ジンバブエ共和国
クエン酸工場建設計画
事前調査報告書

1990年12月

国際協力事業団

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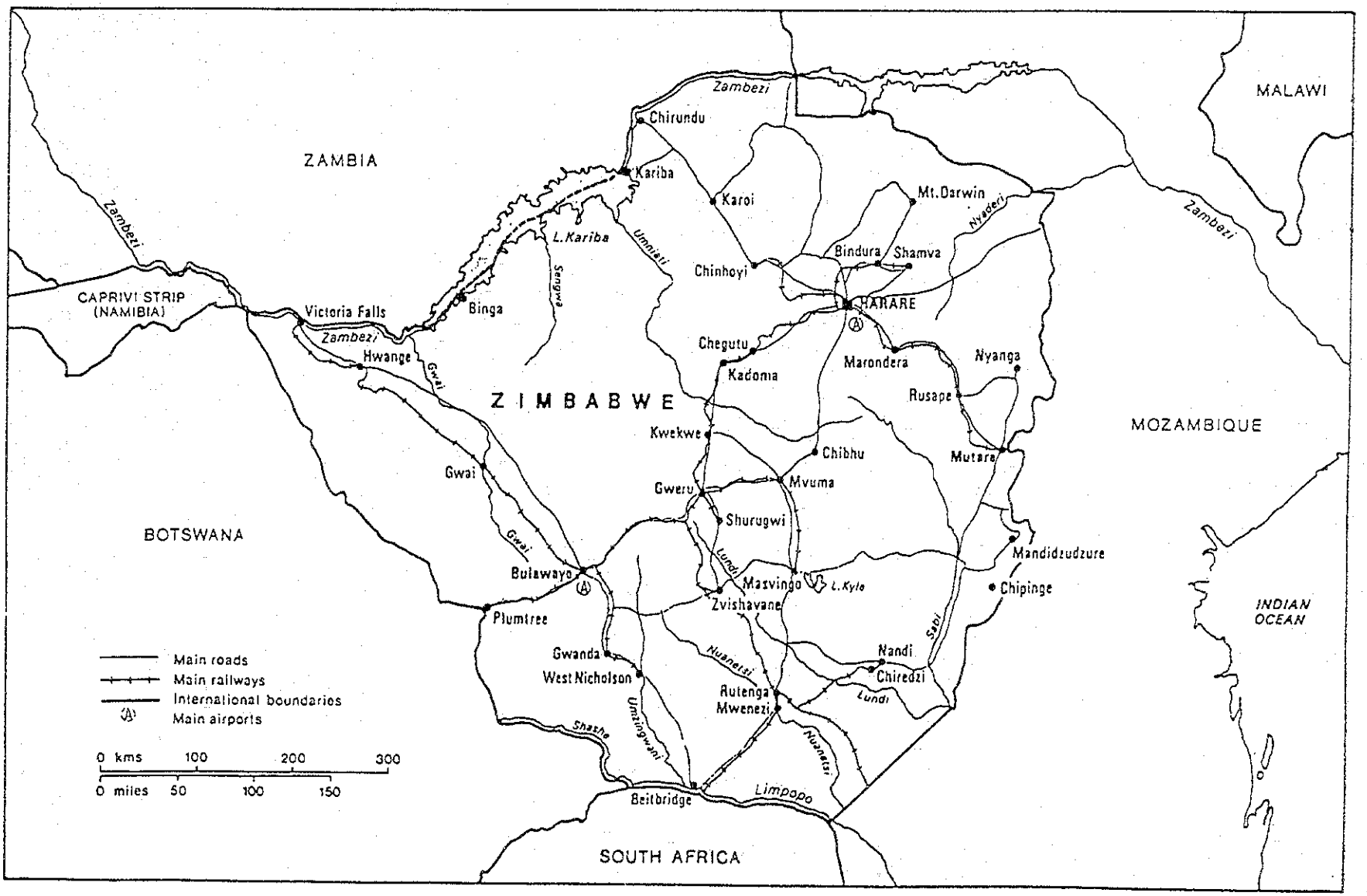
略 号 表

