COURSE TITLE: FOOD PRODUCT DEVELOPMENT

COURSE CODE: FST 502

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LECTURE 1

DESIGN OF PRODUCT AND PROCESS DEVELOPMENT

Product design takes a long time and a great deal of effort. It is important to target the design programme to minimise time and costs; and to achieve success within the allocated time and resources. Time is as very much important as with optimal development. Design the product specifications i.e. the product characteristics as defined by the consumer, the structure and composition, safety factors, convenience and aesthetics, and also indicates the manufacturing, processing and storage variables and their effects on the product qualities.

In the design process, the product and process development are integrated so that at the end of the design stage there is a product with the optimum qualities, and an effective processing operations to produce it.

A. THE DESIGN PROCESS

The activities and some of the experimental techniques in the various stages of product design and process development are:

1. 'Getting the feel',
2. Screening,
3. Ball-park studies,
4. Optimisation,
5. Scale-up (production) and scale-up (marketing).

In the design, both the input variables to the process and the output variables of the product qualities are identified early in the developments.

The input variables are:

raw materials: type, quality, and quantity (formulation)

processing variables: types of processing, processing conditions.

The output variables are:

product qualities;

product yield

1. 'Getting the feel'

This is the process of using the processing methods and conditions outlined in the product design specifications to make the early product prototypes, and the reliability and accuracy of the product characteristics are tested. Depending on previous findings, the consumer may be involved at this stage or not. The choice of no consumer testing depends on the level of consumer knowledge held by the designer. The basic costing used in the company is also identified so that a simple method of determining costs can be used in the next stages of the product design. The consumers are selected to represent already identified target market(s).

2. Screening

Screening reduces the wide range of raw material and processing variables to the input variables affecting important product qualities. Many experimental designs are used to screen the variables but the most common are partial factorial designs, or Plackett and Burman designs. Some food designers have the consumers test many samples in these designs, sometimes for acceptability, but more usefully in product profile tests. Other designers use trained sensory panels.

At this stage, the raw materials are selected, and screened based on quality, availability and costs.

3. Ball-park studies

In ball-park studies, the aim is to set the limits of the raw materials and the processing variables which give acceptable product qualities as judged by the consumer. By this stage, the variables are reduced in number and their outside limits are set. They are examined in factorial designs, and for raw materials in mixture designs.
In food formulations, mixture designs are often used because it is impossible to vary one ingredient while holding all the others constant; in mixture designs, the sum of all the ingredients in the formulation must add to 100%.

Both technical testing and consumer testing of these product prototypes are carried out. The consumers are testing for acceptability and the technical tests examines the chemical, microbiological, physical and sometimes the sensory properties of the products. Accuracy and reliability are important considerations in this testing, both for studying the effects of the input variables on the product qualities and for developing the quality assurance programme.

The total processing costs of these product prototypes are compared to identify the effects of the input variables on the costs, and to check that the costs are within the target cost range.

4. Optimisation

This is the process of determining the levels of the input variables which will give the best possible product quality. While optimising one product quality, another product quality is less than optimum thus the relative importance of each quality must be set. The limits that are acceptable across all the product qualities need to be known so that during the optimising experiments none of the other product qualities become unacceptable.

For raw material formulations, linear programming can be used to optimise a number of product qualities and costs with the amounts of raw materials in the formulation held between upper and lower levels.

5. Scale-up

Scale-up (or ramp-up) of both the production and the marketing is the last stage of the product design and process development. The production scale-up is the in-plant test to verify that the product can be made at the quality and quantity required, and the marketing scale-up is a large consumer test to verify that the target consumers will buy the product and what marketing strategy will encourage this buying.

The aim of the processing scale-up is to determine the optimum production process for product quality, product yield, process control and costs. The scale-up can either be on a pilot plant or short production runs on the main plant.

PRODUCT DESIGN SPECIFICATIONS

'Getting the feel'	Recognising the variables Setting the limits *'Ad hoc' experiments*

PRODUCT 'MOCK-UPS'

Screening	Importance of variables Interrelationships of variables *Simple experimental designs*

ELEMENTARY PRODUCT PROTOTYPES

Ball-park studies	Variables limits Variables interactions Basic packaging *Linear programming* *Factorial designs*

