The Preparation of Soap

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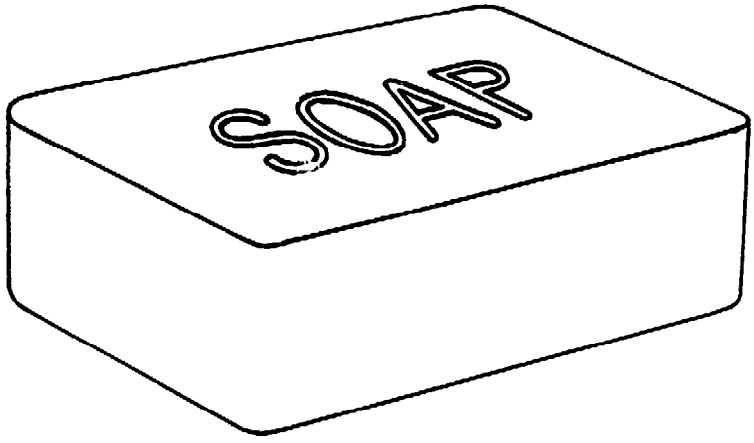

# THE PREPARATION OF SOAP

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CONTENTS PAGE

# THE PREPARATION OF SOAP

## 0. INTRODUCTION

Many people want to prepare soap in order to maintain the necessary hygiene. In tropical countries soap is sometimes either difficult to obtain or very expensive even though the raw materials for the preparation of soap are often available. Anybody can make soap at home as long as he follows the instructions mentioned below.
Some of these instructions may seem somewhat technical but it is necessary to describe directions in this way as otherwise soap of a bad quality may be obtained.

## 1. DIFFERENT KINDS OF SOAP

The soap recipe in this booklet works with caustic soda, which makes hard soap. Soft soap is made by using caustic potash, instead of soda (see chapter 8). If you seperate this pure soap from the brine, (as described in 7.2.), the result will be soft soap. Hard soap can be coloured with pigment, that is, a very fine powder which is mixed with the soap mass, but does not dissolve in it. You will have to experiment with locally available pigments, to find out which colour keeps best. In the tropics a testing period of at least 2 months is needed.
With colour, you can also give the soap a scent. This is done by mixing perfume and/or colour with the warm soap mass, just before pouring it into the moulds. Special scents for the soap industry are commercially available, but if these are not at hand in your area, you'll have to experiment. Bad results will be easily recognised by a very different odour, after waiting a few days.

## 2. EQUIPMENT NEEDED

For preparation of soap we need vessels made of iron or stone.
Aluminium should not be brought into contact with warm soap as this affects the material.
Moreover, a couple of spoons or sticks of the correct size are necessary in order to stir the mixture during the preparation.
To achieve the soap's final form the substance can be poured out into bowls, wooden boxes and even in cardboard boxes as long as these are strong enough. Coconut shells can often be used very well to obtain the good form.
To prepare good soap the raw materials should be mixed in proper proportions for which a measuring-glass, or something like it, is necessary.
For the preparation of soap you will have to melt fats, and thus, some heat source is needed. Because the chemical reactions in the process produce heat, the temperature should not rise over 90°C, if you want to prevent spilling over. Therefore, a well controlled heat supply is recommended.

## 3. THE RAW MATERIALS

As raw material all oils and fats of animal or vegetable origing can be used. Lye, which is often sold on inland markets, and soft water, for which rain-water can be used, are also required.
If there is no sufficient rainwater available you can also add some lye to water of different origin., In doing this it is necessary to stir well after which you leave the mixture for a couple of days. A sediment will then be formed that settles well.
The top-layer of water can then be used for the following recipes.

