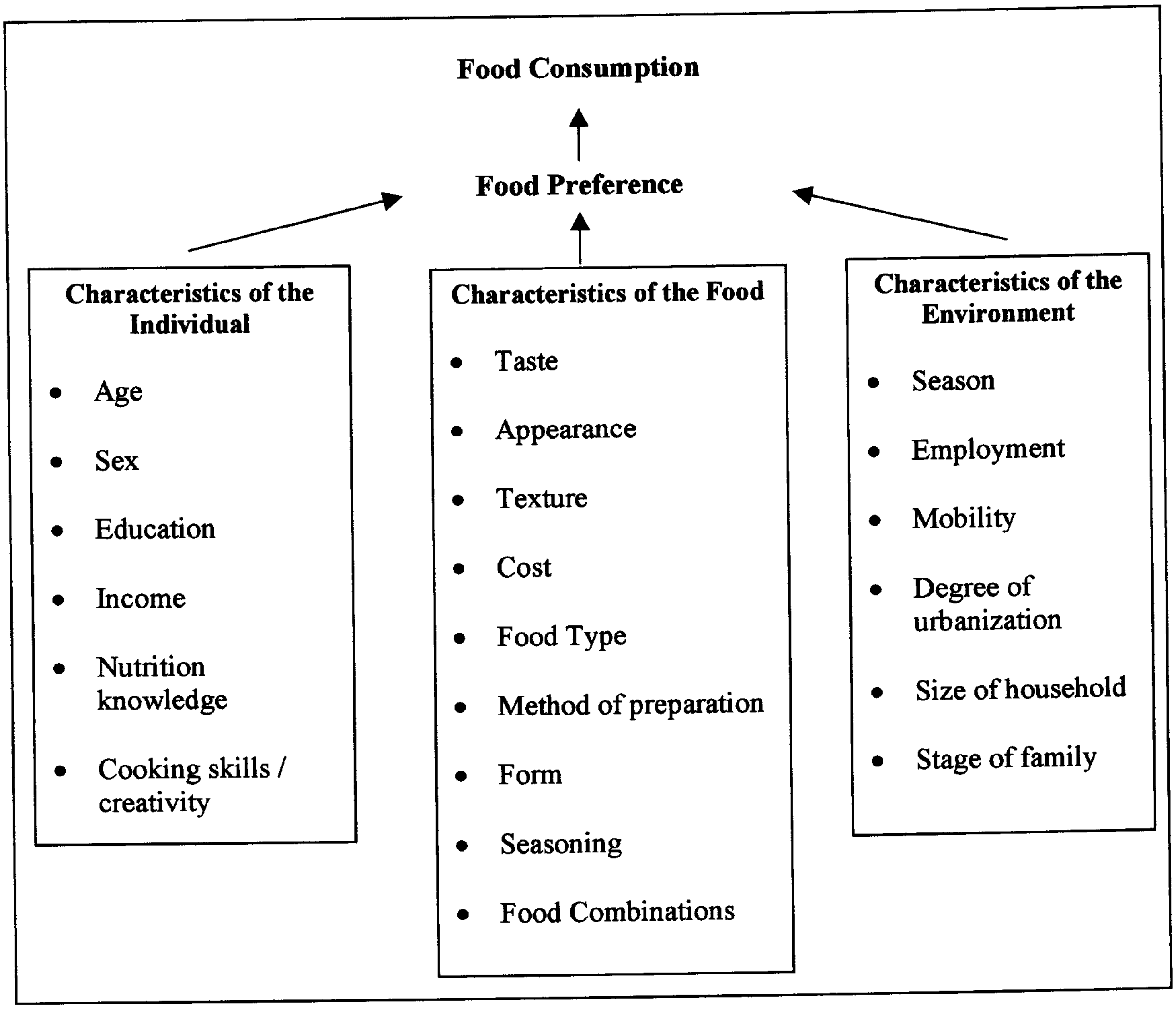


Fig. 3: Factors influencing food preferences (Randall & Sanjur, 1981)

5.2.1 Coffee as a food product

Coffee, along with petroleum and steel, is one of the world's principal commodities. In terms of volume and the number of people employed, the most important global commodity (International Coffee Organisation, 2001). "Coffee" comes from the Latin form of the genus *Coffea,* a member of the *Rubiaceae* family, which include more than 500 genera and 6000 species of tropical trees and shrubs (Coffee Science Source, 2001). During the 1996/97 season the total world coffee harvest exceeded 6,3 million tons (Fig. 4). About 75% of the coffee sold in the world is Arabica, with Robusta and other minor varieties making up the remainder.

Figure 4: Main coffee production areas in the world in terms of number of 60kg bags produced annually (m = million) (International Coffee Organisation, 2001)

The largest consumers of coffee in the world are the countries of Northern Europe. In Sweden each inhabitant drinks an equivalent of 11.04 kg of coffee each year (Table 1) (International Coffee Organisation, 2001). In South Africa approximately R2 946.1 million was privately spent, in 1999 on coffee, tea, cocoa and substitutes, which is approximately a 3.0% contribution to the total consumption expenditure on food (National Department of Agriculture, 2001).

Table 1: Per capita coffee consumption (1995) of a few selected countries (International Coffee Organisation, 2001)

Country	Consumption	Country	Consumption
Sweden	11.24kg	Belgium Luxemburg	5.73kg
Denmark	8.75kg	France	5.51kg
Finland	8.65kg	Italy	4.90kg
Austria	8.47kg	Spain	4.21kg
Switzerland	8.03kg	USA	4.02kg
Germany	7.40kg	Cyprus	3.53kg
Netherlands	6.70kg	Great Britain	2.27kg

The coffee plant originated in Ethiopia and the horn of Africa, where it even today grown wild, but is was in the country known as Yemen, formally called Arabica, where the diffusion and horticultural propagation of coffee began. Some authorities say that the cultivation of coffee began in Yemen in AD 575, but it was certainly highly developed there by the 15th century and it was from there that coffee began its great journey around the world (Sivetz & Desrosier, 1979). The name coffee is derived from an Arabic word 'qahwa', meaning "vegetable drink" (Sivetz & Desrosier, 1979).

The migration of the coffee tree led to the spread of plantations and in the 1860's coffee exchanges were set up. Coffee consumption developed and was invariably popular. However, in some countries it seemed more than a drink - how it was drunk and by whom - was of continuous appeal and mystique (International Coffee Organisation, 2001).

The growing, roasting and chemistry of coffee has been widely studied and has become more sophisticated. The first "coffee shops" were opened in Venice around the middle of the 17th century and since then coffee has confirmed its popularity as a drink enjoyed throughout the world and it's still cultivated, primarily in the tropical zones of Latin America, Asia and Africa (Sivetz & Desrosier, 1979).

5.2.2 Production of instant coffee

Coffee trees reach maturity after three to four years and bear fruit in the lines or clusters along the branches of the trees. Referred to as berry or cherry, this fruit turns red when ready to be harvested. Coffee beans are actually the seeds of these ripened cherries (Coffee Science Source, 2001). The beans are prepared for roasting by means of a dry or wet method. The dry method entails the natural drying of the beans, whilst during the wet method the beans go through a fermentation method. After these processes the selected mixture of beans are dried, hulled, polished, sorted and lastly roasted and grinded. The grinded coffee is now ready for extraction (Coffee Science Source, 2001).

Early attempts to produce a dried soluble extract of coffee were made towards the end of the nineteenth century in the USA. The product was expensive in relation to its quality and was highly hygroscopic. In 1938 Nestle produced the first "Coffee blend", a free-flowing, light coloured powder composed of 50% soluble coffee solids and 50% maltodextrin that retained a reasonably coffee like flavour when reconstituted in hot water (Smith, 1989). In 1950 General Foods introduced the first "Pure instant coffee" product made from 100% coffee solids and the first freeze-dried products in the 1960s (Sivetz & Desrosier, 1979). This was closely followed by the agglomeration of spray-dried soluble coffee, together with aromatisation, involving the adding back to the finished product of aromatic constituents recovered from earlier stages in the processing (Smith, 1989).

The essentials of instant coffee manufacturing consist of producing a coffee extracted by roasting, grinding and extracting the roasted beans, removing the water from the brew by drying the product, followed by agglomeration and packing for distribution (Fig 5).

For the consumer who enjoys coffee but wishes to avoid the intake of caffeine, processes are in place to manufacture caffeine reduced (virtually caffeine free) coffee (Sivetz & Desrosier, 1979). The original process involves wetting the green coffee beans with superheated steam and extracting them with methylene chloride. The solvent is recovered before the beans are dried to their original moisture content (Sivetz & Desrosier, 1979). Alternatively the green beans are extracted counter-currently with a saturated solution of green coffee solubles low in caffeine and the emergent liquor is treated to recover the caffeine (Smith, 1989).

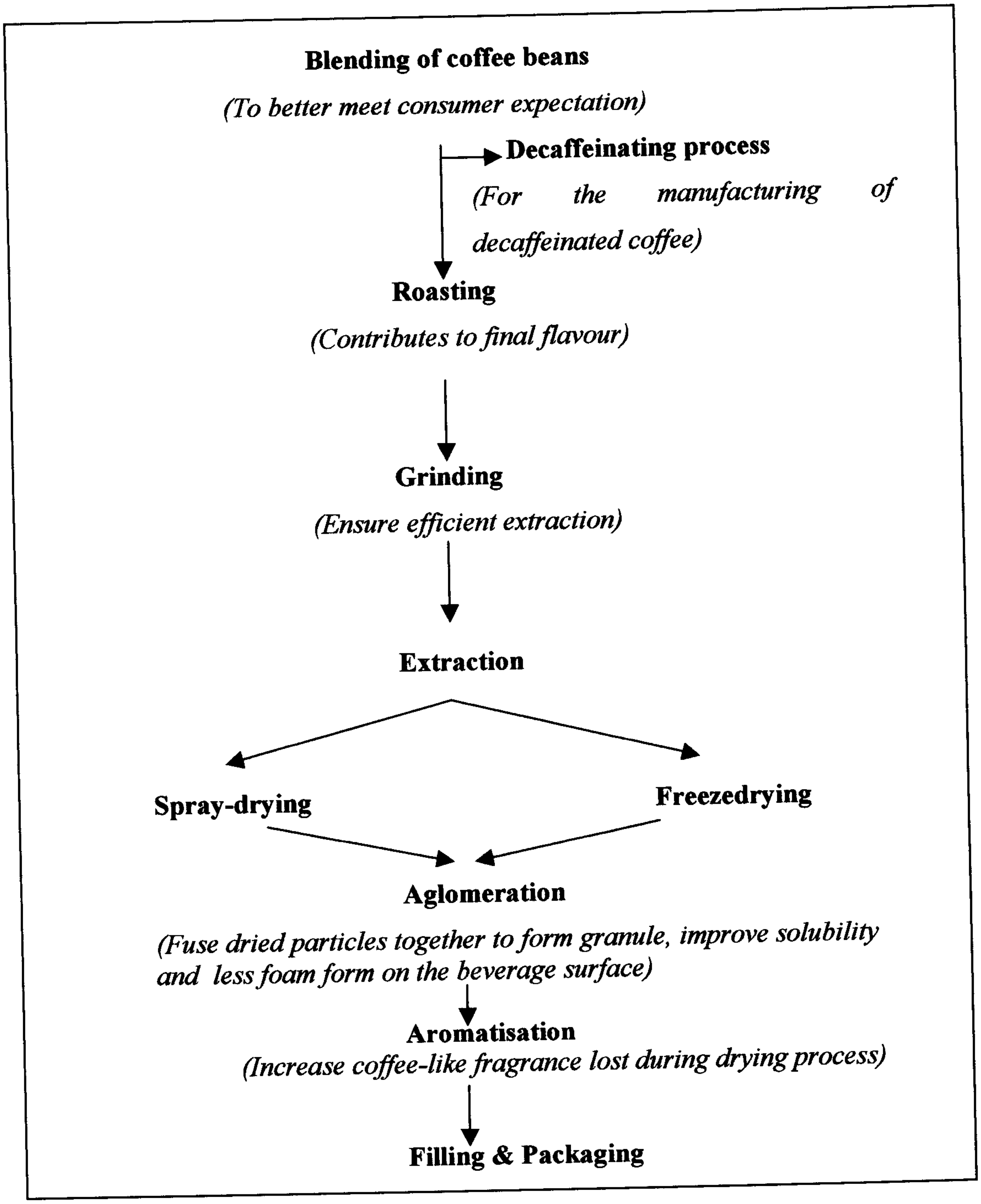


Fig 5: Schematic diagram indicating the main steps in the production of instant coffee (Smith, 1989)

5.2.3 Coffee Composition

The chemical composition of green coffee depends on numerous agronomic factors (Sivetz & Desrosier, 1979). On roasting, there are considerable changes as the more labile components are degraded and the more reactive compounds interact to form complex products. Coffee is probably one of the foods most altered during processing and it is clearly reflected in the change of the sensory characteristics (Smith, 1989). Owing to the variability of composition it is extremely difficult to quote average values, but Clifford (1975) seem to provide a reasonable resume of data available (Table 2).