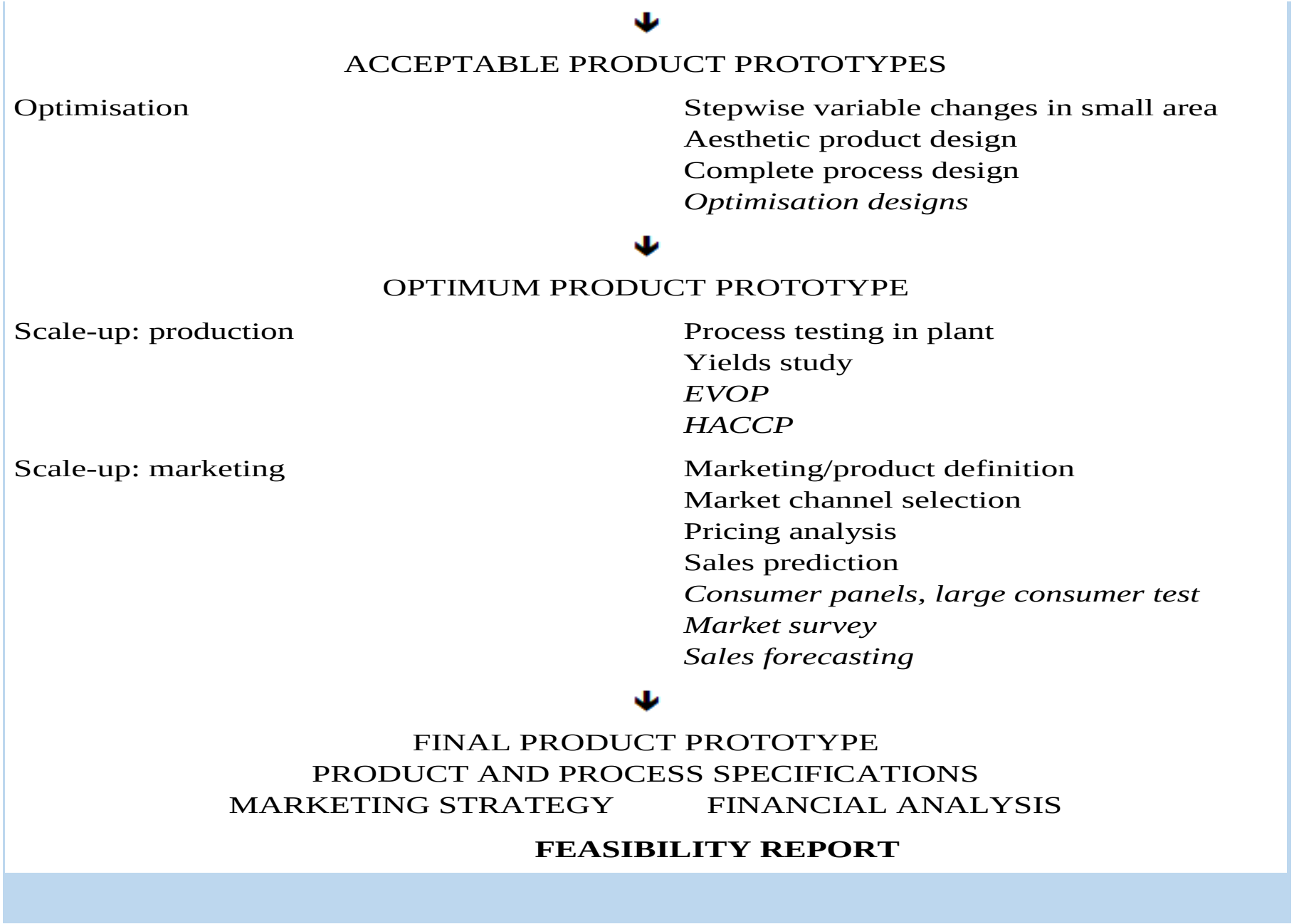

Figure 1: Activities and experimental techniques in product design and process development

PRODUCT DESIGN SPECIFICATIONS			
	Technical	**Consumer**	**Costs**
'Getting the feel'	Setting up Reliability Training	Ideal profiles	Company costs
	Standard tests	*Profile tests*	*Cost analysis*
	Correlation of technical/consumer tests		
	PRODUCT 'MOCK-UPS'		
Screening	Technical Sensory	Product comparison	Raw materials cost limits
	Product testing	*Difference testing*	*Materials cost comparison*
	ELEMENTARY PRODUCT PROTOTYPES		
Ball-park studies	Technical Sensory	Acceptability	Preliminary product costing
	Statistical testing	*Preference panel*	*Spread sheets*