## 4. DISCUSSION OF THE RAW MATERIAL

### *4.1. The fat and oil*

All fats and oils at your disposal can be used for the preparation of soap. Even fat-leftovers and polluted fat can be used provided that the mixture of fats, from which the soap is to be prepared, is melted as a whole.
When the fat-mixture stinks it must be washed with hot water and filtered through a fine-woven cloth in order to remove any dirt.
To obtain a good soap it is advisable to use in any case some coconut fat, palmkernel fat and/or butter fat. These last mentioned fats make a well-foaming soap.

### *4.2. The lye*

It often is not known how strong lye is which is bought on the market. For the preparation of hard soap only caustic soda can be used.
The quantities of lye and fat to be used should be adjusted very carefully to obtain a good quality of soap.
If there is any weighing-device present, it is advisable to weigh the required amounts, according to table 1 ( see page 4 ). For this method however it is necessary to use fresh, dry and pure caustic soda. This will only be so if the caustic soda is packed in a sealed unopened container. If you are not sure about the quality of the caustic soda, you shall have to measure the density of the solution by means of an aerometer, a device costing about 5 £ sterling. The density of the solution should be 1.22 for a 18 w% solution and 1.37 for a 27 w% solution. If no aerometer can be obtained, a battery-acid meter will suffice. You can also try to apply the following trick as described : the measuring stick/tube.

#### *4.2.1. The measuring stick/tube :*

First a saturated rock salt (sodium chloride) solution is prepared.
- dissolve a fair amount of salt in water, stir well
- let stand until next day. If no solid salt is left on the bottom, add more, until some is left. Your solution is now saturated.

- take a small stick of solid wood, tie something heavy to one end ( a pebble, or piece of iron )
- stick this into your salt solution. The stick should stand straight up and a small part of it should stick out of the liquid. If not, adjust its weight.
- mark the stick where it is touched by the surface of the liquid
- you now have a measure for lye concentration, which can be used time and again.

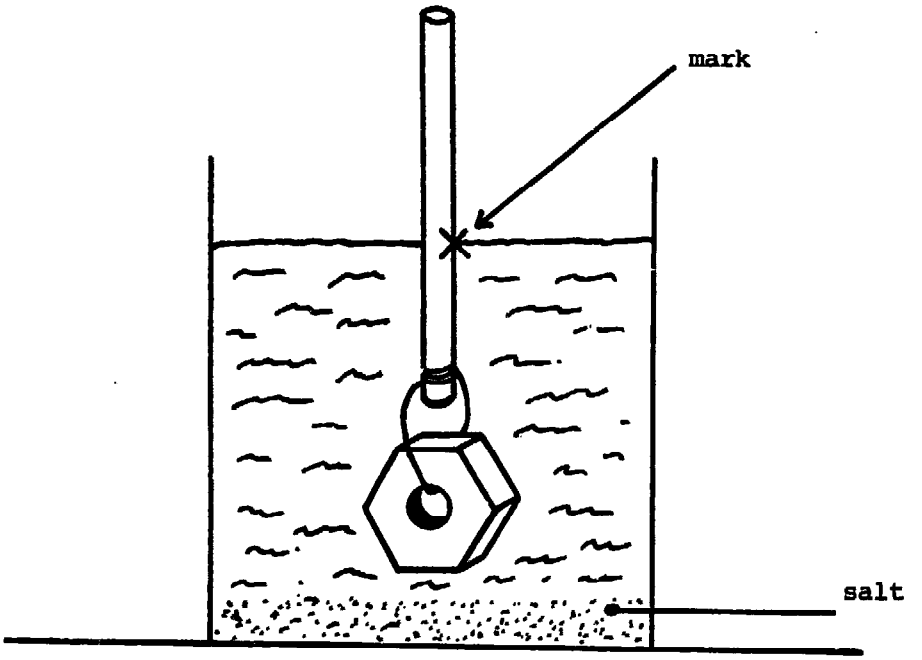


Fig. 1 The gauging of the stick or tube

As by drying out, or by water absorption, the weight of the stick may change, it is necessary to check the stick occasionally. It should dip up to it's mark in the saturated salt solution.
The salt solution for checking the stick can be used as long as solid salt remains in the solution.

