Freezing of fruits and vegetables

An agribusiness alternative for rural and semi-rural areas

FAO
AGRICULTURAL
SERVICES
BULLETIN

158

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Rome, Italy

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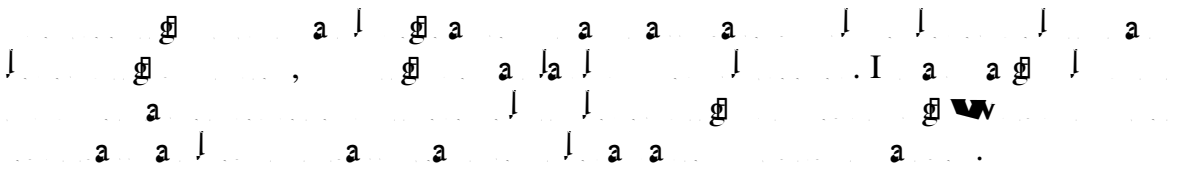
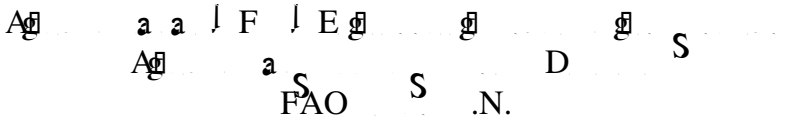




H– F–

IIR

I c

I F

L I

L ca fr ra –

a r c d F d

r a r r f

c a

da

r fr a

r ra

r ar ac a

c fr

S c dar ac a

Ca 1

ee

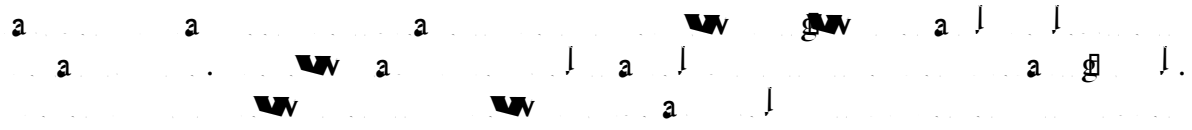
F [illegible] a [illegible] a [illegible] a

– rr a ffr f d d r _ S a d r c r

. I , a $ 75 . $ $ $ 27.3 2001 a (AFFI, 2003). I E , a . , $ 11.1 13 a 2000 (Q F F I a a , 2000). a 1 2001.

Ad a a ffr c d c r

D , ., a a a a a $. a a 7 $., 01.



Early years

Growth and development

Recent years

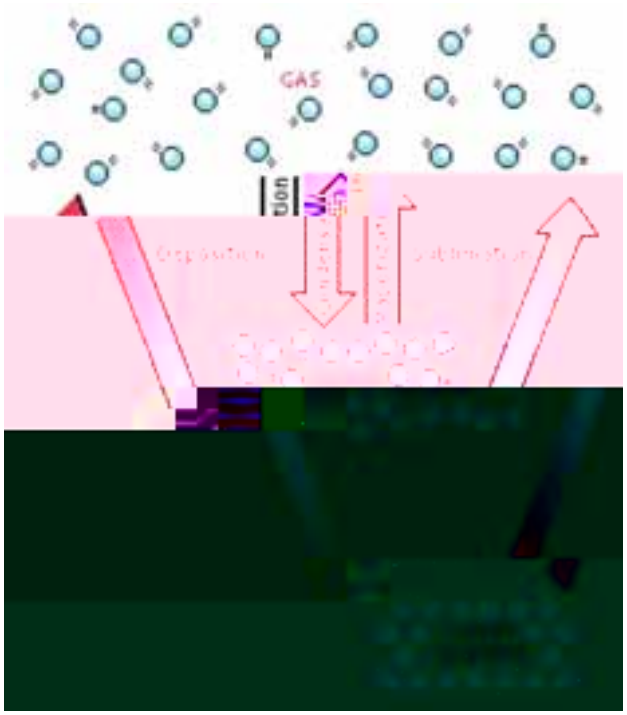
Further reading

, 1977).

1.2

F

Fg 1. A c a c ra f ra fr r c



(L , 1979).

I a a I g a (II) a a a a
g . A g , g a a
, a Fg 2a 3 a .

B g g ag , g
a a a . I a a , g

(P L , 1993).

(P L , 1993).