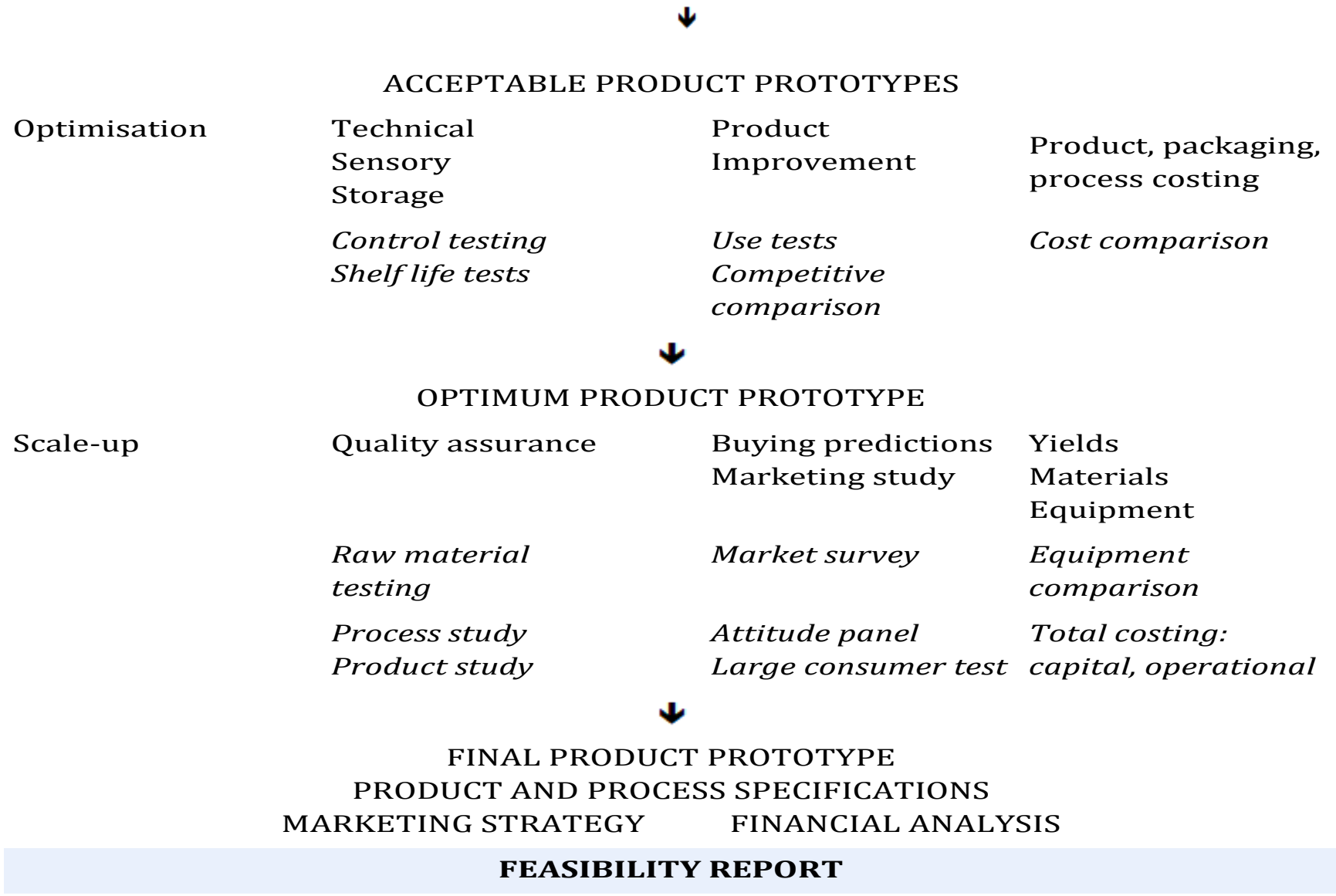

Figure 2: Testing activities and techniques in product design and process development

ACTIVITY 1

Discuss the advantages and disadvantages of consumers testing the prototypes in 'Getting the feel', 'Screening' and 'Ball-park' experimentation.

For what types of products – packaging change, product improvement, product line extension, product innovation – would you use consumer testing and at what stages in the product and process development?

LECTURE 2

B. PRODUCT TESTING

Product testing is an integral part of the product design and process development. To achieve the final product prototype, it is very important that the product is tested at all stages during its design for **technical compliance**, acceptability to the consumer, and compliance with cost constraints. Physical tests, chemical tests, microbiological tests, sensory tests and profile characteristics such as colour, texture, taste, etc are amongst tests carried out in technical testing.

1. Technical testing

Technical testing varies a great deal depending on the type of product, the testing facilities available, safety needs, processing needs and legal regulations. The tests can be physical, chemical, or/and microbiological. The technical testing for consumer acceptance is built up from the consumers' product profile, and suitable technical test methods are sought which relate to the product characteristics identified as important to the consumer.

2. Shelf life testing

Testing shelf life is important in food design because there is usually a target shelf life to be achieved for transport and storage in the distribution chain as well for storage of the product by the consumer after buying.

