P. As a first step the supply of P with the feed should be in accordance with the animal's requirements (SIMONS et al., 1990). Another possibility to decrease excretion of P is a directed choice for those feedstuffs in the mixed feed which have a low total P concentration together with a high P digestibility (JONGBLOED and KEMME, 1990). Recently a microbial phytase product has become available for pig producers. Supplementing the diet with the enzyme is an effective way of increasing the breakdown of phytate P in the digestive tract, which can help to increase the amount of available P in the feeds and reduce the P excretion in the faeces. An increase in the amount of dietary available phosphorus will allow for a reduction in the total P level in rations. The result is a ration closer matched to the pig's actual P requirement, which can be used as a tool to help to reduce the excretion of P from pig production.

According to JONGBLOED and LENIS (1998) phytase is used in more than 70 % of Dutch pig feeds and has been partly responsible for a reduction of 60 % in the excretion of P by pigs in The Netherlands between 1973 and 1996. Phytase is also widely used in other parts of the world. Increasing environmental pressure for the inclusion of phytase in all animal diets is likely to continue.

The general objective of this research is to evaluate the optimum level of microbial phytase to reduce P excretion without reducing performance of pigs fed conventional Thai pig rations supplemented with phytase.

The specific objectives are:

1. To evaluate the optimum level of microbial phytase to improve the bioavailability of P in conventional Thai plant feedstuffs: soybean meal, sunflower meal, corn and rice bran, in growing pigs.
2. To evaluate the effect of the optimum level of microbial phytase to reduce P excretion in growing pigs.
3. To evaluate the effect of the optimum level of microbial phytase to reduce total P content in pig diets and maintain productive performance, carcass quality and bone content in growing-finishing pigs fed conventional Thai pig rations supplemented with phytase.

To meet this objective, the experiments shown in the following diagram were conducted.