Table 2: A summary of compositional data (% on wet base) for green and roasted Arabica coffee beans and instant coffee powder (Clifford, 1975)

Components		Arabica	Instant Coffee
	Green	Roasted	Powder
Minerals	3.0 - 4.2	3.5-4.5	9.0 – 10.0
Caffeine	0.9 - 1.2	1.0	4.5 – 5.1
Trigonelline	1.0 - 1.2	0.5 – 1.0	-
Lipids	12.0 – 18.0	14.5 – 20.0	1.5 – 1.6
Total chlorogenic acids	5.5 – 8.0	1.2 - 2.3	5.2 – 7.4
Aliphatic acids	1.5 – 2.0	1.0 - 1.5	-
Oligosaccharides	6.0 – 8.0	0 - 3.5	0.7 – 5.2
Total Polysaccharides	50.0 – 55.0	24.0 – 39.0	6.5
Proteins	11.0 – 13.0	13.0 – 15.0	16.0 – 21.0
Humic acids	16.0 – 17.0		15.0

5.2.4 The Coffee alternative – Chicory

The high level of consumption of coffee worldwide is mainly due to the fact that coffee is comparatively low-priced and readily obtainable (Maier, 1987). This has not always been the case. Therefore, substitutes for coffee have been prepared from many other plants, mainly from their seeds and roots, which, like coffee beans contain large amount of carbohydrates, protein and other compounds with physiological activity, rarely caffeine. In table 3 the composition of the most popular coffee substitute, chicory is indicated (Maier, 1987).

Table 3: Composition of chicory (Maier, 1987)

Component	**Roasted -%**
Moisture	4.7 – 13.3
Carbohydrates	55.7 – 68.3
Crude Fibre	5.5 – 22.0
Protein	4.4 – 8.6
Ash	2.7 – 8.5
Lipid	1.0 – 4.8

It is believed that coffee-like soups, porridges and beverages had been used before coffee became known. In 1592 Prosperus Alpinus of Padua described coffee as being similar to the infusion from chicory, which implies that chicory was used before coffee (Ukers, 1935).

Chicory is the root of *Cichorium intybus* L. var *sativum* DC, descended from wild chicory seen with its blue flowers along roadsides (Sivetz & Desrosier, 1979). The flavour of roasted chicory is weakly suggestive of coffee and have a 'spicy-peppery' taste, very bitter, depending on the degree of roast (Sivetz & Desrosier, 1979). It is now often converted into instant products, such as instant coffee with chicory or various instant coffee-substitute blends (Maier, 1987).

5.3 How food preference is influenced by consumer characteristics and the eating situation

In general, a consumer is a person or organization unit that plays a role in the consummation of a transaction with the marketer or an entity. Within South Africa, the market for consumer goods now extends to over 4,7 million consumers, which is the total number of salary and wage earners (Statistical Bureau of South Africa, 2000).

The consumer engages in mental and physical activities that result in decisions and actions to pay for, purchase and use products or services (Fig. 6) (Sheth, Mittal & Newman, 1999).

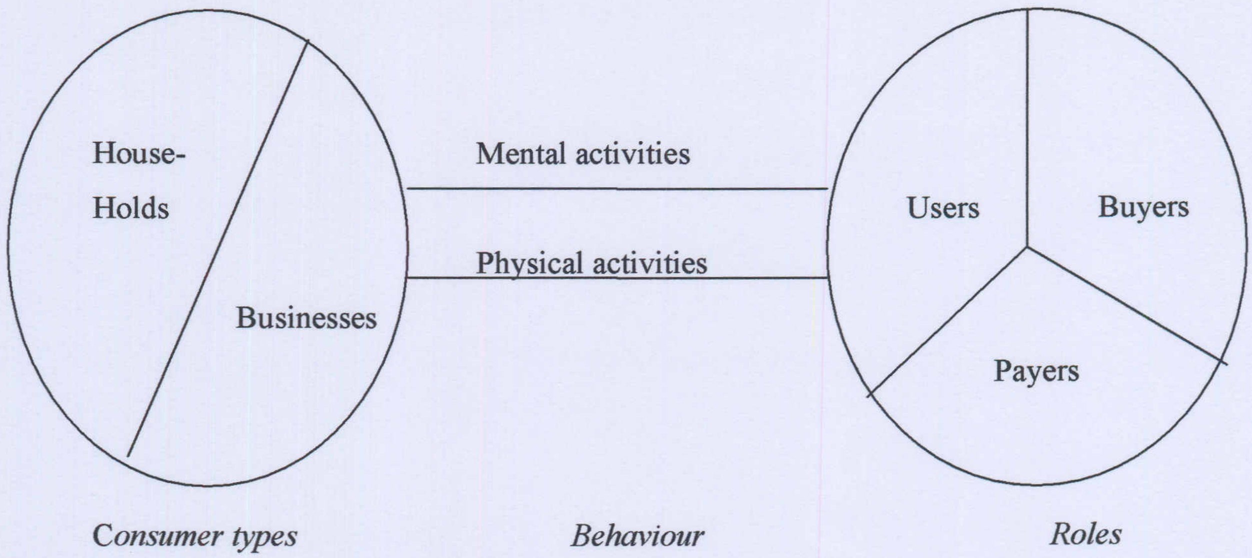


Fig. 6: Consumers can fulfill different roles through mental and physical activities (Sheth, Mittal & Newman, 1999)

The consumer market of South Africa is responsible for all private consumption expenditure and this expenditure can be subdivided into four main groups, illustrated in Fig. 7.

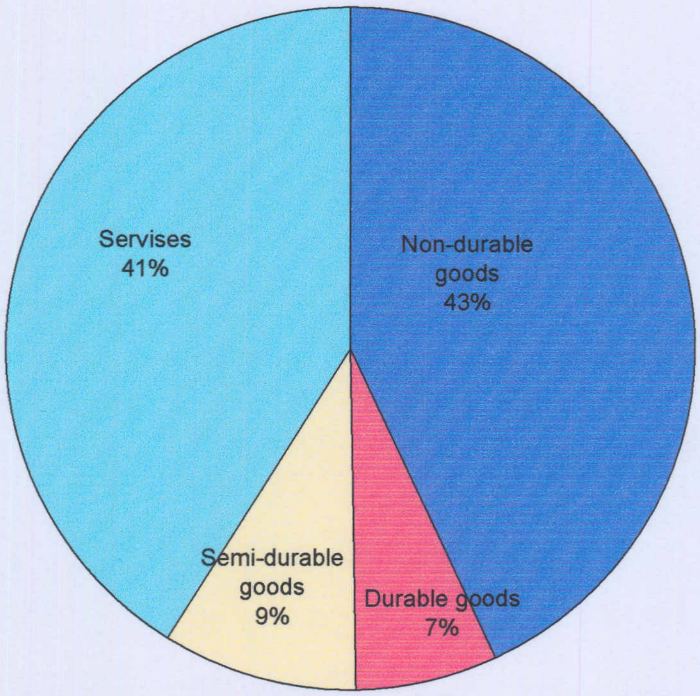


Fig. 7: Main components of consumption expenditure (South African Reserve Bank, 2001)

This indicates that non-durables, i.e. products such as food, beverages and tobacco, are the most important subgroup of products consumed. Services such as rent, medical services, transport and education, rate as high as 41% of private consumption expenditure. This is well ahead of semi-durables such as clothing and footwear, and durables that include products such as furniture and household appliances. Indications would be that consumers more often make decisions about products like food than any other products and therefore be driven by specific factors when engaging in the role of buyer, user and payer of food products on a daily basis.

The consumer is viewed by Hawkins *et al.* (1992) as a problem solver: a decision-making unit (individual, family, household or firm) that takes in information, processes that information (consciously and unconsciously) in the light of the existing situation and takes action to achieve satisfaction and enhance lifestyle (Fig. 8).

Wilkie (1994) suggests that

- Consumer behaviour is motivated
- Consumer behaviour includes many activities
- Consumer behaviour is a process
- Consumer behaviour varies in timing and complexity
- Consumer behaviour involves different roles
- Consumer behaviour is influenced by external factors
- Consumer behaviour differs for different people

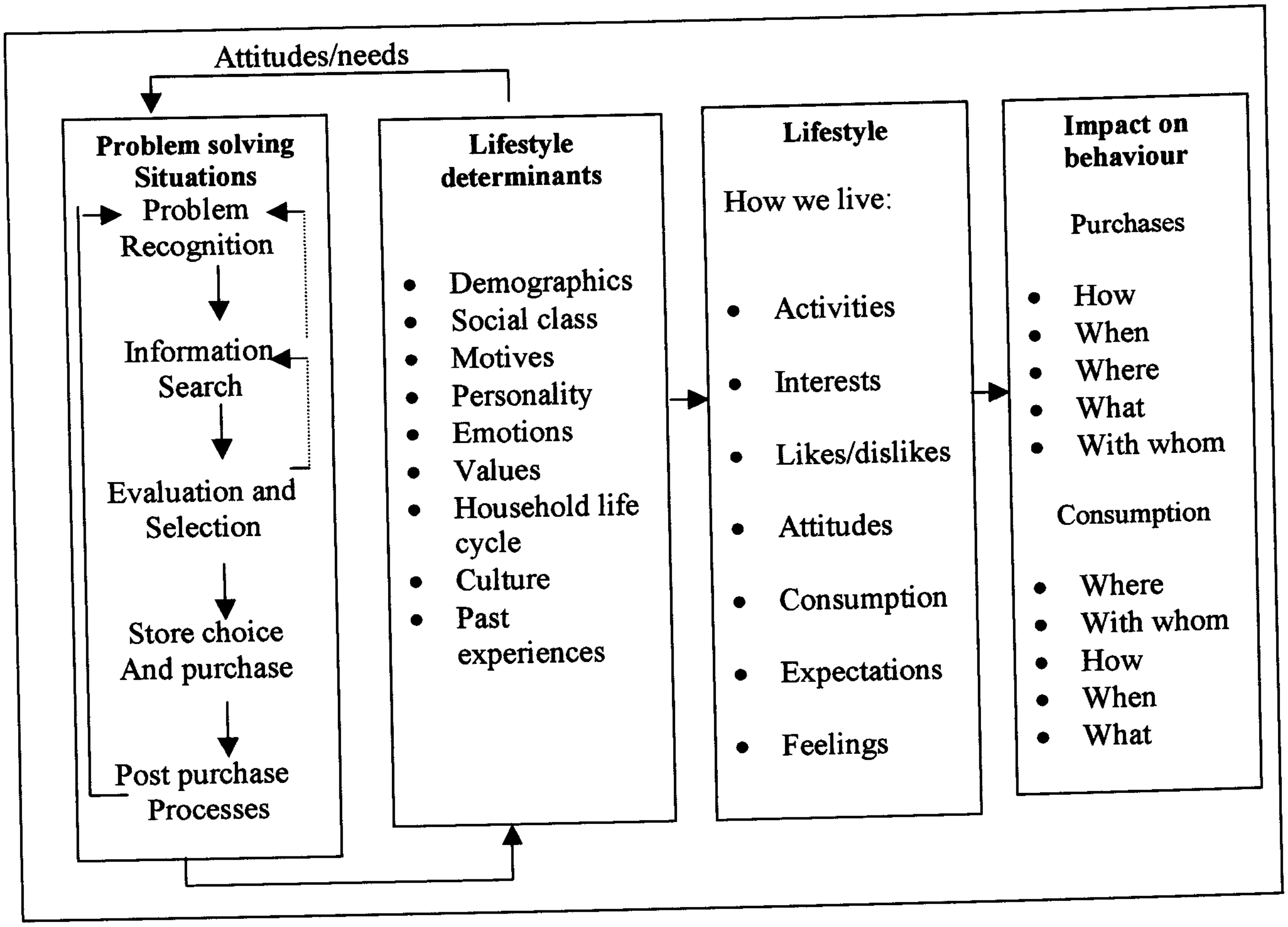


Fig. 8: Understanding how the consumer lifestyle influence consumer behaviour (Hawkins, *et al.*, 1992)

Spoeltra (1991) argued that individuals act and react on the basis of their perceptions, not on the basis of objective reality (i.e. reality as recorded by a camera), thus perceptions affect the consumers' actions, buying and leisure habits. Consumer perception and resulting reaction will be influenced by a number of dynamic and changing factors, either singly or in combination (Fig. 9). Jaeger, Wakeling & MacFie (2000) suggested that perception must rather be viewed as a process of reception followed by evaluation, which enabled them to consider preference formation as a sequence of five separate events (Table 4).