From previous knowledge, some predictions can be made early in the design on the possible shelf life; foods can be divided into short-life products (up to 10-14 days), medium-life products (up to eight weeks) and longer-life products (up to 1-2 years). The possible deterioration reactions in the food are identified, for example chemical reactions like browning and loss of colour, and microbial growth of food spoilage organisms, moulds and yeasts. It may be necessary to carry out accelerated tests under severe conditions to identify exactly what the deteriorative reactions are.

3. Sensory evaluation

Sensory evaluation can be carried out by expert sensory panels or by consumers. Traditionally in product design, the expert sensory panel determines the differences between prototypes and the direction of the differences, while consumer panels evaluate the acceptance of products or preferences between products. **This implies that consumer input does not take place until the final stages of prototype development.** Care needs to be taken when choosing the "consumers" – are they the people who buy the product, who prepare the meal, who eat it?

Differences between sensory panel and consumer panel

A trained sensory panel may consist of between four and ten people, but consumer panels are larger, comprising at least thirty people depending on the type of testing. The members of a trained panel after a month or longer training are able to score the product qualities reliably and accurately. Consumer panels are not trained, but are representative of the users of the product. The consumer panel gives opinions on all product characteristics, not just sensory qualities but others such as safety, nutrition, size, ease of use, transport, storing and convenience. They can also be involved in the design of the package.

Table 1: Differences between sensory panel and consumer panel

Trained sensory panel	Consumer panel
1. Consist of between four and ten people	Larger panel, comprising at least thirty people
2. Gives reliably and accurately score	The scores may not be accurate because they are not trained.
3. The scoring is limited to sensory acceptability	Sensory qualities and others parameters such as safety, nutrition, size, ease of use, transport, storing and convenience are tested.
4. Tests the product at the factory level	Test the final packaged product under the conditions in which they would use it even at home level.
5. Have the interest of both the manufacturer and consumers at heart	Concern majorly for the consumers' acceptability e.g. Is the pack ergonomically suitable (efficient)? Does it fit their hands? Can they open it? Is the product suitable for their equipment and their abilities? Can they prepare and cook the product? Do the other people in the house like it? Is it acceptable to younger/older or people of different sexes?

4. Costs

Costs provide a basic criterion for controlling the design; they need to be monitored throughout the development stages to ensure they are within the target range. At the beginning of the design, the company's cost structure and the target range of costs for the new product need to be agreed by all involved. The basic costs for producing and distributing the product and their simple subdivisions is presented in the next slide.

Some of the manufacturing costs comprise raw materials, packaging, labour, depreciation of equipment, electricity, steam, gas, water, waste disposal and plant overheads. In many companies, during the product design and process development, the raw materials and direct processing costs are continuously determined and are part of the design. Standard percentages or ratios on these materials and processing costs are used to predict the company costs. At the end of the product design and process development stage, there should be reasonably accurate forecasts of production and distribution costs and some indication of the probable marketing costs.

Basic costs for producing and distributing a product

Manufacturing costs	Raw / packaging materials cost Direct processing costs Fixed costs Plant overhead costs
Distribution and marketing costs	Physical distribution costs Market channel costs Promotion costs Sales and selling costs
General company costs	Administration costs Development costs Financing costs

LECTURE 3

THE PRODUCT LIFE CYCLE (PLC)

After launching the new product, management wants the product to enjoy a long and happy life to earn a decent profit to cover all the effort and risk that went into launching it.

Product Life Cycle (PLC) is the course of a products sales and profits over its lifetime. It involves five distinct stages:

- product development,
- introduction,
- growth,
- maturity, and
- decline.