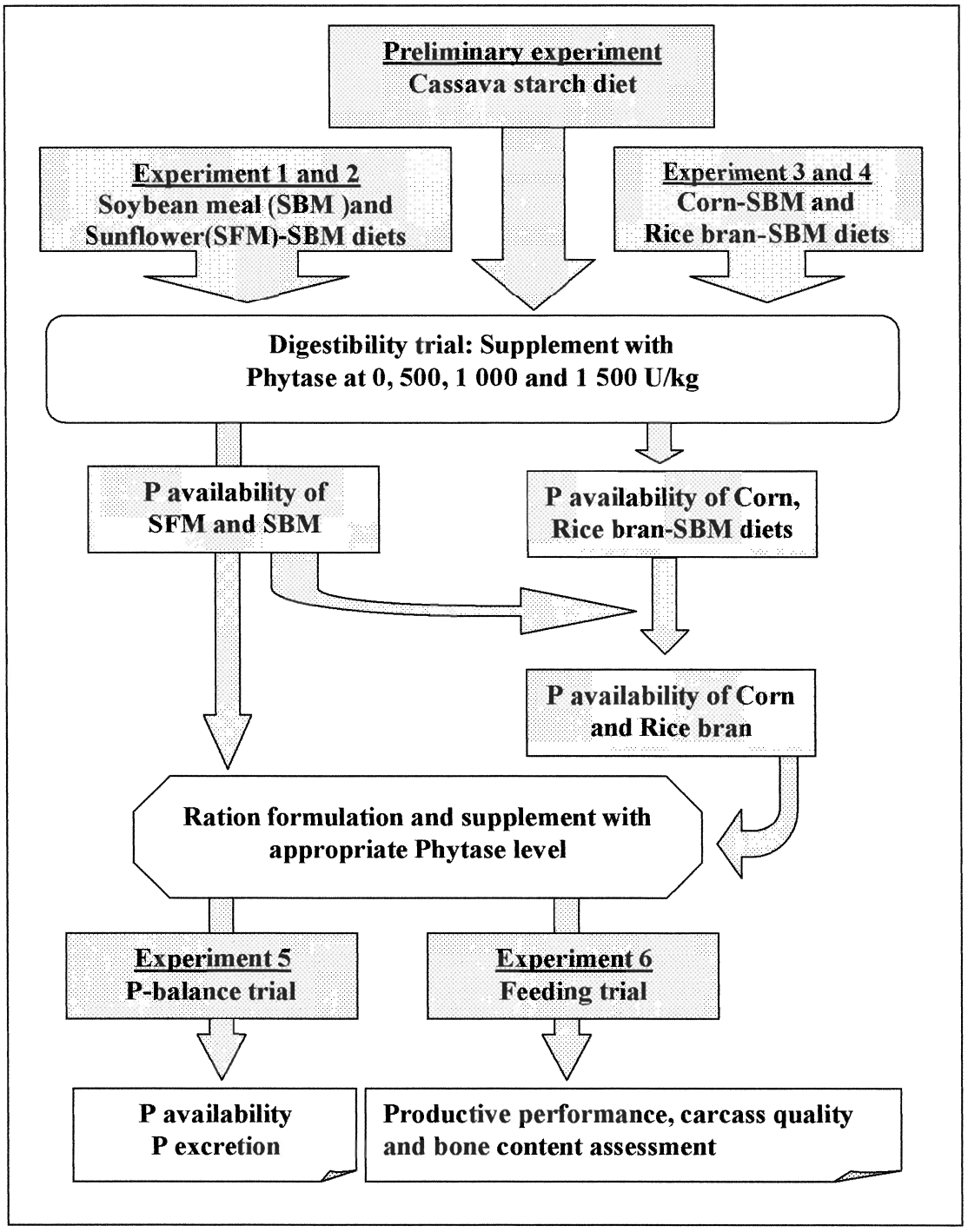

Figure 1.1. Outline of research

2. REVIEW OF LITERATURE

2.1. Need for phosphorus

Phosphorus (P) is one of the major minerals required by animals and is the second most abundant mineral element found in the animal body (McDOWELL, 1992). The bodies of adult animals contain 0.60-0.75 % P, calculated on fresh tissue, 1.9-2.5% on dry tissue and 16-17 % on ash (GEORGIEVSKII et al., 1981; COLE, 1991). It is found throughout of the body, but most of it (about 80 % of the total) is combined with calcium in the bones and teeth. About 10 % is in combination with proteins, lipids, and carbohydrates, and in other compounds in blood and muscle. The remaining 10 % is widely distributed in various chemical compounds in the remaining parts of the body (MINSON, 1990).

Phosphorus probably plays a more varied role in the chemistry of living organisms and has more known functions than any other single element in the animal body (NRC,1980; BONDI, 1987; McDOWELL, 1992; OFFICER, 2000). It has long been recognized as an important essential mineral element concerned with bone development, growth, reproduction and energy transfer.

P plays an important part in the formation of bones and a major role in the development and maintenance of the skeletal system. But it also takes part in many other physiological functions. It is involved in phospholipid formation, fatty acid transport and amino-acid and protein biosynthesis. It is therefore needed in muscle and nerve metabolism and for muscle mass increase. All other synthetic processes connected with growth and production i.e., synthesis of milk components, formation of eggs, growth of wool also involve phosphoric acid compounds. P forms part of the structure of nucleic acids, which are carriers of genetic information and regulate immunity (GEORGIEVSKII, 1981; NRC, 1988; COLE, 1991). A great importance of the phosphate ester is in energy utilization and transfer (ADP and ATP) (MINSON, 1990). In combination with other elements, it helps maintain osmotic and acid-base balance of body fluids (NRC, 1980). The many different physiological functions result in that it is required in large quantities by the animal (McDOWELL, 1992).

2.2 Phosphorus in animal feed

The element P is widely distributed in nature. It is very reactive and never occur in free state. It combines spontaneously and vigorously with oxygen, and even its pentoxide, P_2O_5 combines readily with water to form orthophosphoric acid. P was first prepared in the free state by BRANDT, an alchemist of Hamburg, Germany, in 1669 (NRC, 1980).