An alternative for the measuring-stick is the measuring-tube. This tube consists of a small lenght of plastic (PVC-) tubing, that has been squeezed shut at the bottom so that a piece of stone or iron can be put into it. This tube can be used in exactly the same way as the measuring-stick; it does not dry out or absorb water however, so that it is more convenient. If necessary, the tube can be shut above the stone also, to prevent it from falling out.

### *4.2.2. Checking the lye concentration*

- put your stick into the lye solution, the mark will be above the liquid surface
- add slowly water, stirring well, until the stick floats into the liquid exactly up to its mark. Now your solution has the right concentration. It contains about 18w% of lye. This lye can be used for the preparation of soap.

It is also possible to make lye of the correct density by comparing the weight of a certain volume of lye to that of the same volume of saturated rock-salt solution (without crystals). These weights should be equal.
The above mentioned tricks are only suitable for the preparation of an 18 w% solution. There are no such methods available to prepared a 27 w% solution ; this should always be done by use of an aerometer or battery-acid meter.

## 5. THE MIXING RATIOS OF LYE AND FATS

In table 1 two concentrations of lye are given, 18 weight percent caustic soda in water ( 18 %w ) and 27 weight percent ( 27 %w ) . The 27 %w solution is only suitable for low temperature saponification, meaning that lye is to be added to a fat mixture with a temperature of 60 $^{o}$C ( 140 $^{o}$F ). The 18 %w solution is suitable for boiling saponification.
The solutions can be weighed as follows :

| | 18 %w | 27 %w |
|---|---|---|
| water | 1000 gr (=1 L) | 1000 gr |
| caustic soda (NaOH) | 220 gr | 370 gr |
| caustic soda (NaOH) | 1000 gr | 1000 gr |
| water | 4545 gr | 2703 gr |

Table 1 : The weightratios of the lye solutions

Per 1000 grams of water the indicated weight of caustic soda should be dissolved.
The caustic soda should be fresh, dry and pure.
The lye has to be used immediately because it is not stable on contact with air.
It is also necessary to use all the available caustic soda for the preparation of soap, in other words : to adjust the production of soap to the available quantity of caustic soda. Caustic soda in an opened container is not stable on contact with air.

**WARNING**

As lye is an agressive material it can affect the skin and eyes very badly. If by any chance your skin or eyes come in contact with the lye it is advisable to wash with plenty of water. Your skin, not your eyes, can eventually be treated with diluted vinegar. In any case one must be very cautious with the eyes, since lye may irreparable damage; if possible wear goggles or glasses while working with lye. If somebody has swallowed lye, let him drink as much water as he can and let him/her have lemonjuice, rhubarb, citrus-fruit or vinegar. Always keep the lye away from children.

In table 2 ( see page 6 ) the mixing ratio of a number of fats and oils with lye is given. For solid caustic soda the weights are given, viz. the number of kilogrammes fat or oil to be saponufied with one kilogramme of solid, pure caustic soda. For the solutions volume-ratios are given ( litres oil or fat per litre lye ) as well as weight-ratios ( kilogrammes of oil or fat per kilogramme of lye ). While working with solutions one should use the ready-made solutions as mentioned above.