F

A , S , ( )I I (1986) (P L , 1993). :

- D
- I
- S C
-

G P ' (E .1) P .

a 4. – ff c a d R f E a

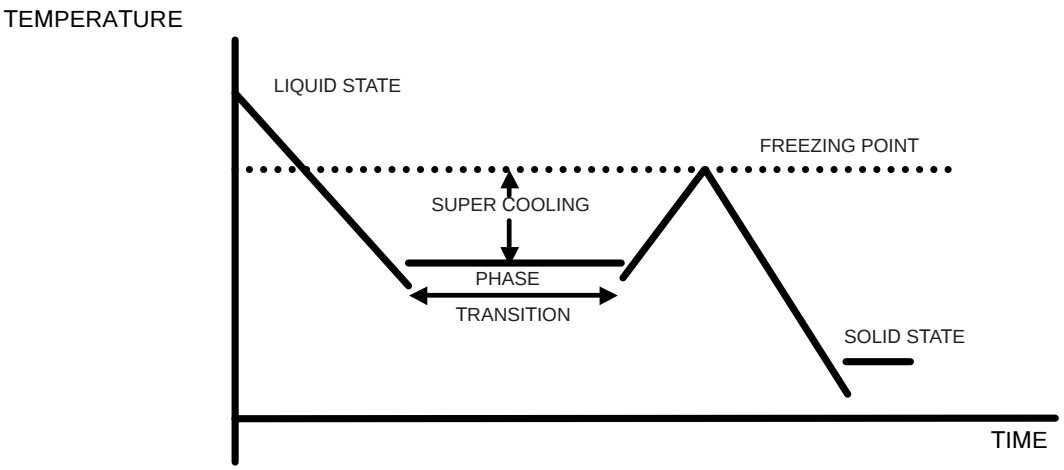
Geome r	P	R	Dimen ion
Infinite slab	1/2	1/8	thickness e
Infinite cylinder	1/4	1/16	radius r
Sphere	1/6	1/24	radius r

$$t_F = \frac{\rho\lambda_l}{T_F - T_e}\left[\frac{e^2 R}{k} + \frac{eP}{h}\right] \quad (1)$$

a l W a a l a , a l a l a l a l W a a . l l a l W l l a W a a a l Pa a 4a l a a a l a l a a a l W l l (. . a , a a l a l W l a l l).

A l a , a Pa a l a a a a a a . H W , l a a a a a a a a l a a l a Pa a l l l l , a l a a a a (Ba a -Ca a a l I a , 2002).