CAM	Citric Acid Monohydrate (Citric Acid)
Food and Industrial	Food and Industrial, The Delta Group, Harare
IDC	Industrial Development Corporation of Zimbabwe Limited
LOC	Lime of Citrate (Calcium Citrate)
MFEPD	Ministry of Finance, Economic Planning and Development, Zimbabwe
MIC	Ministry of Industry and Commerce, Zimbabwe
M／M	Minutes of Meeting, August 28, 1990
PTA	Preferential Trade Area, Southern Africa
SACU	South Africa Common Customs Union Area (South Africa, Botswana, Namibia, Lesotho and Swaziland)
SADCC	Southern African Development Coordination Conference
S／W	Scope of Work, August 28, 1990
ZFC	ZFC Limited
ZIMPHOS	Zimbabwe Phosphate Industries Limited
Z$	Zimbabwe Dollar, US$1.00=Z$2.45… August 20 to 27, 1990
ZW	Republic of Zimbabwe (Zimbabwe)

Zimbabwe


ZAMBIA
MALAWI
MOZAMBIQUE
BOTSWANA
SOUTH AFRICA
ZIMBABWE
CAPRIVI STRIP (NAMIBIA)
INDIAN OCEAN
Zambezi
Chirundu
Kariba
L.Kariba
Karoi
Mt.Darwin
Nyaderi
Umniati
Sanyati
Chinhoyi
Bindura
Shamva
HARARE
Victoria Falls
Binga
Hwange
Gwai
Chegutu
Kadoma
Marondera
Nyanga
Rusape
Kwekwe
Chibhu
Mutare
Gweru
Mvuma
Shurugwi
Gwai
Lundi
Bulawayo
Masvingo
L.Kyle
Zvishavane
Mandidzudzure
Chipinge
Sabi
Plumtree
Gwanda
West Nicholson
Nuanetsi
Nandi
Chiredzi
Rutenga
Mwenezi
Lundi
Shashe
Umzingwani
Beitbridge
Limpopo
Main roads
Main railways
International boundaries
Main airports
0 kms 100 200 300
0 miles 50 100 150

Ⅰ　事前調査の概要

Ⅰ　事前調査の概要

1.　調査の背景・経緯

ジンバブエにおいては、製造業部門が国内生産額の約24％を占めており、その内訳をみると、食品加工部門が24％となっており、農産物加工部門が、食糧自給と外貨獲得の両面でジンバブエ経済に大きく貢献している。

一方、食品加工部門において、現在、ジンバブエは清涼飲料水の添加物として、クエン酸あるいはそのカルシウム塩を輸入している。このため、ジンバブエ政府は、外貨節約さらに外貨獲得のため、クエン酸工場を建設し、内需及びＳＡＤＣＣ（南部アフリカ開発調整会議諸国への輸出用として、クエン酸あるいはそのカルシウム塩の供給体制の確立を目指して、クエン酸工場の建設に関するF/S調査の実施について、1989年9月、わが国の技術協力を要請してきた。

上記要請を受けて、1990年2月に予備調査団が派遣され、要請されたプロジェクトの背景、内容に関する情報収集が行われた。

予備調査団の調査結果に基づき、関係各省間で検討したところ、本件プロジェクトについては、実施へ向けてさらに進捗させることになり、ＪＩＣA専門技術嘱託　冨田堅二を団長として、1990年8月18日から同年8月31日まで、実施細則（S/W）の協議、署名を主目的として、事前調査が実施された。

2.　調査の目的

1)　実施細則の協議

2)　関連工場等の視察

3)　関連情報の収集

3.　調査団の構成

氏　　名	担当事項	所　　属
冨　田　堅　二	団長・総括	ＪＩＣA専門技術嘱託
鈴　木　康次郎	調査企画	ＪＩＣA鉱工業計画調査部工業調査課
桑　原　　誠	プラント技術	ユニコインターナショナル㈱シニア・コンサルタント
安　川　俊　武	クエン酸技術	日本くえん酸工業組合理事