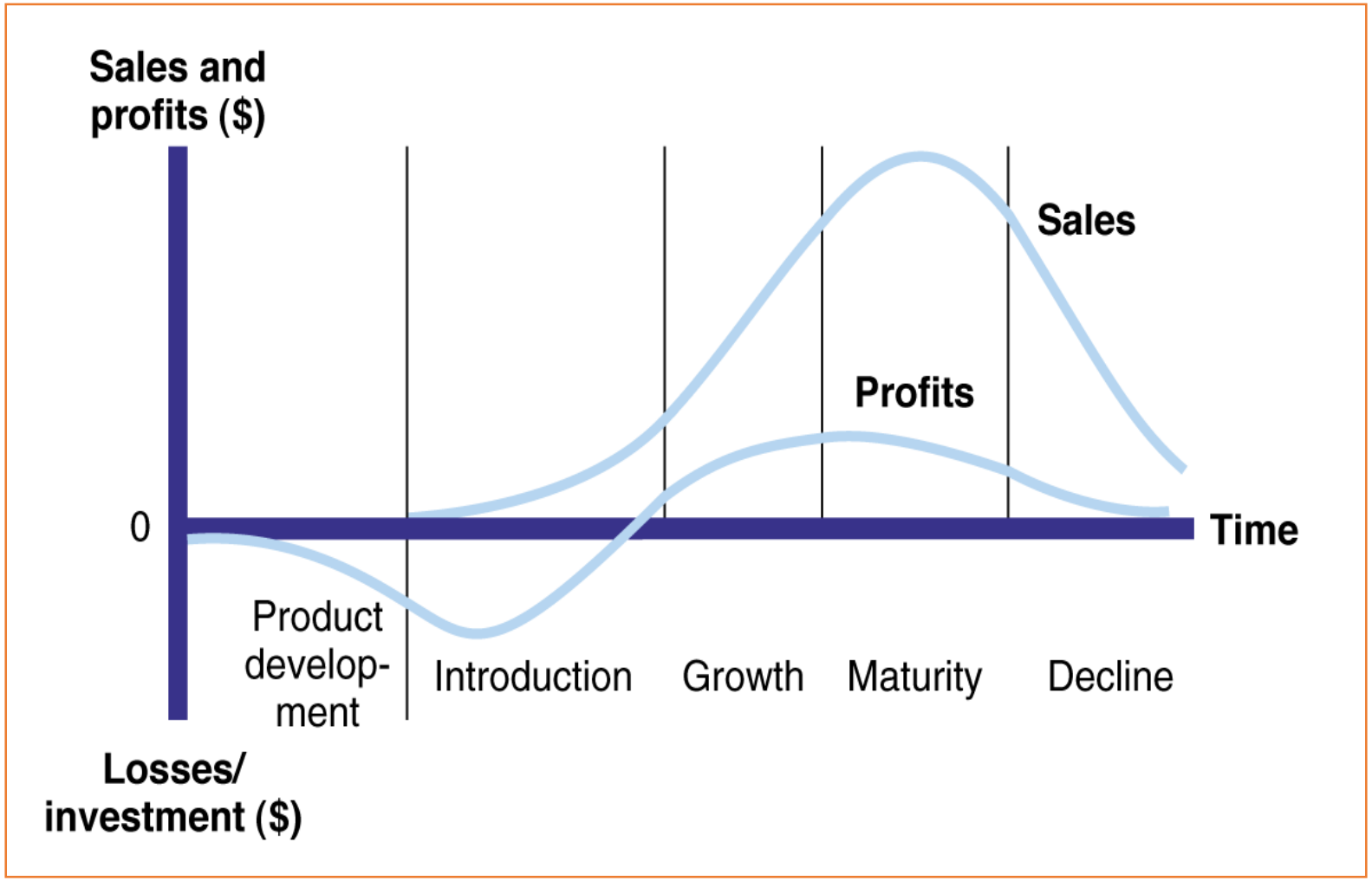

Figure 3: A typical product life cycle (PLC)

Introduction Stage of PLC

The introduction stage starts when the new product is first launched. Introduction takes time, and sales growth is apt to be slow. In this stage, as compared to other stages, profits are negative or low because of the low sales and high distribution and promotion expenses. Much money is needed to attract distributors and build their own inventories. Promotion spending is relatively high to inform consumers of the new product and get them to try it.

Growth Stage of PLC

If the new product satisfies the market, it will enter a new growth stage in which sales will start climbing quickly. The early adopters will continue to buy and later buyers will start following their lead, especially if they hear favourable words of mouth. Attracted by the opportunities for profit, new competitors will enter the market. They will introduce new product features, and the market will expand. The increase in competitors will lead to increase in the number of distribution outlets, sales jump just to build reseller inventories.

Prices remain the same or fall only slightly. Companies keep their promotion spending at the same or a slightly higher level. Profits increase during the growth stage, as promotion expenses are spread over a large volume and as unit manufacturing costs fall. The firm uses several strategies to sustain rapid market growth rate as long as possible.

Maturity Stage of PLC

At this stage, product sales growth will slow down. The maturity stage normally lasts longer than the previous stages and poses strong challenges to marketing management. In any market, most products are in the maturity stages of the life cycle. Therefore, most of the marketing management deals with mature product.