Fg 4. Fr r r a d a c c r



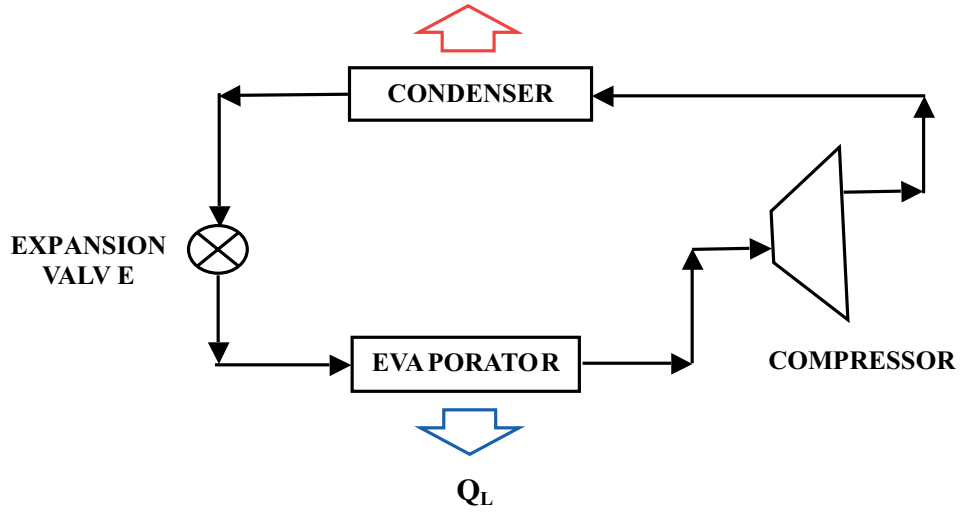
... a ... a ... a

NJ: P ag (D a a)
ΔH : E a a g g a
Δ : a a a a

1.2.3 Ref ige a ion

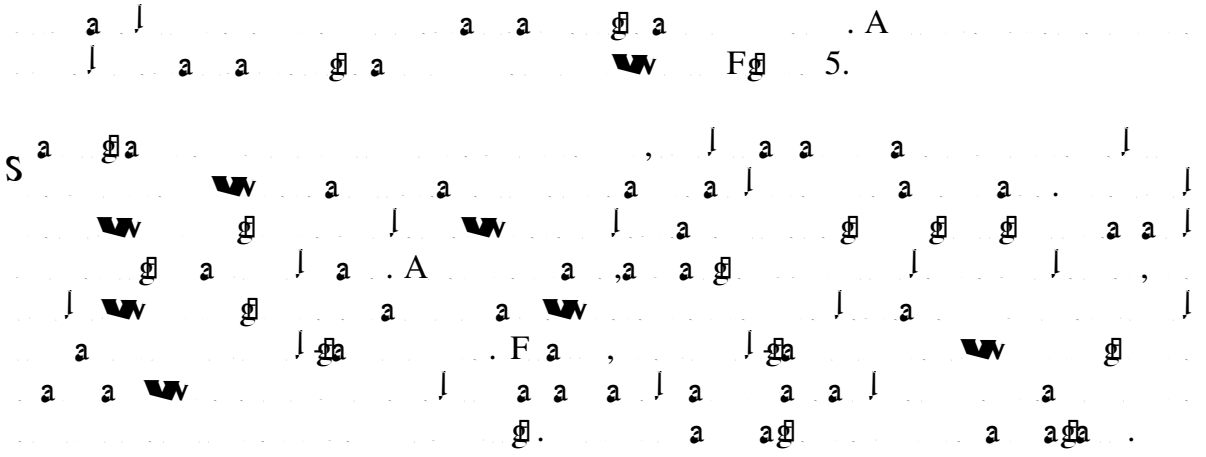
g a a a a a a a a a a a
g a a g . a g a a
a g a g ag a a
g . A g a , a
g a , a a a
g a , a . a a
g a a a a a

Fg 5. A c f r a a c d c a ca r fr ra
Ada d fr S c r F a d R fr ra a d Ar – d
c ra H r



g a . F a , a a g a
g a a , g g
(LIN) a a (CO2),a a .

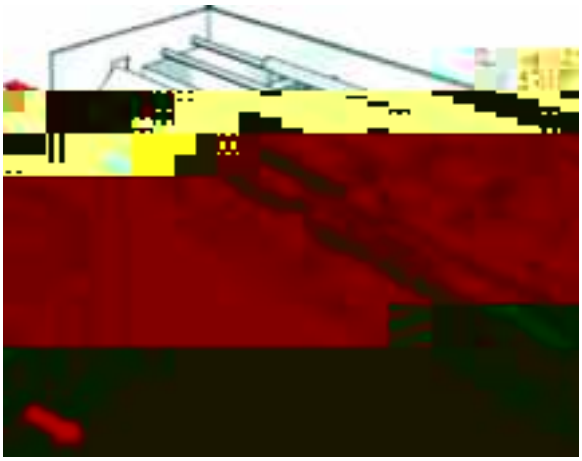
a a a a g a a ,
, a a , a a a . g a
a (HCFC) a a a a a g a



1.2.4 Feeding capacity

1.2.5 Feeding time

Fg 9a. – r c a f a f d d d fr r
– r f Fr ca d a E L d –



a a a a g a a a a

T fr r

I , a a a a a a . I a a , a a . a a , a a a a a a (Ma , 1993). A a F 7.

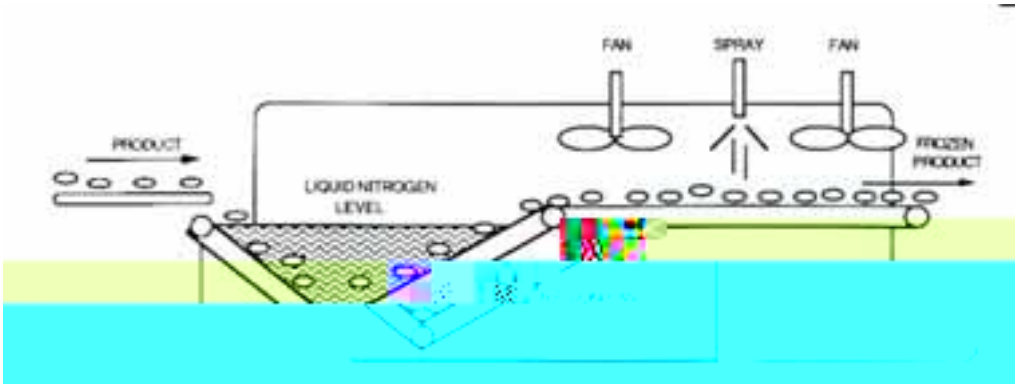
B fr r

B a . A a a a a

a a a a a . A a a . I

, a a - a a , a a (a a , 1999). a

Fg 11. S ra f a ca r fr r F

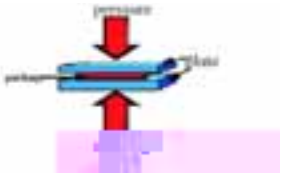


Fg 12. I d r c c ac fr r

, a g a a (G g , 1993). g a g a , a a a a a g a , a a .

a a a a a g a (IQF), a a a g (P a L a , 1993). a a a (IQF) a g a a a

Fg 13 . r r a ca a fr r



g. a a g a a v a g g IQF g. S a g a , v , , - a , a a a v v g . A a - v Fg 9 a a 9 .