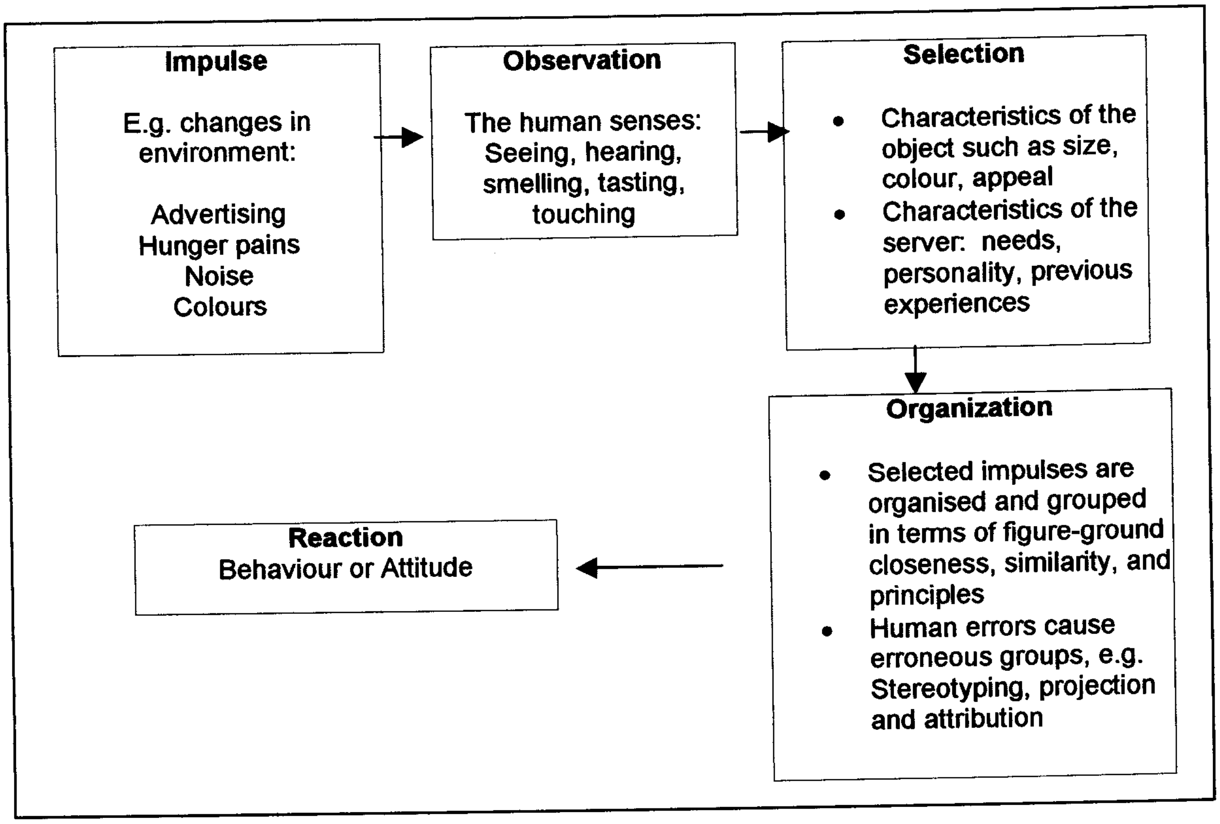


Fig. 9: Perception as a process (a model adapted from Hellriegel & Sloacum, 1979)

When a consumer tastes a product sample, his or her senses are activated through exposure to different sensory stimuli. These sensory inputs are received and identified to some degree during the stage of detection. This leads to the formation of an overall summary of the sample's sensory properties. Together these three stages (activation, detection and syntheses) comprise the overall process of perception. During evaluation the perceptual representation of samples formed during syntheses is compared with a set of distinctive rules that the consumer uses to determine how well samples are liked. Lastly, the overall product evaluation is transformed into a preference score (Jaeger *et al.*, 2000).

Table 4: Information processing model of preference formation (Jaeger, Wakeling & MacFie, 2000)

Information processing model (Engel, Blackwell & Miniard, 1998; McGuire, 1976)	Preference formation model (Jaeger *et al.*, 2000)
Exposure Achievement of proximity to a stimulus such that an opportunity exists for the senses to be activated	**Activation** Activation of sensory senses by exposure to stimulus
Attention Allocation of processing capacity to the incoming stimulus	**Detection** Identification of single sensory characteristics
Comprehension Interpretation of the stimulus	**Synthesis** Formation of perceptual representation of product similarities and differences
Acceptance Persuasive impact of the stimulus	**Evaluation** Perceptual comparison of synthesis to internal personal reference
Retention Transfer of the stimulus interpretation and persuasion into long-term memory	**Scoring** Transformation of the evaluation to a preference score.

These "distinctive rules" consumers use to measure how much a product is liked or disliked is accumulated by the consumer over time as values, tastes, behaviours, preferences and feelings through the learning process. The extrinsic components of consumer behaviour, such as culture, family and small group membership, provide learning experiences which impact on the type of lifestyle one pursues and the products that are consumed (Pitt, 1991).

This is especially true within the boundaries of South Africa (Spoeltra, 1991). With a total population of 43,68 million the consumer market is diverse with major economic and cultural differences (Statistical Bureau of South Africa, 2001) (Table 5).

Table 5: Population patterns of South Africa (Statistical Bureau of South Africa, 2000)

Population	**Number of inhabitants**
Urban	23,12 million
Rural	20,56 million
Total	43,68 million
Culture groups	**Number of inhabitants**
White	4,52 million
Black	33,88 million
Coloured	3,80 million
Asian	1,58 million
Total	43,68 million

Hawkins *et al.* (1992) suggests that personality, lifestyle and values represent important individual influencing variables of consumer behaviour. Personal characteristics are more enduring, integrative, consistent and tend to influence the individual actions and reactions to environmental situations. Consumers' activities, interests and opinions represent lifestyle. Those factors that influence consumer lifestyle are unique to the individual and also include individual development (perception, learning and memory) and individual characteristics (motivation, personality features and emotions). Values refer to beliefs that are culturally derived and give meaning, stability and cohesion to the world of an individual.

Sheth *et al.* (1999) argues that when a person chooses a product he or she is mainly influenced by his/her needs and wants. A need is an unsatisfactory condition that leads him/her to an action that will make that condition better. A want is a desire to obtain more satisfaction than is absolutely necessary to improve an unsatisfactory condition. Thus the difference between a need and a want is that need arousal is driven by discomfort in a person's physical and psychological conditions. Wants occur when and because humans desire to take their physical and psychological condition beyond the state of minimal comfort.

A person's needs are determined by two factors: the individual himself and the person's environment. These determinants have to do with the physical characteristics of individuals and the environment, rather than the social and institutional contact that determines an individual's wants (Table 6).

Table 6: Determinants of needs and wants (Sheth, Mittal & Newman, 1999)

Determinants of needs		**Determinants of wants**	
Personal Characteristics:	**Physical Characteristics of the environment:**	**Individual Context:**	**Environmental context:**
• Genetics (chemical/ biological characteristics) • Biogenics (e.g. gender, age etc.) • Psychogenics (e.g. moods, emotions, perceptions, experiences, memory)	• Climate (e.g. temperature, altitude, rain fall etc.) • Topography (surrounding conditions) • Ecology (e.g. quality of air etc.)	• Personal growth • Institutional growth • Cultural growth	• Economy • Technology • Public Policy

Some factors that can influence the needs and wants of South African consumers include;

➢ *Age and Gender*

Age is a powerful determinant of consumer behaviour. A person's age affects his interests, taste, and purchasing ability (Wilkie, 1994). Therefore the age structure of a population has an impact on the demand for certain products. The rapid population growth that exists in South Africa means that the majority of the population is below the age of twenty-five years (Statistical Bureau of South Africa, 2000). The youth market is thus the aggressive market. However, the older market enjoys the greater spending power, and also comprises the bulk of the work force (Statistical Bureau of South Africa, 2000).

- *Income*

While population plays a major role in both the overall and localised demand for products and services, income plays an equally important role for many products and services. In South Africa 51.47% of the population is economically active of these 76.65% are active workers and 23.35% currently unemployed (Statistical Bureau of South Africa, 2000). Changes in disposable income i.e. income after taxes, can be directly linked to changes in market demand. In South Africa incomes pose a contrast. At the upper end of the scale, a quarter of the employed were earning more than R2,500 per month at the time of the last census (1996), while at the lower end a quarter were earning R500 or less per month. Both gender and population groups have a strong effect. One third of white women versus two thirds of white men earn more than R3,500 per month, but only one in twenty black female or male earners fall into this category (Statistical Bureau of South Africa, 2000).

- *Occupation – Education*

Because occupation influences the clothes people wear, the cars they drive and the food they eat, it's an important factor in the structure of a market (Hawkins *et al.*, 1992). However the level of education as such influences the types of occupations people fill. At present 90,55% of the population aged seven years and older is attending an educational institution, which includes schools, universities, technikons and colleges. Approximately 13% of the population (20 years and older) is trained in skills that can be useful for work (Statistical Bureau of South Africa, 2000).

The psychological and physiological aspects of the consumer is important determinants of food preference but in recent years for product development and food service practises there has been increased attention given to the eating environment/context (Meiselman, 1996) or more simplistically seen as the appropriateness of food in a certain situation (Schutz, 1988). Most apparent is the interaction among meal items. Variety is a key factor in food context. Culinary contexts are one means of achieving variety and have become a growth area for product development (Cardello *et al.*, 1985).

There has been little attempt to organise contextual variables affecting food acceptance and choice. As Rozin and Tuorila (1993) stated: "The context will be taken to mean, that set of events and experiences that are not part of the reference event but have some relationship to it." In other words the reference events include the sensory, physiological and behavioural responses to the reference food, while the context will include those factors which surround the reference event and influence it. Thus three potential organising principles for contextual variables were identified.

Also the physical and social situation has an influence on eating patterns. The individual eater can be considered as part of the eating context and his own preference influenced by other contextual factors, dictates eating habits (Meiselman, 1996). South Africa has such a diverse population in terms of culture, each cultural group has its own lifestyle and way of enjoying food, which is remarkably different to any other, thereby offering interesting challenges to the South African food industry (Spoeltra, 1991).

5.4 Measuring the sensory characteristics of food

5.4.1 Sensory stimuli

The physical, chemical and thermal energies intrinsic to food are transduced into neuro-chemical and neuro-electric events in the peripheral nervous system via receptor organs for each sensory system (vision, kinesthesis, olfaction, etc.). A psychophysical transformation occurs, which gives rise to the basic sensory dimensions of quality (salty, cold, red, etc.), magnitude (intensity, weak strong), and duration (Cardello, 1996).

5.4.2 Why sensory evaluation?

Sensory science is increasingly seen as providing the tools to aid companies to understand those product characteristics, which are important in determining consumer likes and dislikes (McEwan, 1996a). A combination of sensory analysis with trained panels and market research with consumers is recognised by many as a valuable step in product optimisation, to ensure that product development is targeted and focussed (Elmore *et al.*, 1999).

Sensory evaluation has been defined as "a scientific discipline used to evoke, measure, analyse and interpret reactions to those characteristics of foods and materials, as they are perceived by the senses of sight, smell, taste, touch and hearing" (Institute of Food Technologists, 1981). There are many reasons for using sensory evaluation i.e. new product development, product improvement, process change, cost reduction and/or selection of a new source of supply, quality control, product grading or rating, storage stability, consumer acceptance and/or opinions, consumer preference, panellist election and training, correlation of sensory with chemical and physical measurements (Institute of Food Technologists, 1981).

5.4.3 Experimental design

Good experimental design is extremely important in all areas of science, especially where treatment effects are small relative to uncontrolled variation, as in sensory studies (Hunter, 1996). It is generally accepted that a well-designed study that is analysed using simple methods will yield more information than a hastily designed study analysed using sophisticated methods (Resurreccion, 1998). Careful design of sensory experiments is essential in order to derive the maximum amount of useful information from the work of the sensory assessors and the technicians who run the experiments (Meilgaard, Civille & Carr, 1999). Organising a program of sensory research, defining the objectives of each individual experiment and running the experiments efficiently requires an appreciation of many disciplines in addition to the statistical design and analysis of experiments (Hunter, 1996).

The selection of relevant variables and layout of levels by experimental design will ensure that variables are statistically independent of each other (Resurreccion, 1998). Statistical independence enables the investigator to measure what independent variable separately contributes to the consumer response, and add together the accumulated effect of these independent variables (Hunter,1996).

Questionnaires link consumers and researchers (Hunter 1996). The questionnaire requires the panellists to assess the product on a variety of characteristics. If the questionnaire contains the proper attributes with a sufficiently sensitive scale, then the experiment produces usable data. If the wrong questions are asked and attributes are missed, then the results will be worthless no matter how well the study is designed – statistically and executed in the field (Resurreccion, 1998). Questionnaires may require the panellists to rate a product on a full array of attributes. The attributes may include sensory ratings, liking ratings, image ratings (e.g. 'natural', refreshing', 'youthful') and directional indications to figure out what's wrong with the product (Lawless & Heymann, 1999).

Tests can be conducted at a central location or at a home (Lawless & Heymann, 1999). In central locations the samples are prepared under controlled conditions, and test conducted under careful supervision (Meilgaard *et al.*, 1999). In a home-use test the assessors rates the product after (preparing and) consuming of the product at home. Home-use tests provide a more natural environment for product evaluation and usually the assessors evaluate only one product or a few over an extended timeframe (Resurreccion, 1998).