This stage is characterised by the challenge of:

-Competitors' invasion: find better versions of the product

-drop in profit

To solve the challenge faced by the maturity stage:

The company might;

try *modifying the product*— to revitalise consumer buying, change characteristics such as flavours, colours, scents, ingredients, or packages to enhance quality and performance. For example, TABASCO pepper sauce may have been around for more than 140 years, but to keep the brand young, the company has added a full line of flavours (such as Garlic, Sweet & Spicy, and Chipotle) and a kitchen cabinet full of new products under the TABASCO name (such as steak sauces, spicy beans, a chili mix, salsas, jalapeno nacho slices, and even spicy chocolate and a TABASCO lollipop).

try *modifying the marketing mix*—improving sales by changing buyers. It can cut prices to attract new users and competitors' customers. It can launch a better advertising campaign or use aggressive sales promotions—trade deals, cents-off, premiums, and contests. In addition to pricing and promotion, the company can also move into new marketing channels to help serve new users.

Decline Stage of PLC

The sales of most product falls and brands eventually fall. The decline may be slow or rapid depending on the products. Sales may plunge to zero or they may drop to a level where they continue for many years.

Reasons for sales decline may include;

-technological advances,
-shifts in consumer tastes, and
-increased competition.

As sales and profits decline, some firms withdraw from the market. Those remaining may prune their product offerings. They may drop smaller market segments and marginal trade channels, or they may cut the promotion budget and reduce their prices further.

Carrying a weak product can be very costly to the firm, and not just in profit terms; a weak product often requires frequent price and inventory adjustments. For these reasons, companies need to pay more attention to their aging products. The firm's first task is to identify those products in the decline stage by regularly reviewing sales, market shares, costs and profit trends.

NOTE:

Not all products follow all five stages of the PLC. Some products are introduced and die quickly; others stay in the mature stage for a long, long time. Some enter the decline stage and are then cycled back into the growth stage through strong promotion or repositioning. It seems that a well-managed brand could live indefinitely.

Brands like Coca-Cola, Maggi cube, TABASCO sauce, Guinness, Gillette, Budweiser, American Express, Wells Fargo, and Kikkoman for instance, are still going strong after more than 100 years. Guinness beer recently celebrated its 250th anniversary.

Practical Problems of PLC

- Hard to identify which stage of the PLC the product is in.
- Hard to pinpoint when the product moves to the next stage.
- Hard to identify factors that affect product's movement through stages.
- Hard to forecast sales level, length of each stage, and shape of PLC.
- Strategy is both a cause and result of the PLC.

Styles, fashions, and fads concept of Product life cycle (PLC)

The PLC concept also can be applied to what are known as styles, fashions, and fads.

A style is a basic and distinctive mode of expression. For example, styles appear in homes (colonial, ranch, transitional), clothing (formal, casual), and art (realist, surrealist, abstract). Once a style is invented, it may last for generations, passing in and out of vogue. A style has a cycle showing several periods of renewed interest.

A fashion is a currently accepted or popular style in a given field. For example, the more formal "business attire" look of corporate dress of the 1980s and 1990s gave way to the "business casual" look of the 2000s. Fashions tend to grow slowly, remain popular for a while, and then decline slowly.

Fads are temporary periods of unusually high sales driven by consumer enthusiasm and immediate product or brand popularity. A fad may be part of an otherwise normal life cycle or may comprise a brand's or products entire life cycle. Examples of fads include low-carb diets.