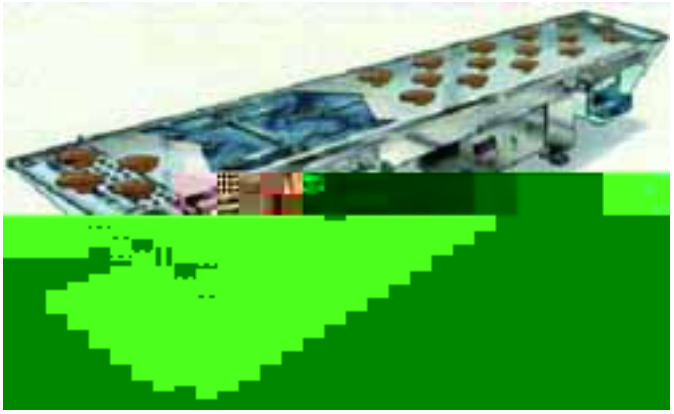
Fg 13 . a fr r a a c r r a d a a r c d r – r f SI Sa f Fr r S r I

C a g va a g a a a . I g, a a a v g . F a , g g a , a g a a . A a a g Fg 10. F a , a a v a v a v g (Ma , 1993).

I r fr r

a a a , a ,
, a , a a .
a , a
, a a (H a

Fg 14. – **ac fr r**
– r f Fr ca d a E L d –



K , 1996). D a a a a
a a a a a .
a , , a ,a
, a a a .
I a a a
a a a a a a
. A a a a a .
, a a a , a
a (G , 1993). A a
Fg 11.

I d r c c ac fr r

I , a a a a a a
a a , a a . a a
Fg 12. I a a a
a a , a a , a

a a . A a ,
a a a a a .

a fr r

a a . I a , a
a a a , a a a
a a a a . P a a a a
a a Fg 13a .
a - a a a a .A a a
Fg 13 .

– ac fr r

a - a - a a
a a Fg 14. a a a a
. a a , , , a a
(P a L a , 1993).

C a a a -60 C a a a a
a a a (H a K , 1996). a
a a ; a
a a a a a - a
a . , a a a a . L a
a a a a a a a (P
a L a , 1993).

L d r fr r

L a a -196 Ca a , a -
a a a . a a a a
2a a , a

L d car d d fr r

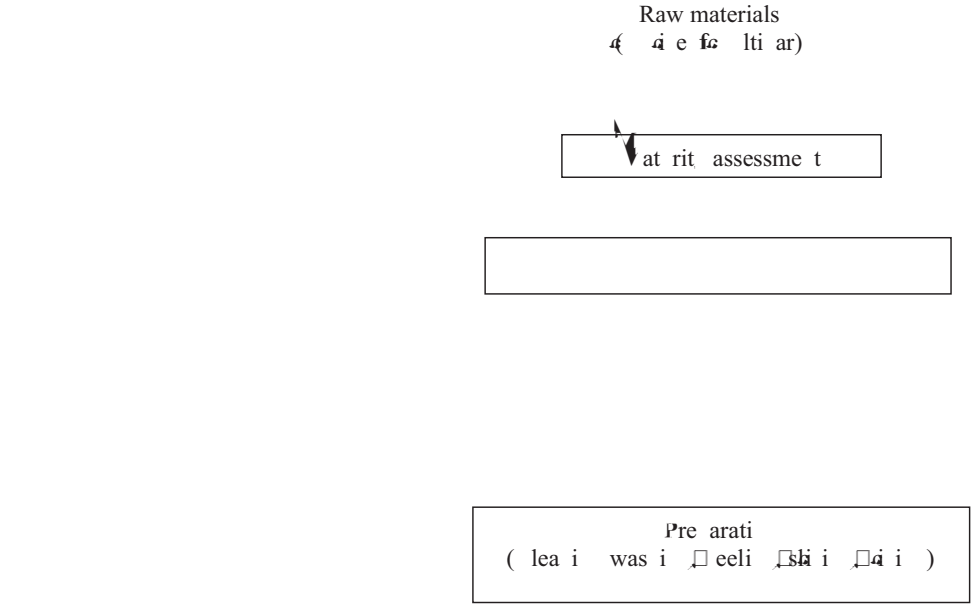
L a . a -70 C, a - a . a (G , 1993).