4. 主要調査日程

月	日	曜	AM/PM	主要調査事項	宿泊地
8	18	土	PM	• 東京発（ＪＬ７７１）	機　中
8	19	日	AM	• シドニー着	シドニー
8	20	月	AM	• シドニー発（ＳＱ０２３）　パース経由	
			PM	• ハラレ着	ハラレ
				• 団員打合せ（第１回）（交渉対処方針打合せ）	
8	21	火	AM	• 大使館（六條臨時代理大使、佐野書記官へ対処方針説明）	ハラレ
				• 大蔵・経済企画・開発省（マチャラガ局長と面談、Ｓ／Ｗへの署名は商工省次官が適切との指示）	
			PM	• ＩＤＣ（ムニャワララ研究開発部長と面談）（本件調査に係わる背景、現状等についてブリーフィング）	
				• ＪＯＣＶ稲田調整員と面談	
8	22	水	AM	• ＩＤＣ（ムニャワララ部長他とＳ／Ｗ協議）	ハラレ
			PM	• ジンバブエ大学（ベニュラ生化学科教授と面談）	
				• 団員打合せ（第２回）（Ｍ／Ｍ案の作成）	
8	23	木	AM	• 澱粉工場（フードアンドインダストリアル）視察、（原料事情について聴取）	ハラレ
			PM	• 肥料工場（ジンバブエ・フォスフェートインダストリー）視察	
				• 団員打合せ（第３回）（Ｍ／Ｍ案の作成）	
8	24	金	AM	• ＩＤＣ（シバンダ部長とＭ／Ｍの作成について協議）	ハラレ
			PM	• 大使館（川尻書記官へ経過報告）	
8	25	土		（資料整理）	ハラレ
8	26	日		（資料整理）	ハラレ
8	27	月	AM	• ＩＤＣ（ムニャワララ部長他とＳ／Ｗ、Ｍ／Ｍ協議）（川尻書記官同席）	ハラレ
			PM	• ＩＤＣ（Ｓ／Ｗ、Ｍ／Ｍの校正）	
8	28	火	AM	• ＩＤＣ（Ｓ／Ｗ、Ｍ／Ｍの最終文書を作成したあと、ジンバブエ側の対応に委ねる）	機　中
			PM	• ＩＤＣ（調査団滞在中にＳ／Ｗ、Ｍ／Ｍへの署名は困難と判断し、今後の対処方針を通告）	
				• 大使館（川尻書記官へ経過報告）	
				• ハラレ発（ＢＡ０５２）	
8	29	水	AM	• アムステルダム着（ロンドン経由　ＢＡ４３０）	アムステルダム
8	30	木	PM	• アムステルダム発（ＫＬ８６１）	機　中
8	31	金	AM	• 東京着	

5. 主要面談者

* Ministry of Finance, Economic Planning and Development
  Mr. O.M. Matshalaga, Under Secretary (Domestic and International Finance)

* Industrial Development Corporation of Zimbabwe Limited (IDC)
  Mr. L.A. Munyawarara, Manager for Research and Development
  Mr. P. Sibanda, Projects Appraisal Manager
  Dr. C. Chitsora, Senior Engineer
  Ms. L. Dhliwayo, Research Economist
  Ms. E. Ndlovu, Research Economist
  Mr. T. Sain, Legal Advisor

* University of Zimbabwe
  Dr. M.A. Benhura, Professor, Chairman, Department of Biochemistry

* Food & Industrial (A Division of Delta Consolidation (Pvt) Ltd.)
  Mr. S.P. Kuipa, Managing Director

* Zimbabwe Phosphate Industries Limited
  Mr. E.M. Makonese, Managing Director
  Mr. T.A. Mashingaidze, Technical Manager
  Mr. D.S. McCullach, Technical Manager