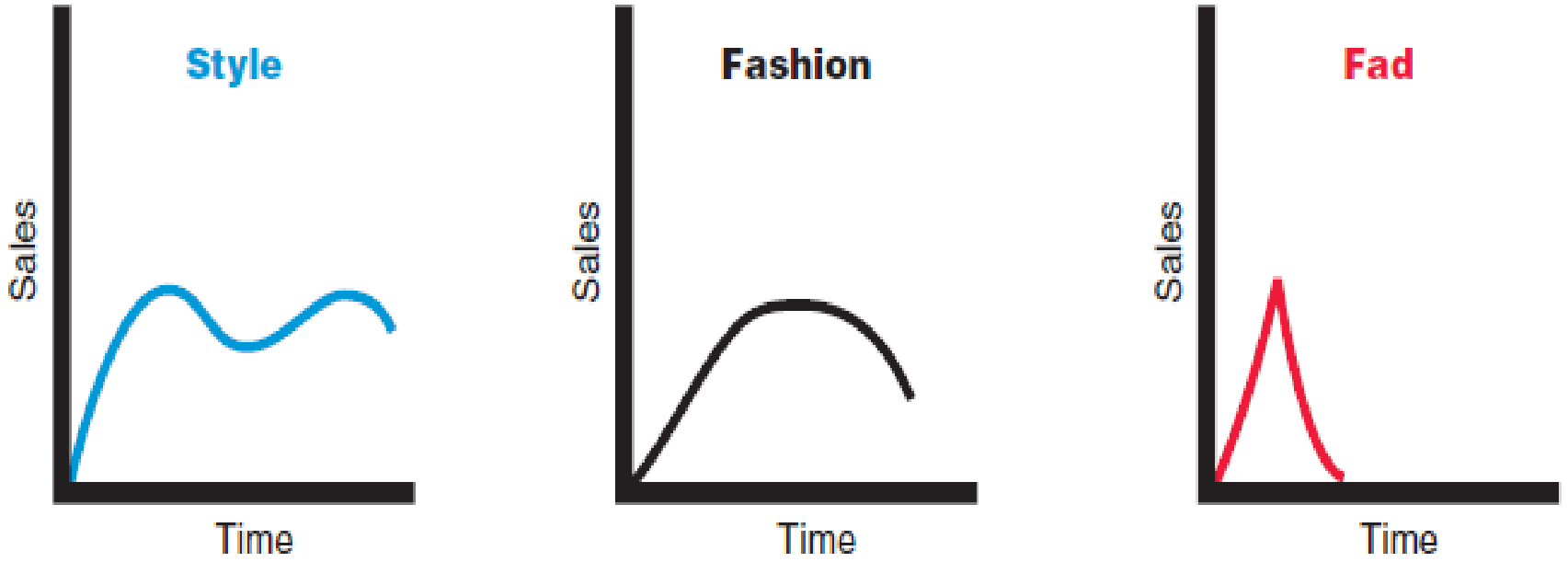

Figure 3: The special product life cycles in terms of styles, fashions, and fads

LECTURE 4

Packaging and Labelling

Packaging includes the activities of designing and producing the container or wrapper for a product. Labelling is also part of packaging and consists of printed information appearing on or with the package.

Packaging

The 1° function of the package was to contain and protect the product. In recent times, however, numerous factors have made packaging an important marketing tool. Packages must now attract attention and described the product. Good packaging creates instant consumer recognition of the company or brand and a tool for decision to purchase.

The package may include the product's 1° container (e.g the tube holding Colgate tooth paste), a 2° package that is thrown away when the product is about to be used (e. g the cardboard box containing tooth paste tube) and the shipping package necessary to store, identify and ship the product.

Developing a Good Package

Developing a good package for a new product requires making many decisions.

The 1st task is to:

- establish the packaging concept- states what the package should be or do for the product.

-offer product protection,

-introduce a new dispensing method, and

-suggest certain qualities about the product or the company?

The 2nd task is to:

- decide on specific elements of the package such as: size, shape, materials, colour, texture and brand mark.

These various elements must work together to support the products position and marketing strategy. For product safety, many companies use tamper-resistant packages. The decisions made must serve society's interests as well as immediate customer and company objectives.

Labelling

Labelling is also part of packaging and consists of printed information appearing on or with the package. Labels may range from simple tags attached to products to complex graphics that are part of the package. They perform several functions and the seller has to decide with ones to use. The label identifies the product or brand. It might also grade the product or describe several things about the product:

- who made it,
- where it was made,
- when it was made,
- its contents, and
- how it is to be used safely

Labelling might promote the product through attractive graphics.

Misleading effect of labels

Labels can however mislead customers, fail to describe important ingredients, or fail to include important safety warnings. As a result, several federal and state laws regulate labelling.

Fair packaging and labelling Act of 1966:

- set mandatory labelling requirements,
- encouraged voluntary industry packaging standards, and
- allow federal agencies to set packaging regulations in specific industries.

Now labelling carries:

Unit pricing – stating the price per unit of standard measure,

Open dating – stating the expected shelf-life of the product, and

Nutritional labelling – stating the nutritional values in the product. The Nutritional Labelling and Educational Act of 1990 requires sellers to provide detailed nutritional information on food products.

LECTURE 5

COST CONCEPTS

Cost is the amount of money or other consideration exchanged for property or services. These include;

a) Unit Costs
b) Total Costs – (i) Fixed cost (ii) Variable costs
c) Direct Costs
d) Indirect Cost
e) Sunk Cost

a) **Unit Costs** – This is the cost of production of one unit of a given product or service. Unit costs are a valuable management tool because they relate input to output, relate expenditures to their purposes and they provide an early indication of problematic situations such as an unexplained increase for an item over time.

b) Total Costs – This is what it costs to operate at some particular rate of output. It is the sum of all costs both direct and indirect. Total cost can either be fixed cost or variable cost.

i) Fixed cost: this is the part of the budget that stays the same regardless of whether production increases or decreases or its even at zero that is they are unaffected by changes in activity level over a feasible range of operations for the capacity or capability available. Examples include overhead, rent on buildings, depreciation etc. because they do not change over time, they are more difficult to reduce in the short run than variable costs that can be altered fairly quickly.

ii) Variable costs: these are associated with operations that vary in relation to changes in the quantity of output or other measures of activity level. Production increases variable cost. E.g. personnel expenses, cost of supplies, cost of material, labour costs etc.

c) Direct Costs: these are costs that can be reasonably measured and allocated to a specific output or work activity. The labour and material costs directly associated with a product or service are regarded as direct cost.

d) Indirect Cost: they are commonly called overhead costs and are necessary for the function of the organisation but not uniquely or easily assignable to a specific output or work activity e.g costs of departmental leadership or budget administration.

e) Sunk Cost: is the portion of fixed costs that is not recoverable and is incurred only once. E.g. costs of equipment that has been paid for and expenditures for personnel time already worked.