1.2.7 Packaging

P a , a , a . a , a (a , 1999). P a a . a : a , a , a . a . S a . a (Ha C , 1993).

P a , a . O a - a , a . M a , a , a . I a , a . D a , a (M , 1999).

A a , a , a . Ga , a , a . Pa a (B ,


Raw materials
at rit assessme t
Pre arati

1982). N - a a - a
a a , a a . B a
a a a a a a a
a a a a (H a a C , 1993). a
a a a a a a .

S a a a a a a a a a
a a a a a a a a
a a . F a a ,
99 a a a - a a

1.3.1 F ee ing f i

g, ag , a ! w g a a

C a a . I , a a a

1978). 30-60

1968).

F

Fruit	Preparation	Packing
Apples	Wash, peel, and slice into antidarkening solution -- 3 tablespoons lemon juice per quart of water	Pack in 30-40% syrup, adding 1/2 teaspoon crystalline ascorbic acid per quart of syrup. Pack dry or with up to 1/2 cup sugar per quart of apple slices.
Apricots	Wash, halve, and pit.	

P a l l gha , ,
a l a . P a a l l gl 1 v l l v 1
va . l a l l 1 ; 1/2 gha a l l l
a l l l ; l l v v a l l va .
P a l a 4 6 a v a l gl
a l l l v a . a a l a l (Ba l ,
2002).

S ar ac
I a gl a gha a , gha l . a
a gl a l gl l v a l gha l l . a
gl a l l a a , v , , a l
, gl v a a
a v gha gl (B , 1996). S

l ac
v l a a a l a va , l - a l , v
va a gl a a l , a l v l . va
l a l gha a , gl l gl a a l
va - a a a . G a , v l a l a v a l
v a v gha a v , a a ,
, a l l a , gl , a , a l a a a gl l
a v gha (B , 1996).

Tra ac
v l a a gl a a l gl a a v a gl a
a l a l a v a , , a l a a gl l a gl
. a v gl gl v
a l a a gl gl .

S ar r ac ac
A a v a l a l gha gha .
v a gha a a l gl l v , v
a gha a l a a l .
F v gha v a l a l v v a
v gha (B , 1996).

1.3.2 F ee ing ege a le
F gl l l a l a a va a
gl a (Ga , 1996). F gl a a l a a gl a
a l (Ma , 1993). a

Fa d ab : a a -b a a d a a

a d a d a

a a a

e e e	P/e r ion	n /ee e
Asparagus	Wash and sort by size. Snap off tough ends. Cut stalks into 5--2q1Tf0.74 03.49D0.0027 (04 1 Tf 0.8949 0 40.0019 Tc (ut)-27m1(nt1 nT q 1Tf 6.4 0))10.	

(L , 1989).

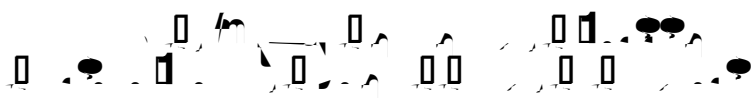
Ba

Ba Pa ( ) , , , , , . I a a , a a . Ba a a , a a . I a a a (D a , 1977).

Ba a 70 105_ C a a a 75a 95_ C 1 10 , (H , 1983). Ba a a (D a , 1977).