* 在ジンバブエ日本国大使館
  臨時代理大使　六 條 幸 雄
  一等書記官　川 尻 幸 雄
  二等書記官　佐 野 浩 明

* 青年海外協力隊
  調 整 員　稲 田 武 司

6. 調査後の経緯

- 1990年11月上旬、ジンバブエ側署名済みのS／W及びM／Mが大使館に提出され、日本側に送付された。ただし、S／Wの署名者名が無記名のままであったので、外務省経由にて確認し、11月27日、ジンバブエ側署名済みのS／W及びM／Mに署名者名を記入の上、富田団長に署名してもらい、外務省経由にてジンバブエ側に送付した。（その際、署名交換の遅れに伴ない、約3ケ月程度のスケジュールの遅れが出ることをジンバブエ側に通報してもらった。）（参考資料－2）
- 1990年11月29日、日本側に、ＩＤＣの副総裁名にて、事前調査時の質問書への回答が送付されてくると共に、調査期間の短縮を希望する旨の内容を記した書簡が送付されてきた。（参考資料－3）
- 1990年12月5日、ＩＤＣより、日本側に原料資料が送付され、クエン酸製造試験が固体醗酵法については、昭和化工㈱、液体醗酵法については、磐田化学工業㈱のそれぞれの好意により実施された。（Ⅳ章参照）

（鈴木康次郎）

Ⅱ　協議交渉内容と結果

II　協議交渉内容と結果

今回のS／W協議に際して、ジンバブエ側は、ＩＤＣのムニャワララ研究開発部長を代表とするチームが対応したが、終始、日本側調査団に応接したのは、シバンダプロジェクト審査部長のみであった。

なお、S／Wへの署名が予定されていた商工省ゲザ次官並びにＩＤＣのサニャンガ総裁の調査団への応接はなかった。

1.　S／Wに関する協議

日本側で作成したS／W（案）について、ジンバブエ側は、下記のとおり、調査目的について修正を提案した以外はすべて原案どおりの内容で了承した。ただし、ジンバブエ政府のUndertaking（U／T）条項については、今後、ジンバブエ側で対応することになっている。

1)　調査目的

- ジンバブエ側は本件調査の目的を具体的に表現したいとの主旨で、下記のとおり、日本側提案を修正したいと提案した。

〔日本側提案〕

to formulate the most optimized project scheme with respect to the production technology of citric acid ……

〔ジンバブエ側提案〕

to establish the technical, economic and financial viability of producing citric acid…

- これに対し、調査団は協議の結果、ジンバブエ側提案を了承した。

2)　S／Wのジンバブエ側署名機関

当初、ジンバブエ側はS／Wへの署名はＩＤＣのみ行うことにしていたが、S／Wにはジンバブエ政府のU／Tも含まれていることなどを考慮し、商工省からの署名も必要である旨、大蔵・経済企画・開発省マチヤラガ局長が決裁した。

これを受けて、ジンバブエ側は商工省ゲザ次官の署名を予定し、調査団もこれに同意したが、調査団の滞在中にＩＤＣとの共同署名を行なうまでには至らなかった。

2.　S／W協議を通じて協議されたその他の主要事項

1)　本件調査に係わる基本指針

本件調査は第１次国家開発５カ年計画（１９８６～１９９０）における工業分野振興計画で強調されている下記の政策の実現を図ることを指針として実施されるということで、調査団とジンバブエ側は合意した。

• 国内資源の活用
• 雇用機会の創出
• 外貨の節約と獲得
• 低投資コスト型プロジェクト
• 経済的・財務的に実行可能性のあるプロジェクトの確立

ただし、上記の指針にすべて適合したプロジェクトの確立は実行可能性の見地から極めて困難であることは明白であるので、これらのなかから、調査の過程で適宜、選択されることになる。

2) 第三国における市場調査

調査団は対処方針に準拠して、本件調査では第三国に関する市場調査はデータ・文献調査によって行ない、実地調査は行わない旨、表明した。

これに対し、ジンバブエ側は、製品輸出が本件プロジェクトの重要な部分を構成するので、F／Sとしては第三国における市場調査が必須の条件であるとして、調査団の表明を了承するまでには至らなかった。