Analysis of data would be determined by what the objectives were, set at the start of the project, thus what information the researcher wanted to gain out of the study (Hunter, 1996). There are numerous statistical programs that can be used to analyse the data, but will only do what the researcher programmes it to perform.

5.4.4 Sensory evaluation measurement

The basic sensory dimensions of quality, magnitude and duration are commonly measured using standardised sensory and psychophysical methods. In the case of sensory quality the terminology used by untrained individuals to describe their sensations is often poor and varies considerably. In order to overcome this problem in defining sensory properties of food, descriptive techniques are used to standardise terminology.

Descriptive analysis is the sensory method by which the attributes of a food material or product are identified, described and quantified using human subjects who have been specifically trained for this purpose (Einstein, 1991). Proper use of the descriptive analysis method requires that the panel be carefully selected, trained and maintained under the supervision of sensory analysts (Powers, 1988). Panel selection, including preliminary screening, is the first step in descriptive analysis (Meilgaard *et al.*, 1999). Training however, is the key to successful employment of descriptive analyses. Training may actually begin during the screening process (Meilgaard *et al.*, 1999).

However, formal training usually begins with the orientation program. During this phase panellists gain knowledge of the senses and the basics for using human subjects as instruments (Meilgaard *et al.*, 1999). The panellists learn to identify all the perceptible attributes and record them in the order that they occur. Samples that vary in attribute strength are also given to the panel to provide an opportunity to measure intensity and to apply this measurement to the same type of scale (Lawless & Heymann, 1999). The key aspect of this phase of the training is that the panellists are expected to identify all the sensory attributes and to come up with descriptive terms for each attribute (Meilgaard *et al.*, 1999). Subsequent panel discussion under the watchful eye of the panel leader results in the elimination of duplicate terms and the final list of attributes to be placed on the sample ballot (Lawless & Heymann, 1999). Once this has been accomplished, including a written definition for each term, references are provided and attached to various portions of each attribute scale. Panellist performances are checked through a series of samples that include coded references and replicates. These results are revealed to the panellist for self – examination (Williams & Longron, 1984).

In addition to being able to describe the quality of a sensation, one must be able to quantify these sensations and at least be able to state whether or not a sensory quality is evident in food (Lawless & Heymann, 1999). The traditional approach to this has been to use threshold methods, by which either the simple occurrence of a sensation or the occurrence of a sensation of a specific sensory quality is determined through statistical estimation of the minimal stimulus energy required to elicit the sensation (Cardello, 1996). More recently, methods based on signal detection theory have also been successfully applied to the determination of human sensitivity to food related attributes. The method enables separation of purely sensory effects from those that may be due to contextual biases of the subject (Irwin, Stillman, Hautus, Huddleston, 1993).

The duration of a sensation is especially important to food acceptance for example the sweetness of fine chocolate. It can be measured using time intensity relationships. The order in which different sensations are perceived can also be a critical factor in more complex foods and beverages such as wine (Cardello, 1996).

Most sensory stimuli, but especially food, elicit a hedonic dimension in addition to the basic dimensions of quality, magnitude and duration. The term hedonic means 'having to do with pleasure' and derives its meaning from the philosophy of hedonism, which holds that pleasure is the ultimate good and the driving force of all human behaviour. The hedonic dimension inherent in food lies at the heart of 'food acceptance' because food acceptance is a hypothetical construct inferred from verbal and non-verbal behaviours that reflects pleasure (or displeasure) aroused by food (Meilgaard *et al.*, 1999). Pleasure and displeasure are affective experiences (emotional responses) whose somatic effects are accompanied by a cognitive experience of the emotion. If one considers the cognitive experience that accompanies the hedonic response to a stimulus, it is clear that it behaves in much the same manner as classical sensory and perceptual dimensions. Affective responses adapt over time and recover following deprivation. The similarities between sensory and affective dimensions have led to the use of similar methods and approaches for these measurements (Cardello, 1996).

For the measurement of hedonic quality, the 9-point hedonic score (Pilgrim, 1957) has become an international mainstay in the field (Lawless & Heymann, 1999). However, the full range of scalar techniques used to measure sensory intensity is also used to quantify the liking / disliking experience. This includes not only traditional univariant measures, but also a wide variety of multivariate measurement techniques as well (Cardello, 1996).

5.4.5 Preference Mapping As Measurement Tool

When measuring preference with consumers the assessment of products traditionally takes the form of a paired preference test, preference ranking or hedonic scaling usually on two, but sometimes three or more products (Stone & Sidel, 1993, McEwan, 1996a). These tests are generally easy to conduct; easy to analyse and are generally thought to give a good measure of relative acceptance or product preference (Amerine, Pangborn & Roessler, 1965). However, these types of research suffer from several disadvantages. Most importantly it can be very limited in providing clear diagnostic information about why a product performs the way that it does (Greenhoff & MacFie, 1994). The reason for this is as follows: -

(1) Consumers have a very limited vocabulary when it comes to describing their perceptions of products;
(2) They often use attribute scales incorrectly and are subject to various biases when completing questionnaires;
(3) Interpretation of paired test data can be more complicated than initially thought.

Consumer research traditionally carried out to obtain information about consumer preferences involves the averaging of scores over consumers for each of a number of test products (univariate analysis). Pangborn (1981) observed that the average response often conceals important information about the interaction of the product with the consumers. Multidimensional preference mapping is a class of alternative methods that overcome these disadvantages (McEwan, 1996a). The basic data is collected, by requiring consumers to assess a large number of products (six or more) hedonically (scaled acceptance, rank preference, or alternatively suitability for purpose, appropriateness to context etc.). Then, unlike conventional analysis, individual subject differences are not averaged, but are built into the model and play on integral role in the fitting algorithm (Greenhoff & Macfie, 1994). However, there are three distinct ways of dealing with this data, known as internal, external and extended internal analysis, which treat the consumer preference data in different ways (McEwan *et al.*, 1998).

❖ *Internal preference mapping (MDPREF)*

With internal analysis the objective is to achieve a multidimensional representation of stimuli based solely on the acceptance or preference data. The dimensions represent diffences among the products and a set of directions, one for each consumer, which show the individual's direction of increasing preference (MacFie *et al.*, 1988). Internal analysis assumes that sensory perception is equal over all consumers and that differences in the rating of the products is due to varying preference and not a difference in perception, but it is possible to relate product information to internal preference map as with the extended preference mapping procedure (McEwan, 1996b).

❖ *External preference mapping (PREFMAP)*

The aim is to relate product acceptability to a dimensional representation of stimuli derived by other means (that is from sensory or instrumental data) (McEwan *et al.*, 1998). The multivariate space onto which the preference scores are fitted is usually derived from Principal Component Analysis (PCA) of the external information. Principal Component analysis and cluster analysis are definied by Resurreccion (1988); "*as forms of multivariate statistical analysis useful for studying the correlation in a set of measurements of a given* *number of variables for a determined number of assessors"*. The preference data obtained from each consumer is related (regressed) to the product coordinates obtained from the external data (Greenhoff & Macfie, 1994). The maximum point of a surface may be interpreted as a point of ideal acceptance and indicates the position of the ideal product for that particular individual.

PREFMAP has four phases of analysis which relate to the four preference-properties models McEwan, 1996b):

Phase 4:	The vector model phase assumes increasing preference in one direction throughout the phase.
Phase 3:	The circular ideal point model phase assumes an optimum combination of the properties of the product (some products have too much of a characteristic and some products too little).
Phase 2:	The elliptical ideal point model assumes customers are weighting the dimensions of the space differently.
Phase 1:	The elliptical ideal point model with rotation is as for phase 3 but allowing rotation of the reference axes of the space.

The simplest regression model is a linear or vector model. This implies a direct relationship between one or more characteristics, which are increasing or decreasing across the stimulus space. A more complex model is the elliptical or ideal point model. This type of model infers that some stimuli will have too much of a particular characteristic, whilst others will have to little, so that there will exist at some point within the stimulus space on ideal strength of that characteristic which will equate with an ideal point. According to McEwan (1996b), Carrol (1972) suggested several variants on the ideal point, which make up the four phases of analyses. But all the ideal point models postulate that there is some optimum combination of the external measurements, which represents the ideal point for a particular product. The ideal point model is in direct contrast to the vector model, which assumes a single direction of increasing acceptance / preference throughout the space, but with no accurate measure of the optimum value required for the external characteristics. In practice the data for all subjects is regressed onto the external co-ordinates for the stimuli using all four PREFMAP models. The variance explained by each model is analysed to identify subjects showing a satisfactory fit on particular models.

When only one of the four models is employed there are often a large number of consumers who are not explained by the resultant preference maps. According to McEwan, 1996a, Schlich (1995) developed an AUTOFIT model, which selects the most acceptable model for each consumer separately. The AUTOFIT model will fit some consumers onto the vector model, some to the circular model and others onto the elliptical- and elliptical with rotation model. These AUTOFIT procedures unfortunately still result in 30-50% of the consumers not being explained in the analysis (McEwan *et al.*, 1998).

❖ *Extended Internal Preference Mapping*

Extended internal preference mapping is essentially internal preference mapping with sensory attributes from the trained panel correlated onto the preference space (McEwan *et al.*, 1998). The advantages and limitations of internal and external preference mapping are summarised in Table 7.

❖ *Some examples of preference mapping applications*

(1) Perculated Coffee study (McEwan, 1996a & McEwan, 1998)

Sixteen samples of high-quality roasted ground coffee were selected to represent the range of coffees typically consumed in Europe. Advice on sample selection was provided by the International Coffee Organisation, which also carried out coffee bean roasting and sample preparation under controlled conditions. Samples were served at a temperature of between 50 and 60°C. The descriptive panels of eight different countries took part and each panel comprised of 10-12 judges. Evaluations was carried out in sessions of four samples per session and three replicate judgments were made on each sample by each judge. Principal Component Analysis (PCA) was used to summerise the key information in the descriptive data. Eight representative coffees were selected for the consumer trials. The data from all 605 consumers were analysed by Cluster Analysis. PCA was performed on the mean sample scores, where the eight clusters represented one group of consumers. The sensory attributes were projected onto the consumers' preference map, which made it possible to identify the direction of common preference and which attributes were the driving force behind preference.

Table 7: Advantages and limitations of external and internal preference mapping (McEwan, 1996b)

Advantages of external preference mapping	Limitations of external preference mapping
Offers a 'relatively' straightforward procedure for relating sensory and consumer information for product optimisation. Specifically where a preference mapping program has been purchased.	A fairly large number of samples (e.g. 12 – 20) are often required to ensure that the preference mapping can be undertaken successfully.
Helps identify new markets	At present, every consumer must evaluate all the samples put forward to the consumer trial. This can be expensive.
Provides direction for future product development	Can be complex to program the procedure, if the user has not bought a ready written preference-mapping program.
Provides information on market segmentation, with regard to sensory preferences. Can identify the need to make alternative types of product for different market segments.	Preference data is not always directly related to the sensory profile map, as the way trained panels perceive products is different from consumers. However, note that lower dimensions of the profile map often relate better to preference than the commonly used first two dimensions.
Using market samples, the technique can be a first step in looking at products currently available to the consumer, before developing specific formulations for a more detailed study.	Tends to be used for understanding and direction, not prediction.
	Not all consumers well represented by the models.
Easier to use and understand than external preference mapping, as similar to principal component analysis.	The program tends to break down after two dimensions in terms of information.
Allow actual preference dimensions to be determined, as only acceptability data is used.	Percentage variance explained by the dimensions is often very low.
Can be used as a screening procedure without sensory profiling, to develop samples worthy of sensory and consumer work.	

(2) Cheese (McEwan, Moore & Colwill, 1989)

Seven varieties of Cheddar cheese were tested using free-choice and Quantitative Descriptive Analysis. The odour, flavour and texture characteristics were evaluated. Generalized Procrustes Analysis was applied to analyse the data. The strength of odour and flavour as well as rubbery and grainy texture were some of the important attributes separating the cheeses in a two dimensional perceptual space. Preference scoring was obtained from consumers using a nine point hedonic scale and the data related to the profile space using Preference Mapping.

(3) Fresh Tomatoes (Wolters & Gemert, 1990)

Through Quantitative Descriptive Analysis (QDA) the trained panel developed their own common "tomato language", based on experience in judging all types of tomatoes. Twenty-three tomato types were described using 56 descriptive terms. Sixty consumers indicated their preference concerning appearance, slice ability, odour, flavour, mouth feel and overall liking. External preference mapping was used to relate descriptive panel data to the individual preferences of consumers.

(4) Powdered chocolate milk (Hough & Sanchez, 1997)

Nine powdered milk formulations, with different gum and cocoa content, measured instrumentally, were evaluated for consumer appeal. Twelve assessors, trained in descriptive analysis, through round table discussions, developed first appearance, texture and flavour descriptors. Data from the panel were analysed using Generalized Procrustes Analysis. Consumer preference were studied using 60 consumers indicating their liking on a nine-point hedonic scale. For external preference mapping the acceptance data for each evaluator were regressed against the scores obtained by Principal Component Analysis gathered from the descriptive analysis. Appearance and texture was explained by four principal components, whilst aroma and flavour was one dimensional and depended on cocoa concentration only. Preference mapping would allow the developer to target the product to the consumers with specific preferences.