| | Saponification value kg fat/kg NaOH | 18 w% NaOH kg fat/kg soln | 18 %w NaOH l fat/l soln | 27 %w NaOH kg fat/kg soln | 27 %w NaOH l fat/l soln |
|---|---|---|---|---|---|
| **Babassu fat** | 5.62 ± 0.13 | 1.01 | 1.32 | 1.52 | 2.14 |
| **Cacao fat** | 7.25 ± 0.16 | 1.31 | 1.61 | 1.96 | 2.62 |
| **Castor oil** | 7.75 ± 0.17 | 1.39 | 1.74 | 2.09 | 2.82 |
| **Cottonseed oil** | 7.25 ± 0.10 | 1.31 | 1.70 | 1.96 | 2.75 |
| **Coconut fat** | 5.46 ± 0.15 | 0.98 | 1.27 | 1.47 | 2.07 |
| **Linseed oil** | 7.35 ± 0.16 | 1.32 | 1.69 | 1.98 | 2.74 |
| **Mustard oil** | 8.00 ± 0.25 | 1.45 | 1.89 | 2.17 | 2.82 |
| **Olive oil** | 7.35 ± 0.16 | 1.32 | 1.73 | 1.98 | 2.80 |
| **Palm oil** | 7.09 ± 0.10 | 1.27 | 1.65 | 1.91 | 2.67 |
| **Palmkernel oil** | 5.65 ± 0.13 | 1.02 | 1.31 | 1.53 | 2.12 |
| **Peanut oil** | 7.30 ± 0.16 | 1.31 | 1.72 | 1.97 | 2.79 |
| **Rapeseed oil** | 7.94 ± 0.19 | 1.43 | 1.87 | 2.15 | 3.03 |
| **Safflower oil** | 7.35 ± 0.16 | 1.33 | 1.72 | 1.99 | 2.79 |
| **Sesame oil** | 7.35 ± 0.16 | 1.33 | 1.72 | 1.99 | 2.79 |
| **Shea butter** | 7.58 ± 0.23 | 1.38 | 1.80 | 2.07 | 2.92 |
| **Soya oil** | 7.35 ± 0.10 | 1.32 | 1.71 | 1.98 | 2.77 |
| **Sunflower oil** | 7.41 ± 0.16 | 1.33 | 1.73 | 2.00 | 2.80 |

**Table 2. The saponification of fats and oils with NaOH ( caustic soda )**

A number of fats and oils that have not been included in table 2 can be compared quite good to fats and oils that are included. These fats and oils can be divided into two groups :

Group 1

| | |
|---|---|
| butter | |
| foot oil | |
| chicken fat | |
| horse fat | comparable to : |
| hog grease ( pig fat ) | palmkernel oil |
| beef suet | |
| mutton fat | |

Group 2

| | |
|---|---|
| maize oil | |
| hempseed oil | comparable to : |
| tea oil | olive oil |
| tung oil | |
| walnut oil | |

If the fat that you are using is not included in this list, it can be compared best to olive oil. With this table and list you can now calculate how much oil or fat you will need for the available quantity of caustic soda.

Example :
If you have 10 kg of fresh, pure caustic soda, you can prepare

10 x 4545 = 45450 grammes = 45.5 litres of lye. ( 18 w% )
With this solution you can saponify various amounts of fats and oils, e.g. :

| | |
|---|---|
| 10 litres of lye for | 10 x 1.27 = 12.7 litres of coconut fat |
| 12.5 litres of lye for | 12.5 x 1.73 = 21.6 litres of olive oil |
| 12.5 litres of lye for | 12.5 x 1.65 = 20.6 litres of beef suet |
| 10.5 litres of lye for | 10.5 x 1.73 = 18.2 litres of maize oil |

## 6. PREPARATION OF THE SOAP

- melt the fat until completely liquid
- add eventual soap rests of earlier preparations
- add very carefully one cup of lye. Keep stirring well.
  The mixture should become thick and heavy to stir.
  If not, add a little water.
- Let the mixture come to boil softly, take care of possible spray.
- when adding more lye, the mass might boil over, pour on a little cold water
- keep stirring, gradually pour in remaining lye. If the mass thins out, stop adding lye, let mixture become thick again. If this would not happen, add a little more water.
- when all lye has been added, let boil for one hour. Keep on stirring, to avoid burning.

## 7. FURTHER PROCESSING

Now you can either :
pour the soap directly ( 7.1. )
or
prepare boiled down soap ( 7.2. )

If the first time the soap feels to "slippery" on your skin, use next time somewhat less lye.