3) 調査期間の短縮

ジンバブエ側は本件調査の期間（12カ月）短縮を強く要請した。

これに対し、調査団が期間短縮の困難な事情を説明したところ、最終的にジンバブエ側は原案どおりで了承した。

4) その他の事項

ジンバブエ側は、①最終製品の比較調査、②クエン酸に関する生産・需給・価格情勢の調査期間の延長、などを要請したが、いずれも調査団の説明を了承し、原案どおりとなった。

3. 協議の結果

1) 実施細則（S／W）

S／Wについては、別添のとおり、ジンバブエ側は商工省ゲザ次官と、IDCサニャンガ総裁を署名者とする合意文書を作成したが、ジンバブエ側の必要手続が未了のため、調査団のハラレ滞在中には署名交換は行われなかった。

今後、ジンバブエ側は必要手続を進め、商工省及びIDCの署名がえられ次第、日本国大使館へ提出することになっている。

2) 会議議事録（M／M）

M／Mについては、別添のとおり、下記事項を記載したものを作成し、ジンバブエ側はIDCプロジェクト審査部長シバンダを署名者とする合意文書を作成したが、上記と同様

の理由で署名交換は行われなかった。

- 本件調査の基本指針となる政策
- 調査団によるブリーフィングの実施
- 調査団からの質問書への回答と試料送付の期限
- 第三国での市場調査
- 工場等の視察

3) 調査、分析データの提出と試料送付の依頼

調査団は、各種原料に関するデータ、分析値の提出と、試料の送付を依頼したところ、ジンバブエ側はいずれも、本年9月末までに対応する旨、表明した。

（富田堅二）

Ⅲ　技　術　評　価

III 技　術　評　価

1. 原料及びプロセス技術評価

1990年2月に行なわれた予備調査では、クエン酸の液体醗酵法製造原料として廃糖密は利用出来ないこと。また、ジンバブエのクエン酸輸入・消費量は500ＴＰＹ程度であることが判明した。この様な、原料および市場環境を前提として、日本で確立された甘藷およびキャッサバの澱粉抽出粕を原料とする固体醗酵法をジンバブエのクエン酸製造に適用することが可能であるか目途を立てるとともにＳ／Ｗにサインすることが事前調査の目的であった。

液体醗酵法は資本集約型で自動工場操業、かつ規模の経済性が高く、年産6,000ＴＰＹ能力以上の大型工場に適し、一方、固体醗酵法は労働集約型、人力依存操業、かつ規模の経済性が低く、年産2,000～6,000ＴＰＹ能力の小型工場に適している。低コスト固体醗酵原料が供給可能なら、ジンバブエの内需指向型の2,000～6,000ＴＰＹ能力の小型工場に適している。低コスト固体醗酵原料が供給可能なら、ジンバブエの内需指向型の2,000ＴＰＹ程度の能力の固体醗酵法工場が適しているが、低コスト液体醗酵原料が豊富に供給可能なら、ジンバブエの内需充足および輸出指向型の6,000ＴＰＹ程度の能力の大型液体醗酵法工場が有利になる可能性が高い。

今次事前調査においてはＩＤＣを通し、クエン酸原料供給可能性に関する資料入手に努めたが、結局平成2年9月末日までにＪＩＣＡに提出するとの宿題となった。質問事項、試料提供要求についてはＭ／Ｍの5項に明記されている。原料試料については脱脂メイズ、メイズ澱粉抽出粕が送付される予定であるが、Masese については事前調査団が持ち帰り、小規模・半定量試験を行なった。

脱脂メイズ到着を待つ間、クエン酸固体醗酵法の模擬試験を行なったので、その結果を説明する。脱脂メイズの代替としてグルテン除去小麦澱粉（日本で入手）を使用した。理由は両者の組成、性状が類似していると判断したからである。試験の規模は実験室内の小規模（250ｇ／Batch）半定量試験である。

2. 原料分析値（%）

原　料	有姿基準 水　分	乾燥物基準 全糖濃度	乾燥物基準 粗蛋白	備　考
小麦澱粉	11.8	104.4	0.5	日本で入手、多分米国産
甘藷粕	75.5	60.5	0.5	日本で入手、鹿児島県産