(5) Low sugar strawberry gels (Damasio, Costell & Duran, 1999)

To optimise the acceptability of a low-sugar strawberry gel, using different levels of strawberry pulp and of mixed kappa-carrageenan-locust bean gum, preference mapping was utilised. A group of 91 consumers scored 16 formulations on an unstructured 10cm anchored line scale. Internal preference mapping was obtained using the MDPREF Program of the PC-MDS Multidimensional Statistic Package. According to the results obtained for 24% of the consumers the product's acceptability could be explained by the composition changes considered. For the rest no clear statement could be made about the influence of the compositional factors on the acceptability of the low-sugar strawberry gels.

(6) Lamb sausages (Helgesen, Solheim & Naes, 1997)

This study used preference mapping in assessing six dry fermented lamb sausages. It was found that acceptance was definitely directed by juiciness, acidic flavour and odour, greasiness and lamb flavour. Using Cluster Analysis four subgroups with different preference patterns were identified and showed there was a market for each of the six products.

Other products where preference mapping was used as evaluation method include, sweeteners (Tunaley, Thomson & McEwan, 1988), restructured steak burgers (Nute, MacFie & Greenhoff, 1988), canned meat (Jones, MacFie & Beilken, 1989), chocolate confectionery (McEwan & Thomson, 1989), southern hemisphere apples (Daillant-Spinnler, MacFie, Beyts & Hedderley, 1995), meat patties (Beilken, Eadie, Griffiths, James & Klein, 1995), frozen chicken nuggets (Arditti, 1997), ranch salad dressings (Yackinous, Wee & Guinard, 1999) and another coffee study by Heyd & Danzart (1998).

5.5 Measuring some physical and chemical properties of coffee

To understand the acceptability of a product and ensure the correct processing of a product, like coffee, it is necessary to have knowledge of the physical as well as chemical properties of the product (Cardello,1996, Sivetz & Desrosier, 1979). Coffee is a natural substance, therefore its properties are variable and it is frequently necessary to state ranges for properties rather than exact figures for constituent concentrations. Quality control tests are closely associated with coffee properties and include laboratory methods for example: density, colour, particle size distribution, solubility, moisture content, chemical composition, coffee volatiles composition and many others tests.

5.5.1 Density

Bulk density of coffee is an important property that is continually monitored and controlled in the spray drying of the extract. It is usually measured by placing 100g of powder into a 1000ml accurately indexed Pyrex graduate. The graduate is then placed on a vibrator table or tamping mechanism to yield the settled powder volume in 15s. If the settled powder volume is 500ml, the bulk density is 0.2g/ml (Sivetz & Desrosier, 1979). Powder bulk densities are invariably the result of the coffee properties. High powder bulk densities characterise a powder with poor fluidity because of fines. Low bulk densities with discrete beady particles usually have good fluidity. Agglomerated particles give lower powder bulk densities and poor fluidity (Sivetz & Desrosier, 1979).

5.5.2 Particle size

As coffee particles are made finer, their physical and chemical nature changes. Coffee powder particle size is measured using a simple screening mesh method (Sivetz & Desrosier, 1979). Beady spray dried powders have 10% to 35% on a 40 mesh (350mμ) and up to 10% through a 80 mesh (180mμ). The appearance of the particles are examined by means of a microscope and chichory can be distinguished from pure coffee granules (Association of Analytical Chemists International, 1995). Utilising electron microscopy agglomeration patterns can be examined. With the use of infrared spectroscopy and chemometrics blend compositions can be identified (Briandet, Kemsley & Wilson, 1996).

5.5.3 Colour measurement of instant coffee

Ever since green coffee beans have been roasted, to give the coffee granules their distinctive brown colour, the degree of coffee flavour development in the roaster has been judged by the colour of the roasted beans. Roasted bean colour is a fair criterion of coffee flavour development. But in the case of instant coffee the powder colour is not an indication of degree of roast, but rather of the physical particle size of the spray dried powder. That means that a dark roast instant coffee may have a very light powder colour because the particles are fine. On the other hand a light roasted instant coffee may form dark, beady particles. But the consumers tend to prefer darker powders, because they resemble the familiar appearance of roasted coffee (Sivetz & Desrosier, 1979). Surface colour measurements are used to specify colours perceived by the human eye. Verbal descriptions of colour can be difficult and confusing, as different terms are used by different people to describe the same colour.

The manner in which colour is perceived would depend on factors like:

(1) The sensitivity of an individual's eyes
(2) The size of the sample being looked at
(3) The type of light source, the background colour, contrast and;
(4) The angle at which the sample is viewed.

Quantifying colour simplifies colour communication and standardization. Visual colour were measured in the past using a light reflectance probe and meter, but colorimeters (colour difference meter or chromameters) have been developed and utilised (Sivetz & Desrosier, 1979). Several chromameters are available such as the Gardner colorimeter models, the Hunter colorimeter and the Minolta chromameter (Wall & Bosland, 1998).

The International Commission on Illumination (CIE for Commission Internationale de l'Eclairage) established a tristimulus colour system commonly used for surface colour measurements. The tristimulus values, XYZ, were based on the theory that the eye possesses receptors for three primary colours (red, green, blue) and that all other colours are perceived as mixtures of these three colours. The XYZ values were determined from colour-matching functions that corresponded to the eye's sensitivity at various wavelengths of the visible spectrum. The CIE developed the XYZ colour space from the tristimulus values. The XYZ space (a numerical expression of colour) was improved to the L*a*b* (CIELAB) system and is the most widely used system today. This system is based on a three dimensional colour space with three coordinates (L a b). In the CIELAB system, colour is represented spherically (Wall & Bosland, 1998) (Fig 10).

The elements of perceived colour are lightness, hue and chroma and they are determined from the L a b coordinates. The L coordinate measures the value or lightness of a colour and is located on the vertical axis of the CIELAB colour space. This axis is achromatic and ranges from black (0) at the bottom to white (100) at the top. The a and b values are chromaticity coordinates and indicate directions away from the centre of the colour sphere. The a coordinate denotes red when positive and green when negative and the b denotes yellow when positive and blue when negative. Hue angle and chroma can be determined from the a and b values. Hue sets the kind of colour while chroma is a measure of the colour saturation or purity (Pomeranz & Meloam, 1994). Colour saturation is measured by the equation:

$$\text{Colour Saturation} = \sqrt{(a^2+b^2)}$$

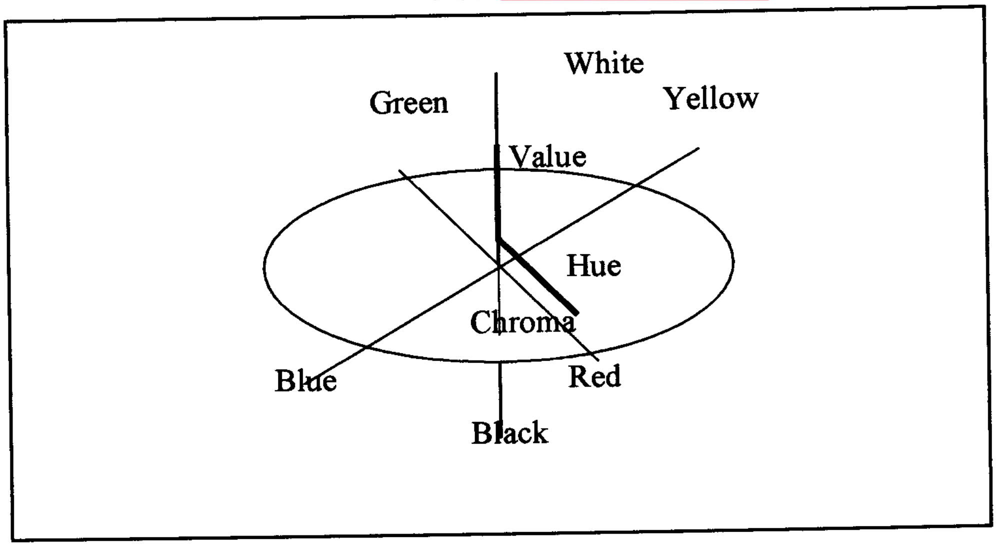


Fig.10: The visual perception of colour represented in a simple case by three variables hue, value and chroma arranged in a cylindrical coordinate system (Bernhardt, 1969)

5.5.4 Powder Solubility

When 100% coffee in the form of spray dried, beady particles was placed on the market as a "soluble coffee product", it was initially termed "soluble" because they were water soluble (slowly, not instantly) and "coffee product" because they had about 50% carbohydrates (Sivetz & Desrosier, 1979). Later the 100% beady powder was named "instant coffee" because it dissolved in boiling water in a few seconds. Instant spray dried coffees dissolves quickly at 66°C. Instant coffee that dissolves in less than 10s upon addition of boiling water is considered fast dissolving. High levels of carbohydrates and low quantities of fatty acids often cause poor solubility. Agglomerated fine particles dissolve quickly because they are fused together. The thicker walled, larger beady particles also dissolve well since they have less surface per unit weight for air absorption. Granule defects and poor coffee powder mixes may influence solubility negatively (Sivetz & Desrosier, 1979).

5.5.5 Moisture content

Water is an important component of coffee and has an influence on the coffee product's storage stability (Clarke, 1989). Instant coffee contains up to 4-5% and many methods exist to determine water content of instant coffee and include methods like the drying oven method (AOAC International, 1995), vacuum oven method and Karl Fischer method (Chassevent, 1971). Moisture content of coffee is also measured using an infrared reflectance meter (Paardekooper, Driesen & Cornelissen, 1969).

5.5.6 Electronic nose

When consuming foods, colour, texture and flavour are all important in our appreciation and expectations of a product. However, flavour is generally accepted as the most important sensory characteristic associated with food. Flavour perception consists of three components, taste, aroma and tactile mouthfeel (Jellinek, 1985) (Fig 11).

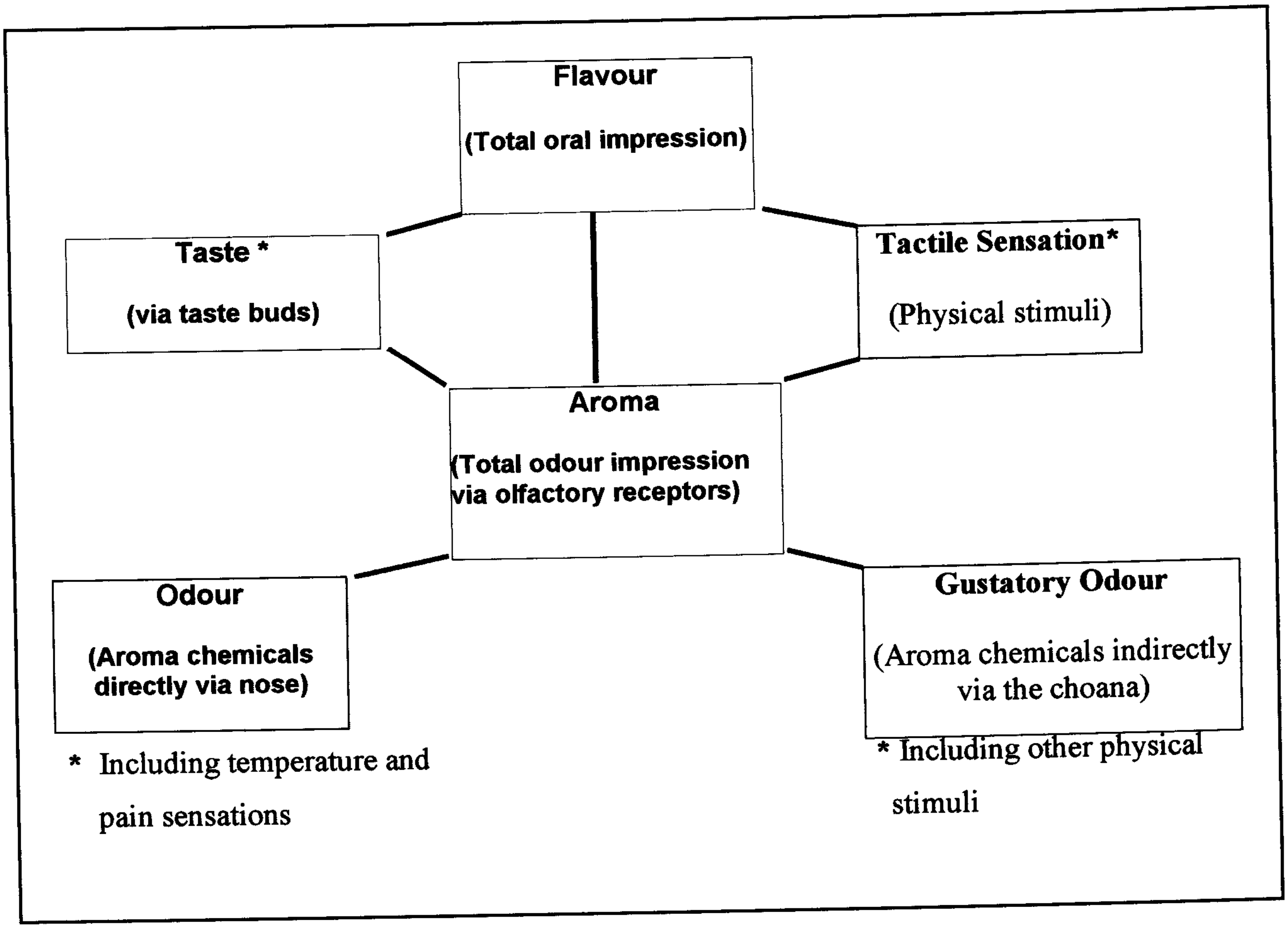


Fig. 11: Co-operation of the various factors in aroma and flavour development (Jellinek, 1985)

Taste arises from the presence of non-volatile compounds, which interact with sensors in the mouth and on the tongue and give rise to the basic tastes of sweet, sour, salty and bitter (Amerine *et al.*, 1965). Although important, it is unlikely that the flavour of a food can be defined by taste alone. What is far more important are the many hundreds of volatile compounds that are responsible for the aroma of a food product (Table 8)(Caul, 1957). It is these compounds that define the nature of a product and contribute to consumer preferences between brands of products (Amerine *et al.*, 1965).