### *7.1. The pouring out of the soap*

The prepared substance should be poured into the moulds when it is still warm. For larger quantities you can use a wooden chest, lined with paper on the inside. This paper prevents the warm soap from loaking through the seams and sticking to the wood.
Small quantities of soap can be poured in bowls, coconut shells etc.
When you have cardboard boxes at your disposal you can use these too, provided that all seams are carefully closed ( adhesive tape ) and the sides of the boxes are well supported, otherwise the warm soap will distort the box.
The poured-out soap must remain in the mould for at least 24 hours, after which time the soap blocks so obtained can be cut into pieces and left to dry in the air, if necessary.
The best way to cut the soap is to use a piece of thread on which a piece of wood is fixed on both ends, to have a good hold.

### *7.2. Making boiled down soap*

You can make so-called boiled-down soap by adding salt. This makes the mixture divide into two layers, i.e. an upper soap layer and a lower brine layer.
This treatment should be done when the liquid mixture is still hot.
The top layer of the soap must first be ladled into the mould. See to it that the bottom layer is not taken along. Also the dirt and colouring-matter that often settles between the two layers, should not be taken along with the soap. It does not matter when some soap is lost as this soap can be used again for the next soap preparation. You can simply add this material to the fat mixture, as mentioned in 3.1.
Take into account that no extra lye will be necessary for the added soap !

Boiled down soap makes hard soapcakes, which last longer, are more economical in use than softer soap.

## 8. PREPARATION OF SOAP WITH POTASSIUM LYE

### *8.1. Preparation of soft soap*

Beside the preparation of soap with caustic soda you can also make soap by using caustic potash. This process will always yield soft soap. For the preparation of soft soap you need a 24 %w solution of caustic potash. This solution is prepared by dissolving 316 grams of caustic potash in one liter of water. The density of the solution should be 1.3 ; check this with an aerometer.
The caustic potash must be dry, pure and fresh. The quantities needed can be measured according to table 3 on page 10 . Fats and oils not mentioned can be compared in the same way as done with the caustic soda.

The preparation of the soft soap is done in exactly the same way as has been told in chapter 6. The soap will not solidify but will remain a paste ; therefore, it is no use to pour the soap into molds. You can let it cool off and scoop it from the vessel.

**WARNING**

As lye is an agressive material it can affect the skin and eyes very badly. If by any chance your skin or eyes come in contact with the lye it is advisable te wash with plenty of water. Your skin, not your eyes, can eventually be treated with diluted vinegar. In any case one must be very cautious with the eyes, since lye may irreparable damage; if possible wear goggles or glasses while working with lye. If somebody has swallowed lye, let him drink as much water as he can and let him/her have lemonjuice, rhubarb, citrus-fruit or vinegar. Always keep the lye away from children.

| | Saponification value kg fat/kg KOH | 24 w% KOH kg fat/kg soln | 24 w% KOH 1 fat/1 soln |
|---|---|---|---|
| **Babassu fat** | 4.01 ± 0.10 | 0.96 | 1.35 |
| **Cacao fat** | 5.18 ± 0.11 | 1.24 | 1.69 |
| **Castor oil** | 5.54 ± 0.12 | 1.33 | 1.82 |
| **Cottonseed oil** | 5.18 ± 0.07 | 1.24 | 1.78 |
| **Coconut fat** | 3.90 ± 0.11 | 0.94 | 1.33 |
| **Linseed oil** | 5.25 ± 0.11 | 1.26 | 1.77 |
| **Mustard oil** | 5.71 ± 0.18 | 1.37 | 1.93 |
| **Olive oil** | 5.25 ± 0.11 | 1.26 | 1.81 |
| **Palm oil** | 5.06 ± 0.07 | 1.21 | 1.74 |
| **Palmkernel oil** | 4.04 ± 0.10 | 0.97 | 1.38 |
| **Peanut oil** | 5.21 ± 0.11 | 1.25 | 1.80 |
| **Rapeseed oil** | 5.67 ± 0.14 | 1.36 | 1.92 |
| **Safflower oil** | 5.25 ± 0.11 | 1.26 | 1.84 |
| **Sesame oil** | 5.25 ± 0.11 | 1.26 | 1.80 |
| **Shea butter** | 5.41 ± 0.16 | 1.30 | 1.88 |
| **Soya oil** | 5.25 ± 0.07 | 1.26 | 1.79 |
| **Sunflower oil** | 5.29 ± 0.11 | 1.27 | 1.81 |