2.2.1. Phosphorus in plants

2.2.1.1. Definition and chemical structure of phytic acid and phytate

Phytic acid phosphorus represents 60-80 % of the total phosphorus present in plants (KORNEGAY, 2001). Structurally, phytic acid consists of a fully phosphorylated myo-inositol ring, with six phosphoric acid esters on the 6-hydroxyl groups as presented in Figure 2.1. The correct chemical description for phytic acid is myo-inositol 1,2,3,4,5,6 hexakis dihydrogen phosphate ($C_6H_{12}O_{24}P_6$). It is commonly abbreviated PA though the abbreviation PA stands not only for phytic acid, but also for phytates, the salts of phytic acid. Phytates are potassium, magnesium and calcium salts of phytic acid. They are present as chelates in cereals, legumes and oilseeds (MAENZ, 2001).

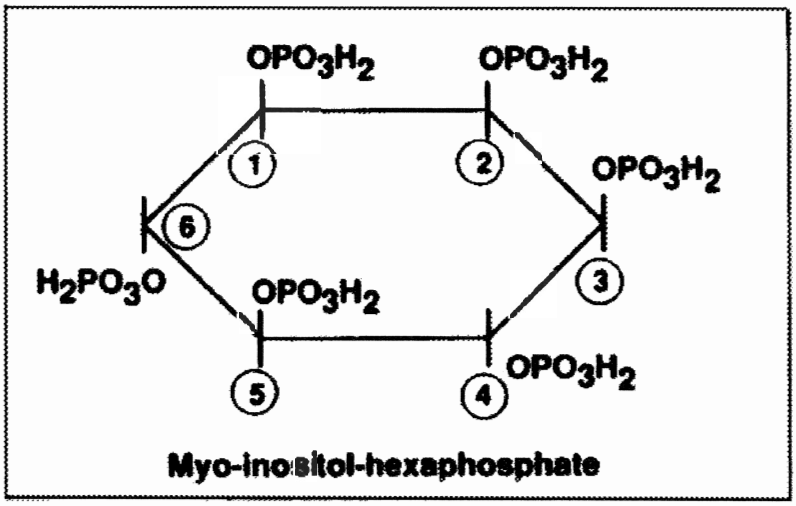

Figure 2.1. Phytic acid (SEARS and WALSH, 1993)

2.2.1.2. Phytic acid and phytate in plants

P occurs in plant mainly as organic compounds-salts of phytic acids, phospholipids, nucleic acids and other compounds. Phytic acid is the primary source of inositol (and inositol phosphate) in plants. Several physiological roles have been suggested for it. The two major roles are: 1) the supply of inositol phosphates which are responsible for transport of substances and are secondary messengers involved in signal transduction in plant cells and 2) the storage of phosphorus in dormant seeds which is used in the synthesis of ATP during germination (MAENZ et al., 1999). In addition phytic acid probably serves several other unknown functions in seeds (REDDY et al., 1989).

The localization of phytic acid in the seed varies. In grain, PA lies mainly in the bran (aleurone layer, testa and pericarp), in the case of maize it is found mainly in the endosperm. In legume seeds, PA accumulates in the cotyledon (O'DELL et al., 1972; de BOLAND et al., 1975). Its approximate distribution in grain is as follows: soluble and insoluble phytates 50-70 %; phospholipids, phosphoproteins, nucleic acids 20-30 % and mineral phosphates 8-12 %. Its concentration in grain (seeds) is 3-4 times higher than in straw (GEORGIEVSKII et al., 1981). Thus the largest amount of phosphorus in plants is in the form of phytates (COLE, 1991).

The P levels are dependent on the plant species, the level of soil fertility, and the stage of maturity at the time of analysis. The contents of total P and phytate P for some feedstuffs are listed in Table 2.1.