Cash Flow Concepts

When a company makes a number of different products, it will want to know the profit on each one, hence:

Profit = Total Income – Total Costs

For a product that sells at a fixed price per unit,

Income = price per unit (UP) x number of units sold (N)

Thus,

Total Cost (TC) = Fixed Cost (FC) + Variable Cost (VC)

$$TC = FC + VC$$

Breakeven Point is the number of units ‘N’ the company must sell before it starts to make a profit. i.e when income = total cost

Income = FC + VCxN

UP x N = FC + VCxN

Breakeven Point = N = FC/(UP-VC)

Average Cost = Total cost/Number of Units

Examples:

1. Altos Car parts sell an exhaust system for $130 a unit. The FC for buildings, machines and employees are $6,000 a week while raw material and other Variable costs are $50 a unit. (a) What is the break even point for the system? (b) What is the profit if the Altos sell 100units a week? (c) What is the profit if the UP is lowered to $80 and sales rise to 250 units in a week?
2. The fourth Bana serves 200 meals a day at an average price of $20. The VC of each meal is $10 and the FC of running the restaurant is $1750 a day. (a) how much profit does the restaurant make (b) what is the average cost of a meal (c) How much does the average cost of a meal fall to if the number of meals serves rises to 250?

SECOND TEST ON FOOD PRODUCT DEVELOPMENT

1. At what stage(s) in the design of product and process development would you use consumer testing and why? **5 marks**
2. In tabular format, distinguish between trained sensory panel and consumer panel. **5 marks**
3. Make a well descriptive sketched graph to explain the stages involved in a product's life cycle. **5 marks**
4. Mention the basic costs (with their simple subdivisions) for producing and distributing a product. **5 marks**

Time Value of Money

Money borrowed over time must be paid back with interest inferring that the value of money today will increase tomorrow. The amount borrowed is called **principal** and the increase over the original amount is **interest.**

For example, if Mr Alex puts an amount of money (AP) into a bank account and leaves it untouched for a year earning interest at an annual rate i, at the end of the year he will have AP x (1+i)

With compound interest, if he leaves the money for a 2^{nd} year, he will earn interest not only on the initial deposit but on the interest earned in the 1^{st} year i.e. he will have AP x (1+i)(1+i) = AP x $(1+i)^2$

Then, at N years, the Future amount (AF) that will be in his account will be AF = AP x $(1+i)^N$.

Present Value of Money can then be calculated as AP = AF/$(1+i)^N$.

In Engineering Calculation, the following symbols are used:

P = value or some of money at a time denoted as present

F = value or sum of money at some future time

A = a series of periodic, equal amounts of money

n = number of interest periods

i = interest rate per interest period

The standard notation which represents the various factors is given in the general form: (x/y, i%, n) where x = what you want to find

y = what is given

i = interest rate in percent

n = number of years involved

The following examples illustrate the use of these symbols:

1. If a man borrows N2,000 and must repay the loan plus interest at a rate of 7% per year in 5 years, what is the total amount he must pay? PFIN (b) If he must repay the loan in equal yearly payments, what will he be required to pay? PAIN
2. If a woman deposits N600 now, N300 two years from now and N400 five years from now, how much will she have in her account ten years from now if the interest rate is 5%.

PFIN = Present Worth, Future Worth, Interest, Number of years

PAIN = Present Worth, Annuity, Interest, Number of years.

NB: Make use of the compound interest table

Net Present Value (NPV) and Internal Rate of Return (IRR)

NPV is the sum of the present values of the individual cash flows of the same entity. It can also be regarded as sum of discounted revenues minus the sum of discounted costs. A project is regarded as best amongst others if it has the highest NPV. If NPV is greater than 0, it means the project may be accepted, if less than 0 the project should be rejected and if equal to 0, it means the project will add no monetary value to the firm.

NPV = $\sum_{y=1}^{N} \frac{P}{(1+i)^y}$

where P is the cash flow, i = interest rate, y = number of year, N = total number of periods