Table 8: Comparison of the number of different compounds found in vapours of selected food products (Hodgins, 1997)

Vapour	Number of compounds
Coffee	670
Whisky	260
Tomato	>250
Tobacco	>600

It is thought that humans may have up to 10,000 individual sensors and that these may be linked to form a significantly smaller number of groups (Hodgins, 1997). The brain generates a pattern from the inputs of the sensor or sensor groups. The exact way in which the individual sensors interact with a complex vapour is not well understood, although it is accepted that each sensor does not only detect one specific compound. The electronic nose was developed to mimic the human olfactory system. Three basic building blocks namely, sensory array, conversion of sensory signal and software analysis, make up the electronic nose system (Fig 12) (Hodgins, 1997).

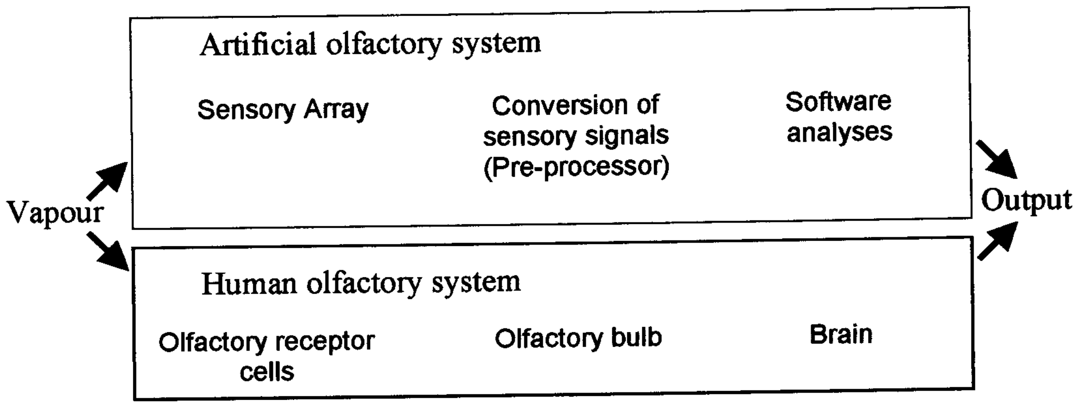


Fig. 12: System block design of the electronic nose and its similarity with the human olfactory system (Bartlett, Elliott & Gardner, 1997).

In humans, the sensory array represents the sensors in the nose. The circuitry represents the conversion of the chemical reactions on the human sensors to electrical signals into the brain. Finally the software analysis represents the brain itself (Bartlett, Elliott & Gardner, 1997). A system needs to be able to analyse a complex vapour, as it exists, without affecting it in any way. The vapour will normally exist as the headspace above a liquid or solid sample (Hodgins, 1997). Analysing a complex vapour cannot realistically be achieved by using discrete sensors as: -

(1) Many thousands of different compounds can and do exist in the headspace of a sample. We perceive coffee as having an easily distinguishable and unmistakable odour, but coffee aroma consist of hundreds of different odorous molecules: 108 furans, 79 pyrazines, 74 purroles, 70 ketones, 44 phenols, 31 hydrocarbons, 30 esters, 28 aldehydes, 28 oxazoles, 27 thiazoles, 26 thio phenes, 21 amines, 20 acids, 19 alcohols, 13 pyridines, 13 thiols / sulfides (Table 8) (Barlett, *et al.*, 1997)

(2) Individual molecules join together to form complex structures. Odourant molecules are generally small (molecular weight 20-300 Daltons) and polar and can be detected by humans at a level below 1 ppb (Barlett, *et al.*, 1997).

Thus it is important that the electronic nose must be non-selective (must respond to many different individual and complex compounds) and must respond to compounds known to be detected by humans (aromatic compounds with a sensitivity similar to that of humans) (Hodgins, 1997).

The electronic nose generally gives comparative rather than quantitative or qualitative information. It is similar to the human ability in that the exact composition of vapour is not the result, but it does not define what the complex vapour is or whether it is acceptable to the human. This information needs to be obtained from a human and therefore this system can only by complementary to the human (Hodgins, 1997).

5.5.7 Caffeine Content

Coffee, and in particular the caffeine that it contains, has been accredited with a wide range of physiological effects on the human body (Quinlan, Lane, Moore, Aspen, Rycroft & O'Brien, 2000). In man, a fatal dose of caffeine is estimated as 100 grams or about 50-100 cups of average coffee, and depends on age, weight, tolerance etc. A serving of pure instant coffee contains up to 60mg of caffeine (Borone & Roberts, 1996). Over 1 gram of caffeine or the equivalent of 5-10 cups of coffee (depending on strength and volume) can cause excessive influence on the central nervous and respiratory systems, characterized by restlessness, excitement and insomnia (International Coffee Organisation, 2001).

Caffeine (Fig 13) is odourless but has a marked bitter taste (Macrae, 1985). The methods applied to determine caffeine content have changed dramatically, but caffeine is still the single most frequently determined compound in coffee products. The original method adopted was based on the gravimetric measurements of caffeine in a chloroform extract or determination of the alkaloid nitrogen in a similar extract by the Kjeldahl procedure (Macrae, 1985). This so called macro Bailey-Andrew method was subsequently simplified to give the micro Bailey-Andrew method, which was still based on the determination of the alkaloid nitrogen. This remained the official method of analysis for years and it was not until the development of reliable spectrophotometric methods had been achieved that the situation changed (Macrae, 1985). The relatively poor specificity of the above methods prompted the development of a wide range of improved chromatographic methods, which include thin layer gas and high performance liquid chromatography (Aucamp, Hara & Apostolides, 2000). The most recently developed technique for caffeine determination is capillary electrophoresis (Sadecka & Polonsky, 2000)

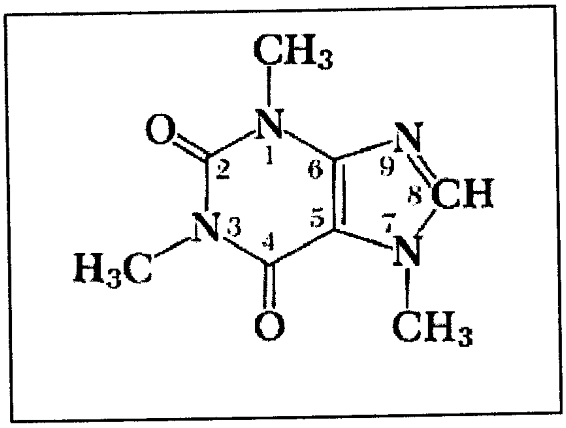


Fig. 13: Chemical structure of Caffeine (Macrae, 1985)

6. EXPERIMENTAL PROCEDURE

In order to measure the acceptability of instant coffee and instant coffee blends in South Africa, the Khan (1981) model (Fig 1) was adapted (Fig. 14) to reach the objectives of this study. Elements like aroma, colour and caffeine content (physicochemical structures) were measured and together with sensory evaluation (descriptive analysis and consumer evaluation) it was possible to obtain a product map which resulted in a visual picture of intrinsic elements that have an influence on consumers perceptions of instant coffee and instant coffee blends.

6.1 Preliminary Study

To determine the ability of consumers to distinguish between commercial instant coffee and instant coffee blends, preliminary experiments were conducted on 20 April 2000 using instant coffee blends available commercially in South African. This helped to define which samples should be included in the research as well as to clarify sample preparation and serving procedures.

Apart from this sensory experiment, training was done with regard to the electronic nose and the chromometer to gain information about the aroma profiles and colour composition of the various coffee granules, respectively.

6.2 Descriptive analysis

Descriptive analysis of 11 coffee samples (Table 9) was conducted during September 2000. Two-hour sessions were scheduled during the afternoons with a 10-minute break after the first hour to establish a vocabulary that could be used to describe the 11 South African commercially coffee products included in this study.

6.2.1 Product

Eleven of the most well known locally available commercial instant coffee brands, from three manufacturers, were evaluated during this study (Table 9 & 10). Where possible, product samples were purchased that had the same expiry date indicated on the bottom of each container.

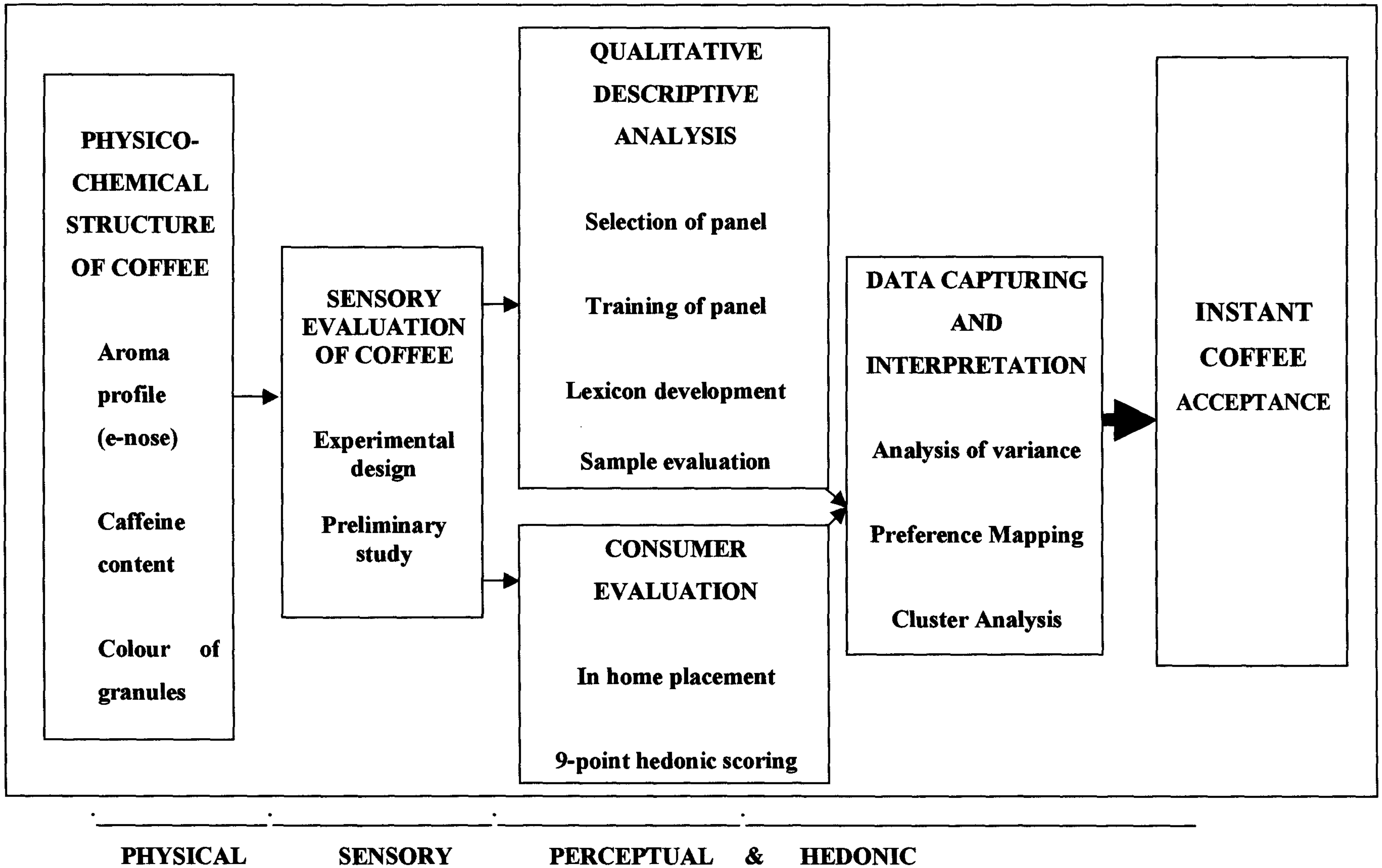


Fig. 14: Summery of the experimental design follow for this study to determine the acceptability of instant coffee and instant coffee blends

Table 9: The nature of and code names used for the eleven instant coffee samples, from three manufacturers, evaluated during the study

Coffee Samples	Company X	Company Y	Company Z
Pure coffees (PC)	PC_X	PC_Y	PC_Z
Pure coffee, decaffeinated (PCdec)	$PCdec_X$		
Coffee blends (CB)	CB_{X1}	CB_{Y1}	
	CB_{X2}	CB_{Y2}	
		CB_{Y3}	
Coffee blend, decaffeinated (CBdec)	$CBdec_X$		
Chicory Instant Drink (CID)		CID_Y	

6.2.2 Sensory Panel

Eighty six volunteers, responding to an advertisement (Appendix 1) placed in the local university newspaper were telephonically screened (Appendix 2) for suitability to participate in the sensory panel. From these, twenty five participants were selected based on their performance in "Threshold tests" as described by ASTM Committee E-18 (1991) to establish sensitivity for the four basic taste sensations, bitter, sour, sweet and salty (Appendix 3).