Table 3 : Saponification of oils and fats with KOH ( caustic potash )

## *8.2. Making lye out of plant-ashes*

Ash from plants exists of anorganic materials that are partly soluble in water, partly not. In the soluble part you will find potassium carbonate together with other salts like potassium sulphate, phosphate, etc.
Plants grown on saltish oil will give ash that may contain a substantial amount of salt ( NaCl ). It is not possible to remove that salt. That is why you better not use ash coming from plants that have grown on saltish soil.
It is also no good to use ash coming from brown coal or pit-coal.

Stir the white-burned ash with water ( 1 kg ash in 1 litre water ). The specific gravity has to be 1.23 now. You can determine that with an aerometer.

If the specific gravity is too high, you may add some water. If it is too low, you may add more ash. In the latter case, when you cannot reach the specific gravity of 1.23, the ash contains an insufficient percentage of potassium-carbonate and you will have to try another kind of plant, or you can drain off the liquid and evaporate some water.

Once you have the good specific gravity, let the solution settle down one night. After that night, you may pour it off.
Take care to pour it off without shaking. It is not so bad if some sediment goes with, provided it is just a little bit. One possible way to do this, is to place the pot on a small bench before letting the solution settle down ( see figure 2).Next day you can easily pour it off.
The thus obtained carbonate solution is stable and may be obtained unlimited, provided no rain-water falls in it.

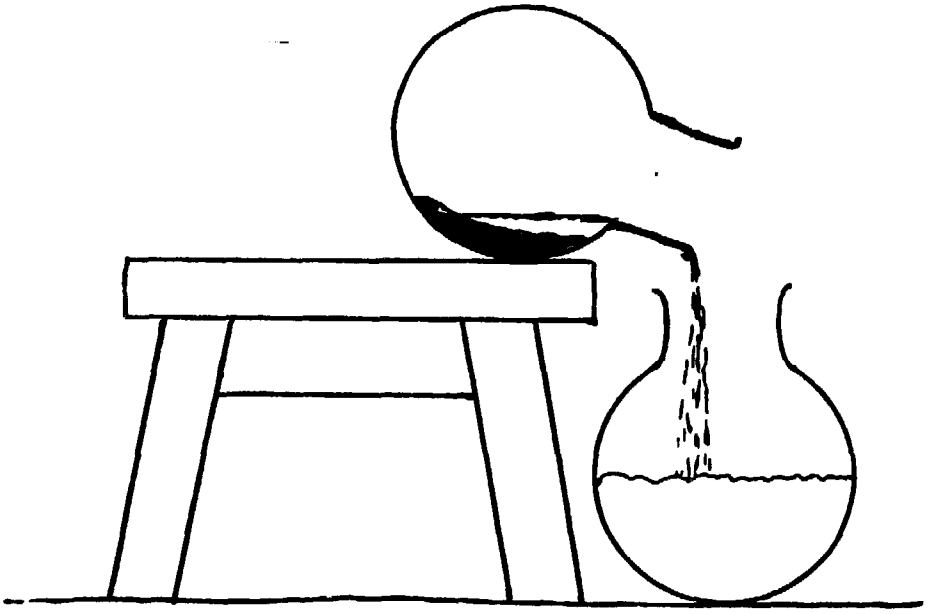

Figure 2. The pouring off of the clear solution

Add - very carefully - quick lime to the carbonate solution. This quick lime must be burned new. You cannot keep quick lime. The ratio has to be : 1 kg. new burned quick lime in 7 litre carbonate solution (with a specific gravity of 1.23).
It will become turbid that settles down slowly. The pot must be sealed well with a (thick) plastic cover. After one night you can pour off the clear solution. Now take care no sediment goes with,because this will affect the quality of the soap.
The now obtained solution is a 24 % potassium (lye) solution that may be used for the preparation of soap. It is not a stable solution, so you have to use it immediately, just like the quick lime.