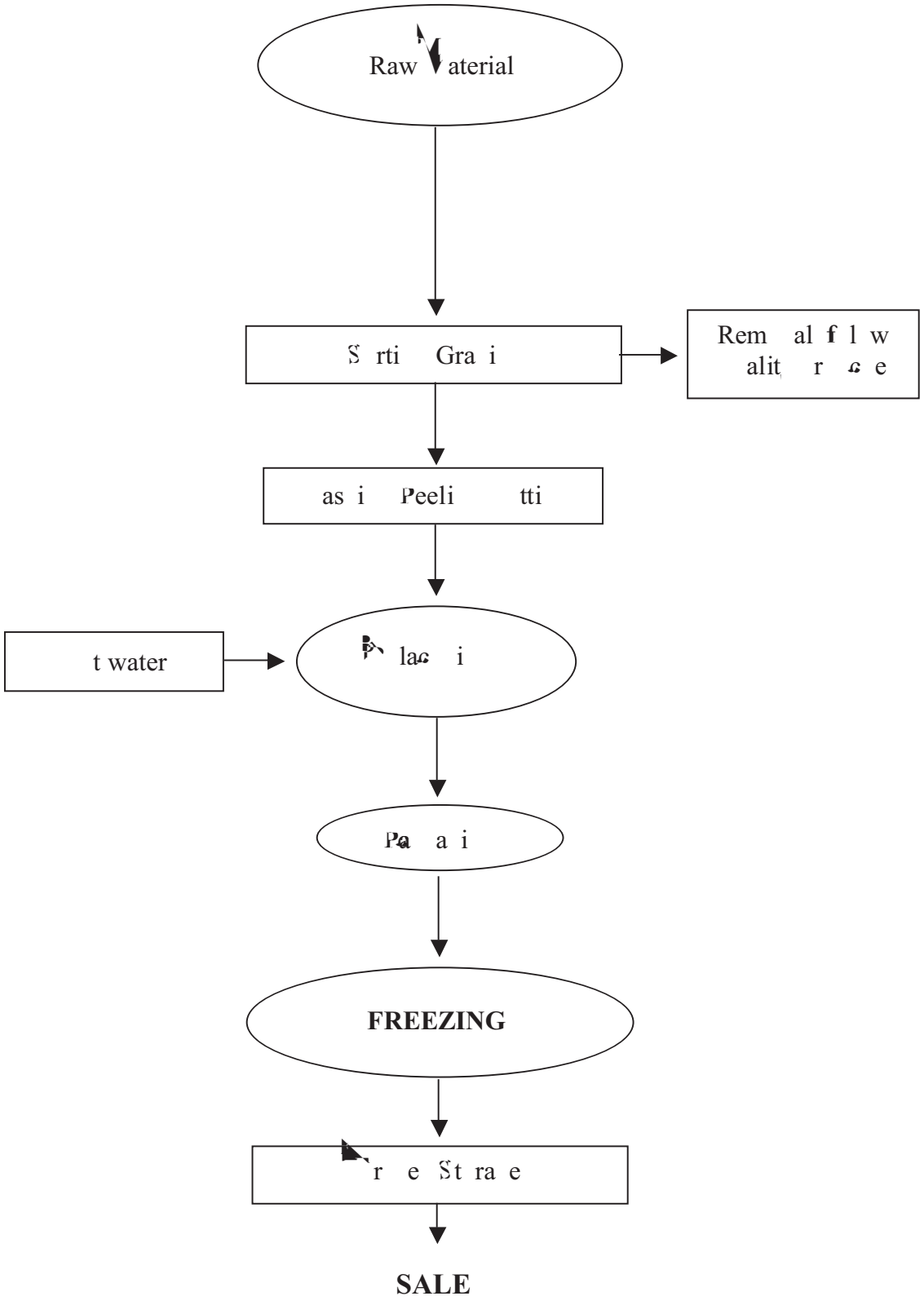
a , a , a . P a a a , a a a (A , 1993).

a a a , a , a . H a a a . Ba a 6 a a . F a , a a a a a a a a (A a , 2003). a a a a S a a .



G a a a

Fg 19. F d a ra ffr r c f a a d r d c



I a . a a a

E (H , 1968).

Ca 3

3.1

a a a a a . , a
a a . I a a ,
a a .

3.1.1

a -a a a -a a a a
:

- F -a a
  a , a , a (40)
- a -a a
  Ga , a , a , a

3.1.2

A a a , a a
a a a .
a a a , a
a 1 000 a (a) a
a a a - a a a a a a
a a a a .S
a a a a a a a a .
C a a a a
a a . C a a
a a a , a CF146
a 414 , a a a a
a . F 20.

Fg 20. a – F c fr r a f

7 7 1

a - g a a a ag g a wa g a g, wa a g, a a ag g. I g a , g g a . a a a ag a .

7 . ,

F w g g a , a a a a ag , w a a a a . D g ag , a g a a a a g a , w a a a ag a (Ba a a Fa , 1987). F a ag a a a g a , a g wa w a a a a w a a a g a a . , a a a a a ag g a w .

C a g a a a a 30 Ca a a a ag . a a ag a a g, aa , a . H w , a a a - a a a a a a a (J a , 1994).

Ca 4

a a a

D a a a , a a a

. Ma a a a , a a a a a a a a .
. Ma a a a , a a a a a a a a .

F ab d

a. a a a a a a .
. Ma a a .
. Ma a a a , a a a a a a a a .