The final panel of 15 assessors was selected from the 25 candidates by means of further screening that consisted of three tests, which were duplicated

- Taste thresholds by a forced-choice ascending concentration series method of limits (ASTM, 1991) to establish assessors' sensitivity for specifically bitter and sour to eliminating any assessors, which were bitter blind. (Appendix 4)
- Duo-Trio tests to establish assessors' sensitivity for (a) a coffee blend versus a chicory drink, (b) Caffeinated coffee versus decaffeinated and (c) a pure coffee versus a coffee blend. (Appendix 5)

Descriptive tests, using basic aromas like chocolate, citrus and spicy on smelling strips. The assessors were asked to smell and describe the aroma or identify the substance (Appendix 6). This was used to evaluate the assessors' abilities to communicate what they were experiencing through their senses (Zamora & Calvino, 1995).

Table 10: Photographic images, brief physical description, ingredients list and expiry date information of each instant coffee sample

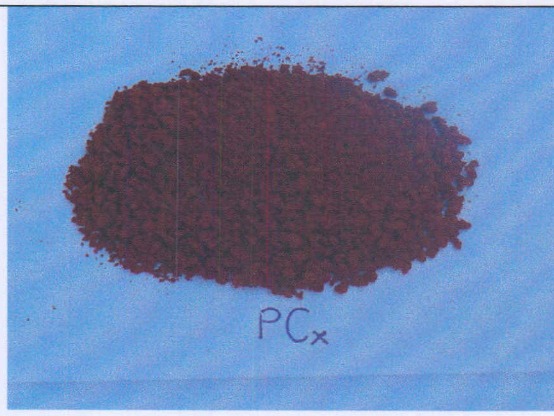
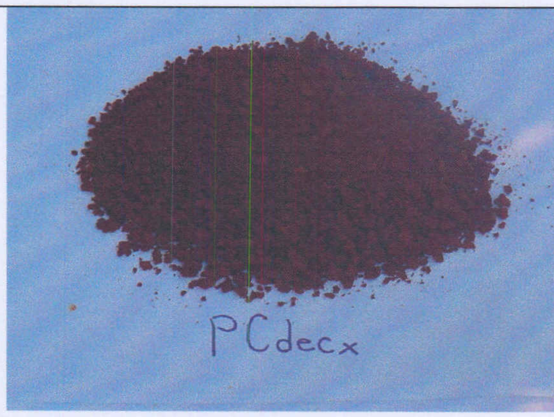
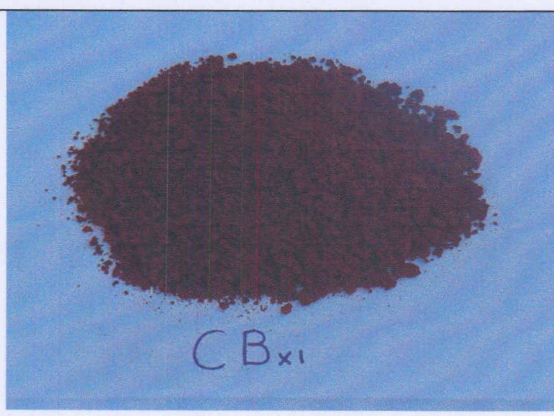
Samples	Photograph	Description	Ingredients list & Expiry date
PC_X		Light brown, asymmetric, perforated granules	Soluble solids of only pure coffee, nothing added 6/2003
$PCdec_X$		Dark brown, compact, asymmetric granules	Soluble solids of only pure decaffeinated coffee 6/2003
CB_{X1}		Medium brown, asymmetric, perforated granules	Extract of coffee and chicory – nothing else added 7/2003

Table 10: Photographic images, brief physical description, ingredients list and expiry date information of each instant coffee sample (continued)

Samples	Photograph	Description	Ingredients list & Expiry date
CB_{X2}		Yellowish brown, asymmetric, perforated granules	Soluble solids of choice fresh roasted coffee beans and chicory, dextrins, maltose and dextrose 6/2003
$CBdec_X$		Yellowish brown, asymmetric, perforated granules	Soluble solids of fresh roasted decaffeinated coffee beans and chicory (naturally caffeine free), dextrins, maltose and dextrose 6/2003

Table 10: Photographic images, brief physical description, ingredients list and expiry date information of each instant coffee sample (continued)

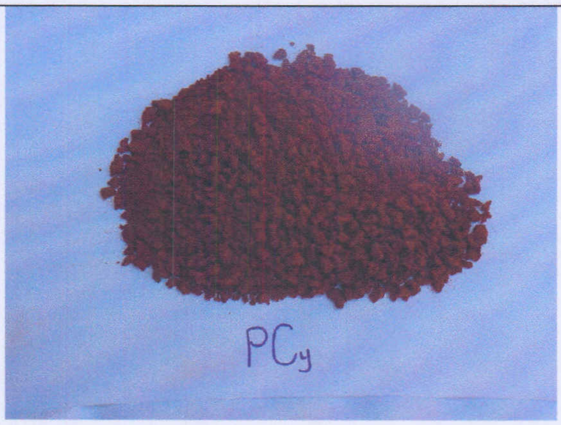
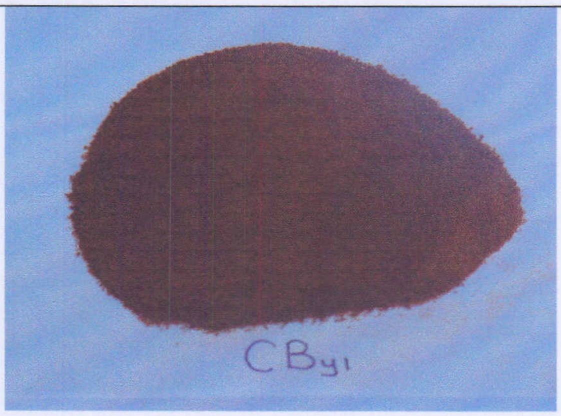
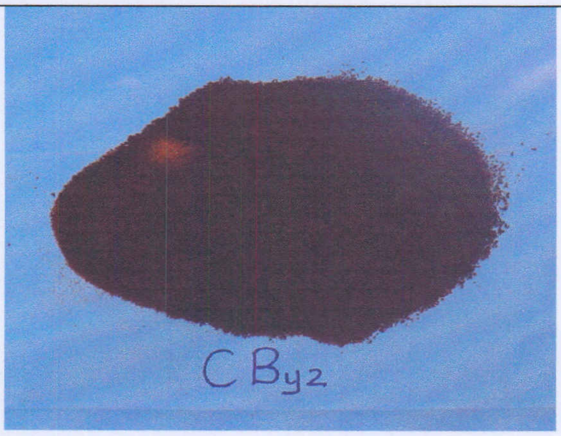
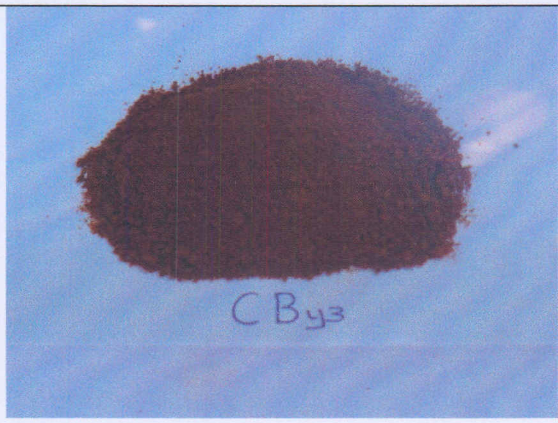
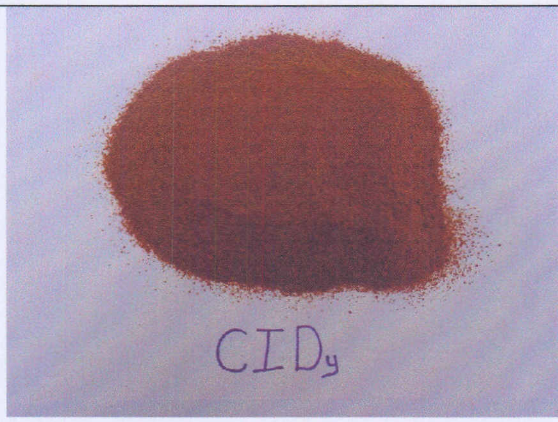
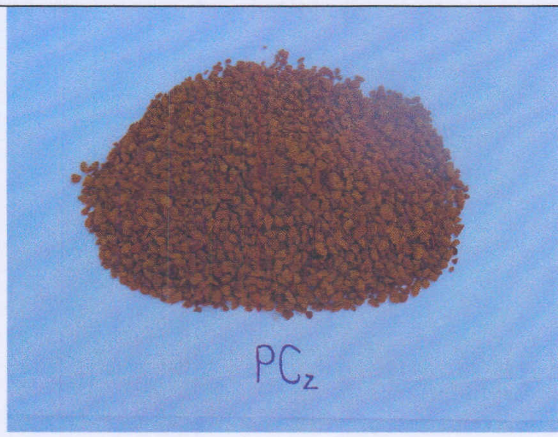
Samples	Photograph	Description	Ingredients list & Expiry date
PC_Y		Red brown, asymmetric, perforated granules	100% pure soluble coffee 5/2003
CB_{Y1}		Dark brown, fine (powder like) appearance	Extract of fresh coffee beans and chicory, dextrin, maltose and dextrose 7/2003
CB_{Y2}		Dark brown, fine (powder like) appearance	Extract of fresh coffee beans and chicory, dextrin, maltose and dextrose 7/2003

Table 10: Photographic images, brief physical description, ingredients list and expiry date information of each instant coffee sample (continued)

CB_{Y3}		Very dark brown, asymmetric, sticky granules	Coffee and chicory with dextrin, maltose and dextrose added 5/2003
CID_{Y}		Light brown, fine (powder like) appearance	Corn syrup solids, chicory and caramel 3/2003
PC_{Z}		Light brown, asymmetric, smooth surface, compact granules.	Freeze-dried soluble coffee 6/2003

The final panel of 15 assessors consisted of eight females and seven males between the ages of 17 and 27 years, five panellists were white and the remainder black. Due to circumstances only 12 panellists completed the research. Most of the participants had no experience in descriptive analysis of coffee. Training consisted of more basic taste identification, threshold tests and identification of various aromas that could possibly be associated with coffee. A list of 25 descriptors with definitions was obtained from literature (McEWAN, 1996a), but the panel developed their own vocabulary and definitions for coffee flavours and odour characteristics (Table 11, 12 & 13) using the technique of Generic Descriptive Analysis (Einstein, 1990).

Table 11: Descriptors used to characterise coffee samples

Appearance and aroma of dry coffee granules	Appearance (in cup)	Aromas	Flavours	Mouthfeel
Fishy aroma	Solubility	Roasted	Bitter	Body
Symmetry	(Floating	Sweet	Roasted	Astringency
Coarseness	particles)	Acidic	Acidic	
Density	Cloudiness	Malty	Sweetness	
Colour		Fenugreek	Malty	
		Spicy	Nutty	
		Earthy	Earthy	
		Root		
		Leather/animal smell		
		Nutty		
		Toasted cereal		
		Chocolate		
		Mushroom		

Table 12: Definitions of terms used by panel to describe the appearance and aroma of instant coffee samples

Appearance of the dry coffee powder:	
Colour	Intensity of brown colour of coffee samples evaluated under white light conditions.
Coarseness	Coffee granules are coarse when there are relatively large particles, with a rough in texture.
Simmetry	It is when two halves of a particle mirrors each other or the ability to divide a particle into two halves, which are exactly the same but the opposite way around.
Density	Particles that are packed close together and appear smooth are defined as dense, whilst less dense particles look perforated (small but visible wholes on the surface).
Aromas	
Animal – like/Leather	This odour descriptor is reminiscent of the smell of animals. It has the characteristic odour of wet fur, leather or hides. It is not necessarily negative, but is generally used to describe strong notes.
Chocolate – like	This aroma is evocative of the aroma and flavour of cocoa powder and chocolate (including dark and milk chocolate). It is sometimes referred to as sweet.
Fishy (dry granules)	This aroma is evocative of the aroma of tinned fish (e.g. tuna).
Malty	This aroma is characteristic of the odour and flavour of raw cereals and malt extract.
Toasted cereal	Is very similar to "malty", but has more the scent of roasted grain, freshly baked bread and freshly made toast.
Nutty	This aroma is suggestive of the odour and flavour of fresh nuts (not rancid nuts) or almonds.
Earthy	This odour is reminiscent of fresh wet soil odour or raw potato flavour. This is considered as an undesirable flavour when perceived in coffee.
Spicy	This descriptor is used to describe the odour of a spice cabinet containing notes of spices like clove and cinnamon but also sometimes notes of spices such as pepper.
Roasted	This odour is reminiscent of odours and flavours found in burnt food and burning wood smoke.
Acidic	This term is used when a strong acidic or fruity note is found. This term does not refer to a sour of fermented flavour.