Plants cannot stand lye, quick lime and carbonate.
So take care of the remainders and sediments and dilute it always with much water before throwing it away.
A fair amount of carbonate is yielded by using plantain peels, cocoa husks, peanut shells and coconut shells. Other plants may also yield good results, but you'll have to find out by trying.

## *8.3. The burning of lime*

Lime ( calciumhydroxyde, $Ca(OH)_2$ ) can be made from all compounds that contain a substantial amount of calciumcarbonate. By heating this carbonate it will be converted to calciumoxide (CaO) and carbondioxide ($Co_2$) :
$CaCO_3 \rightarrow CaO + H_2O$.
The calciumoxide can be converted to slated lime by adding water :
$CaO + H_2O \rightarrow Ca(OH)_2$ .

The calciumcarbonate will have to come from limestone or from shells. To convert calciumcarbonate to quicklime (CaO) two matters are important :

1. There has to be a fairly high temperature in the kiln
2. The kiln should be well ventilated so that the formed carbondioxide can be carried off.

### The kiln

Limekilns can be made in several types, but if you want to make use of simple techniques, you need a vertical kiln. There is a choice between kilns with or without grid.
The kiln without grid should be at least twice as high as its greatest inner diameter. The opening on top should be about one third of the greatest inner diameter. This type of kiln is very simple in building and operation. A grave disadvantage however is the fact that, because fuel and lime are mixed before burning, the product will be rather polluted. The burned lime

may not be homogenous and will differ in color form the other batches. These disadvantages are however no objections for the intended use of the lime.
Sometimes it will happen that the lime and the ashes form a smelt that will give a hard, baked cake on cooling off. The conversion will not be complete if this is the case.
A kiln with grating has the same dimensions as a kiln without grating. A slightly greater height will probably give better ventilation. Under the grating wood or charcoal can be burned. A disadvatnage of this type is, that too small lumps of limestone will fall through the grating. To prevent this, rather large lumps have to be used. This, of course, will lead to a longer burning time and a higher fuel consumption.

## The burning of lime

To get a good conversion of the lime, it should have a temperature of 500 to 600 $^{o}$C, with good ventilation.
The ventilation can be promoted by the use of fair-sized lumps, by a long chimney or by blowing air into the kiln. This last method has certain disadvantages, because it requires a compressor to blow the air, and because it will lead to cooling in the kiln. This means that the burning time will have to be prolonged.
To get a good quality of lime one will have to do some testruns. Only from experience will it be clear how long and how hot the lime has to be heated to get a good quality of quicklime from the available kind of limestone.
In general it can be said that the required temperature will be reached after a day ( 24 hours ) of burning. The quicklime will have the desired quality after two more days of burning. The process is fairly lengthy, as you see. Sometimes the quality of the quicklime can be estimated by using a metal rod to stick into the lime. The less resistance the rod encounters, the better the lime is burned.

One has to take care that, if the kilns are filled with wood, no irreparable damage to the environment will result. If deforestation results, the soil will be washed away by the rain ( erosion ). In the long term this can even lead to severe droughts.
This can be prevented by sufficient new planting, by thinning the woods only, by sowing soil-covering crops like leguminoses ( peas and such ) and by leaving trees standing in rows, making sure they don't die in the open landscape. The rows should be perpendicular to the most common wind-directon.

Please communicate any problems or suggestions for improvement you might have to the author, who will incorporate these in future issues. Thus, other fieldworkers can benefit from your experiences.