F a a , a a , a a a a a a a a

F ! g a a , a a ag a :

r Fac

g ¾ (85g)

S g S P C a 5

S A g

Ga 25 Ga a 0

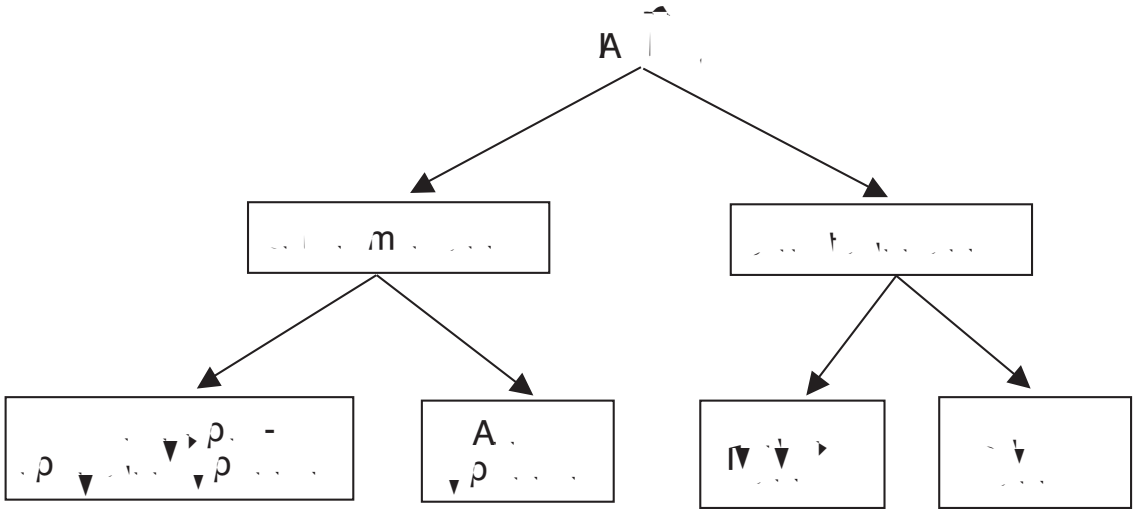
% Da a *

a 7. – ar f fr f r a fr a d a
e al.

e o	roxim ef ree in ime
(10):	
A	3 5 1/2 2
B :	
B	20 30 m 5 10 m 1/2 1 m

F .1

a a g a g a l l l w a a a :
e a l d e . a l w l l a
a w w :



– $1 000 /

5.1.1 Investment costs

– : $250 (,

a 9. E a f a c f r fr a

e o

e	n i	ni Co	o Co
- K	1	250.00	250.00
D	1	100.00	100.00
D F	1	600.00	600.00
	1	300.00	300.00
	-	150.00	150.00
		O AL	$ 1 400.00

r ra c _ S
A c _ S
I c _ S

ar a c
a a a g a g a a w
a a g a . w g :

- w a a ;
- a g a ;
- w a (a , , , g a w a ,);
- a a a a ;
- a g ;
- a a a g .

F dc

F a a a

3. Ca a ... a a a ... 100 g ... .

R m eri n ie 100 e e e			
R eri ... ni	ni Co	o Co	
C ( )	25	1.25	31.25
G B ( )	25	2.50	65.50
O ( )	25	1.25	31.25
C ( )	25	2.00	50.00
( )	500	0.01	5.00
P M	200	0.05	10.00
		O AL	$ 193.00

4. Ca a ... a a a ... 1 000 g ... .

a a a ... : $ 193 10 = $ 1 930.00
La : $ 600.00
E g : $ 75.00
T a ar a c $

F d e : a

1. Ca a ... a :

A a ... a = a / 8
M ... a = A a ... a / 12

a a = $ 1 400.00
A a ... a $ 1 400 / 8 = $ 175
M ... a $ 175 / 12 = $ 14.58

2. G a a a l a :

D a :		$ 14.58
A l a :		$ 425.00
T a f d c		$

a a a :		$ 2 605.00
a l :		$ 439.58
T a r d c c		$

Ca a a d . P a
1 000 / a 500 a a a a a .

(a a) = $ 3 044.58 / 2 000 = $ 1.52

a a a $ 3.20 a .

E a a a a a . E a a a a a :

M = F / (a a)

a a : a a a / 2 000

ar a – r ac a S

M = $ 439.58/($ 3.20 - $ 1.30)
M : 232 a a

I , 232 a a 2 000 a
a .

AFFI 2003. A a F F I ,
(a . /a a - a) : NPD, G , I ., F
I , F F Ag , I I, Na a a A a , , I ,
a A a .

Arc r d – a d A 1995. a a
g a a v a g a
a a a - v . I a a
J a F a g . 30, . 711.

Arc a 2003. F g g a G E-320. N v M a ,
g Ag a H E E .

Ar 1993. F g g a a . I : Ma , C.P. ., F F
g C a a a Ha , L , K.