Table 12: Definitions of lexicon used by panel to describe the appearance and aroma of instant coffee samples (continued)

Aromas	
Sweet	This aroma refers to the candy-like notes when sugar is heated (not necessarily caramelised).
Mushroom	This descriptor is similar to the odour of freshly picked mushroom or a freshly opened packet of raw mushrooms. It is not the same as earthy as it has more humus nuances.
Fenugreek	This descriptor was used to describe "meaty-like" notes in the coffee (it was similar to the flavour of diluted Fenugreek flavour, from Sensient flavours). This note also seems to be associated with savoury spicy notes like pepper. This is not necessarily considered as a negative attribute.
Root-like	This term is used to describe the smell reminiscent of cooked sweet potatoes.

Table 13: Definitions of terms used by the trained sensory panel to describe the taste and mouthfeel of instant coffee samples

Tastes:	
Acidic	A basic taste characterized by the solution of an organic acid. Described as sharp and pleasing as opposed to a fermented sour taste.
Bitter	A primary taste characterized by a solution of caffeine, quinine and certain alkaloids. This taste is considered desirable up to a certain level.
Sweet	This is a basic taste descriptor characterized by a solution of sucrose or fructose, which are commonly associated with sweet aromas such as chocolate-like.
Mouth feel:	
Body	This attribute describes the physical properties of a drink. Intense body would describe a strong full mouthfeel as opposed to being thin.
Astringency	This attribute is characteristic of an after-taste sensation, which is almost like a drying effect in the mouth area.

6.2.3Sample preparation

To prepare the coffee samples for evaluation by the trained panel 2g of pure coffee (PC) and 5g of the coffee blends (CB), respectively, were individually weighed (Sartorius electronic scale, PC Lab Services, Aston Manor) into 175ml white polystyrene cups and covered with plastic lids (Mono Paper and foam cups, Cape Town) 24 hours before the next training or evaluation session (Mr. N. Spitzer, National Brands, 2000 - personal communication). Boiling water from a 12 litre electrical kettle (Caterpride Urn) was provided to each panel member in insulated one-litre coffee flasks (Royal Vacuum flasks). The appearance of the samples was first evaluated in the dry form (granules) after which the water was added. Samples were left to cool to a temperature between 50°C and 60°C before tasting.

6.2.4 Lexicon development facility

Discussion sessions were carried out in facilities designed for sensory analysis at the Department of Food Science. The area is equipped with an oval discussion table and chairs; it is well ventilated and spacious to encourage discussion between panellists. The conditions for language formulation were relaxed but monitored by the mediator to ensure persistent flow of discussion and to implement standardised procedures for sample evaluation. The profiling task performed by the panellists included the following sequence: (1) appearance of coffee granules, by looking at the dry powder; (2) aroma characteristics, by sniffing the dry powder and the coffee solution and (3) flavour by sipping some coffee solution, keeping it in their mouth for a few seconds and panellists were given the option to swallow the coffee or spit it out, but had to continue with the chosen practise throughout the testing time. Panellists were requested to cleanse their palates, with water, unsalted biscuits and/or fresh apple squares, between samples and if necessary between attribute scoring.

6.2.5 Testing location

The final evaluation (Appendix 7) of the attributes by the panel was done in a sensory evaluation laboratory with partitioned booths at the Department of Food Science (University of Pretoria). This evaluation area seats 16 panellists and the individual booths eliminated any distractions and prevented communication between panel members. The area was well ventilated and white light conditions prevailed throughout the sessions. Each booth was equipped with lighting and a stainless steel washbasin. The sample trays were prepared in a preparation kitchen, adjoining the testing area.

Four samples were evaluated per session. Two sessions were planned per day and was held from 14:00 to 16:00 each afternoon. As assessors were unable to evaluate the 11 samples of coffee in a single session, a balanced incomplete block design was used where all coffees were evaluated in duplicate. The order of presentation of samples to panellists was also randomised across sessions. The panel rated all the attributes for each coffee on separate 100 mm structured scales anchored and labelled as low intensity at the left hand and high intensity at the right hand.

The multivariate statistical procedure, Principal Component Analysis (PCA) was used to summarise the key information in the data in order to explain the differences among samples.

6.3 Consumer testing

The consumer trials were conducted during the last two weeks of October 2000. This study was only conducted in the Gauteng area (Johannesburg and Pretoria). This area is 97% urbanised, the majority of people are educated and employed, increasing their buying power (Table 14) (Statistical Bureau of South Africa, 2000). The evaluations were conducted in the comfort of the homes of the respondents.

Consumers were recruited for testing in the interviewers immediate residential area. The potential consumers were selected if they indicated that they consumed at least one cup of coffee per day. First the selected consumers were asked to complete a sensory evaluation product attitude survey which was used to obtain general subject information and to assess product usage and liking. General information included name, age, gender, occupation and income (Appendix 8). Ideas for answer categories in the questionnaire were collected from work of Solheim & Lawless (1996). Consumers then indicated how much they liked or disliked each coffee sample.

Table 14: Gauteng area population overview (Statistical Bureau of South Africa, 2000)

Population	7.35 million				
Age distribution	**0-24 yrs**	**25 49 yrs**	**50-74 yrs**	**75+ yrs**	**NS***
	43.7%	42.0%	11.4%	1.46%	1.36%
Sex distribution	**Male**		**Female**		
	51.0%		49%		
Income	**Economically active**		**Economically not active**		
	62.4%		37.6%		
Education	**Attended educational institution (7yrs and older)**		**Skilled (20yrs and older)**		
	93.27%		67.0%		

* Not Specified

8.3.1 Population and sampling

The target consumer population for commercially available instant coffee was defined as "*South African citizens consuming one or more cups of commercial instant coffee per day*". Two hundred South African households were approached and supervised by ten well-informed fieldworkers in the Johannesburg and Pretoria area. They were asked to make the coffee samples as they would normally do and add milk and sugar as normal, but keep the quantities constant throughout the test period. They were asked to evaluate the acceptability of each sample using a 9-point hedonic scale (Appendix 8). The respondents assessed all eleven variants. Each respondent evaluated the samples in a randomly selected order intended to achieve a complete balance of order and position for every 11 respondents.

6.4 Measurment of some physical and chemical properties of the coffee samples

Sensory science were used for measuring consumer perceptions of coffee, but it was considered important to also select some characteristics which could be measured, using laboratory methods. The coffee samples were each evaluated for:-

Colour of the coffee granules using a chromometer

Aroma evaluation of the coffee granules using electronic nose technology; and caffeine content of brewed coffee measured by means of capillary electrophoresis.

6.4.1 Chromometer colour measurements of coffee granules

A single sample of each coffee variant (4g-5g) was wrapped in clear polyethylene plastic wrap (Glad Wrap, Multifoil Trading, Bryanston), which was cut into squares of 15 x 15cm and the wrap was folded to form a closed pocket in which the coffee was evenly spread out. A Minolta chromometer CR – 200 was used to measure the CIE L a b values of each coffee sample. The chromometer was calibrated by wrapping the calibration plate in the wrap as well. The *"target colour select"* – indicators, on the calibration plate, were selected. Reflectance was measured with the sensor, making sure that the measurements conformed to the specification on the calibration plate. The L a b colour measurement program was selected by pressing, "*colour space select*". The sensor was placed onto the coffee samples and the measurement sequence switch activated. The sensor was placed on three areas of each sample to ensure the whole sample was represented.

6.4.2 Electronic nose measurements of dry coffee granule aroma profile (Polymer Sensor Array or Aromascanner)

The same dry coffee granule samples as were evaluated by the descriptive sensory panel were used and the opened samples were stored at room temperature (25°C) in their original containers with airtight lids. One sample (60ml = 16g-19g) of each coffee variant was measured and placed in separate 100ml glass bottles. The samples were analysed in dry form, as many volatiles would have escaped the system if the coffee samples was first made up with boiling water and then had to be conditioned in the Electronic nose. The Aromascan Labstation A325 was used to analyse the samples and five consecutive headspace samples were analysed of each coffee variant.

- *Instrument details*

Instrument serial number	32 - B - 06 - 0184 - 305
Sensor type	32 x 1
Sensor temperature	35 °C
Internal pump air flow rate	150 ml/ min

- *Valve sequence*

Reference air	30 seconds
Sample	180 seconds
Wash	30 seconds
Reference air	180 seconds
Wash	De-ionised water
Relative humidity	20%
Sample equilibration time	30 minutes

The sensor data between 185 and 205 seconds were recorded by means of computer recognition software. These data are transferred to Windows-based statistical software where PCA was performed on the data. The points were then plotted onto a 2 dimensional or 3D surface to create an Aromascan map.

6.4.3 Caffeine content measured by means of Capillary Electrophoresis

Coffee granules of each coffee variant were dissolved with boiling water and made up to a concentration between 0.1% and 1%, depending on the composition of the coffee samples, which had different levels of pure coffee (caffeine component) and some samples had other ingredients such as chicory and maltodextrin which can effect the accuracy of the test. A separate standard solution of caffeine was prepared at a concentration of 10%. Capillary electrophoresis was carried out, in triplicate on each coffee variant concentrate, using the Beckman P/ACE 2100, with on-column detection. An uncoated fused-silica capillary column with an internal diameter of 50µm and a total length of 57cm was used. The effective separation length was 50cm. The operating temperature was 25°C. Detection was effected by measurement of ultraviolet light absorbance at 200nm. The instrument was connected to a computer which recorded the absorbancy levels that results in a number of peaks that can be measured and from where concentration of for example caffeine can be measured.

6.5 Statistical Analysis

All data was captured in Microsoft® Excel 2000 (Microsoft Corporation) and all statistical analyses were performed using Statistica 5.0 (Statsoft Inc., Tulsa, OK 74104) or SPSS 11.0 for Windows (SPSS Inc., Chicago, Illinois 60606).

6.5.1 Descriptive sensory data

To determine the significant differences among the 11 coffee samples, analysis of variance (ANOVA) and where appropriate Fisher's least significant difference test (LSD) for each of the attributes (data averaged across the 12 panellists), were assessed using STATISTICA and/or SPSS computer programmes. The univariant analysis showed significant differences among the samples for 23 of the 29 identified attributes ($p < 0.05$). The six attributes that did not distinguish significantly between the samples were dropped from subsequent analyses. Using Principal Component Analysis (PCA) a perceptual map was plotted of the descriptive sensory ratings.

6.5.2 The Consumer data

The hedonic data were first analysed using analysis of variance (ANOVA) and where appropriate Fisher's least significant difference test (LSD) ($p<0.05$). PCA was used to obtain a consumer preference map from the plot loadings. To understand consumers' responses further, the preference ratings were also analysed by Cluster analysis using Euclidean distances (a hierarchical cluster analysis method). This method assigns rows (in this case consumers) that are close in the multivariate space to the same cluster. In this way, clusters of consumers, which are homogeneous in their preferences for the 11 coffee samples could be identified. The characterisation of the clusters in terms of gender, age, etc., was done by simple tabulation (Excel spread sheet) and by means of Pearson's chi-square test (X^2) (SPSS software) to test for similarities among the clusters ($p<0.05$).

6.5.3 Internal preference mapping

By means of PCA of the matrix of data, consisting of products and consumers, the major variation within the preference data was identified. This result is revealed in a product map and a consumer map, corresponding to the scores and loadings of the PCA.

6.5.4 Extended internal preference mapping

Firstly, PCA was conducted on the descriptive sensory panel data. The average preference ratings for each of the 11 coffee samples as calculated for each of the consumer clusters, were related to the descriptive sensory data space by means of regression analysis, resulting in a map revealing which attributes and samples were related to preferences of consumers in the four different clusters.

6.5.5 Chemical and physical laboratory test results

To determine the significant differences among the 11 coffee samples in terms of chromometer colour measurements and caffeine content measurements, analysis of variance (ANOVA) and LSD was calculated by SPSS software. The Karl Pearson's correlation coefficient was calculated to determine the relationship between colour observations of the sensory panel and the chromometer measurements as well as panel bitterness perception relationship to caffeine content measured using capillary electrophoresis. The data from the electronic nose were analysed using PCA and Cluster analysis to identify coffee samples that are similar/dissimilar in their aromatic make-up.