ASHRAE Ha d 1994. g a a A a , A a
Ha g, g a g, a A - g E g , A a a , GA,
A.

Bar a – a a a d I ar A 2002. O a F E g g.
C C P , B a a , FL, A.

B a ard a d Fra F 1987. I a a a -
. F a a , Aa P , L , K,
. 51-65.

B dr AE 1981. F a a a . N a F I , Na gd . 19, . 24.

B F a d f rd ER 1968. aa gda gd , F gd P a F , 3, 4 ., A I , C , A.

B F F r B a d f rd E R 1977. F gd . I : D , N. ., , D.K. , F a a F F gd. A P gd I . , A. . 135-215.

Br d A 1982. Pa Ma a . 4 ., B w , L , K.

– a ad a F d I c A c a 2004. P a a P C a , F a D gd gd a , C. .C., 870 (w . gd .a/ gd / gd/ gd .).

– a a d ar A 1992. Pgd a a a w . J a Agd a F C . 40, . 2141.

– a 1996. gd a , F gd E Qa , Ma D , N .

– a ar A a d F r – 1990. F gd a a a , I a a a a gd. J a F . 55, 4, . 1070.

– – 1985. a a a gda w gd a a a a . J a F .

– a a d a d – a a d A – 1987a . P gda w gd -a a a . Pa :1 gd a a . I a a J a gd a . . 10, . 156-164.

– a a d a d – a a d A – 1987 . P gda w gd -a a a . Pa : 2 I gd a a . I a a J a gd a . 10, . 234-240.

ad A E a d S 2000. Ha a a gd gd ,a w . J a F E gd gd. 47, . 157-174.

r r a d r r . 1977. P F l F g, g F l F g, 4 l., A I P g C . I . C , S A.

r r a d Tr r 1977. F l a a F l F g, A I P g C . I . C .

r c – R L a H a d B 1959. - a a l. III. E a g l a a , F l g , 13:258.

SI Sa f Fr r Sr I I a (w w w . l a .).

E c a R a d r c R 1977. F F l , P F l F g, g F l F g, 4 l., A I P g C . I . C , S A.

F 2000. F l g g , a l a . C C P , B a a , FL

F a 1977. L a a l l . F l g , 12:32-38.

F a R 1973. w a P a l a l g a . F a , O. ., N w , . D., Ma , E. H., E l , P , N w , C . 3.

Fra F 1985. B a l a w a , Ga l g P , Ga l g , K. . 21.

Fr ca d a L T (w w w . l . /FMC).

r R 1993. F g l l l . l F l S a l g . 4, . 134.

c d 1968. P g a l w a ag , w a a a l g a , I w a B g F l , A l a F l S , 4, P g a P , L l .

rad H 1988. ag , a a l a g

a a a . D A I B48:9.

Harr R S a d ra r E 1975. N E a a l P g, 2 l l. A P g C. , S A.

Harr a d – r c r 1993. Pa a g g F F l, F F l g (Ma CP l.) C a a a l Ha , L l , K.

H rr T 1968. C a g g a l g a a g F F l P g Pa , H S g , A a a , 23 l la A .

H d r S 1983. P a F a l g a F l P l , Ma a P , L l , K.

H H a a a S ra a E rr a d 2004. Ha l g a P a a l P g. Ma D , I .

H – a d 1996. F la a a - a g. F l 50:59.

, 14:549.

a – 1993. F F l gd . Ca a a l Ha , L l , K.

a T ad T 1993. P l a Fa C , F F l gd (Ma CP l .) Ca a a l Ha , L l , K.

c a Sa r E 1999. C a gd. P gd F l Sa (. . . l / / / l 01/01600506.).

ad A 1978. E gd, agd a l l a a l a l, a a a l gd a . F l Qa a l N , A l P L l . L l , K.

a a a Ta Sa d Ha S 1955. E gd a - a , P . 9 I C gd gd, Pa , Fa .

r a d L da 1993. F gd gd , F F l gd (Ma CP l .), Ca a a l Ha , L l , K.

a T ad a R F 1977. M gd a a l I a a F F l . I : Qa F F l , E , M. C., H gd, ., E l . Ca a a l Ha , N w

a R 1980. E E l F a I l a l a A a , Ba a: .

c Fr F d I r a a 2000. G a F F l A a a , 33, N .2.

Ra a S 1999. Ha l F l P a , Ma D , N , S A.

Ra a a H S a d T A 1984. A w l gd gd l . J a F l P E gd gd . 7, . 169-203.

R d L 1949. C a E gd gd gd . 21, . 340.

R r L 1985. Ca gd a l a w l gd gd a l agd . F l C , . 17, . 25.