3. クエン酸固体醗酵条件（%）

全糖濃度	18.0
水　　分	67.5
米糠と助剤	4.0

4. 試験結果

(1) 小麦澱粉のみの場合、全糖濃度18.0%で完全に固化してしまい固体醗酵は不可能である。

(2) メイズ粕（日本で入手）およびジンバブエより持帰りMaseseサンプルはともに吸水性が低く、固体醗酵繊維媒体として不適当である。

(3) 甘藷粕を併用した場合、小麦澱粉の配合最高限度は全糖濃度比で15.0%である。この場合も全糖濃度に対するクエン酸収率は約95.0%に低下する。

(4) 固体醗酵の基本条件は吸水性の高い繊維物質が多量に含まれ、好気性条件が維持されること。更に蒸煮殺菌処理で固化、糊化せず好気的性状が維持されることである。これらの条件を満たすものは、甘藷およびキャッサバの澱粉粕に限定されている。脱脂メイズ澱粉および小麦澱粉は甘藷澱粉粕に対し糖度で10%程度の補完糖質としてのみ利用出来ると判断される。

5. 技術評価の展望

本計画調査の目標はM／M－3に明記されているようにジンバブエ政府の工業セクター開発政策に基づき次の四項目の実現にある：

(1) 国産資源の有効活用

(2) 新規雇用機会の創出

(3) 外貨の節約と新規獲得

(4) 低投資コスト型プロジェクトの確立

甘藷澱粉粕あるいはキャッサバ澱粉粕の低コスト安定供給が確保されれば、クエン酸の国内需要をまず満たし、余剰製品の周辺諸国輸出を考慮した固体醗酵法工場を建設することにより上記四項目の実現の可能性は高いと判断される。しかし、現時点の原料供給に関する技術評価は楽観を許さない。

ジンバブエは原糖、メイズ澱料および廃糖密（場合によっては）の大供給基地であり、低コスト安定供給が確保される可能性が高い。この場合クエン酸製造は液体醗酵法によることになるが、スケール・メリットを追及するため規模は大型となり、周辺諸国への輸出市場に

大きく依存することになる。上記四項目の(4)および(2)の条件を充分に満足させることは困難となろう。

第3の方策は澱粉抽出を行なわず、甘藷あるいはキャッサバを直接原料として、繊維基質としてバガスなどで補強する固体醗酵法を採用することである。しかし、本法は実績がないため本格調査の一環として充分な試験と研究を実施し、工場の概念設計が可能なレベルまで研究開発を実施しなければならない。

その他、第4および第5の方策も提案することは可能であるが、ジンバブエの現状解析不充分の現段階では無意味に近い。いずれにしろ、本格調査は広範かつ精度の高い技術調査が必要であり、固体醗酵法および液体醗酵法双方について醗酵技術専門家の積極的参画が必須である。

（桑原　誠・安川俊武）

Ⅳ　原料評価研究・試験結果

IV　原料評価研究・試験結果

1. クエン酸製造用ジンバブエ送付原料試料と評価研究・試験

ＩＤＣ、ジンバブエより、平成２年１２月５日に原料試料２ケ口、約３０kgが日本側に到着し、試験評価が行なわれた。クエン酸製造試験は固体醗酵法については昭和化工㈱、液体醗酵法は磐田化学工業㈱の好意により実施された。送付された試料は Masese および Corn Starch である。Masese は事前調査団のコンサルタントの安川が少量持ち帰り、定性試験で固体醗酵法への適用性を評価した結果は、否定的であった（III参照）。

2. Corn Starch と Masese 原料の固体法クエン酸醗酵製造評価試験

ジンバブエに於ける、クエン酸（ＣＡＭ）固体醗酵法製造原料として可給性があると想定された諸原料のうち、Corn Starch を炭水化物源、Masese を支持担体とするクエン酸製造研究・試験を実施した。

1)　原料の性状

(1)　Masese　：異臭強い。炭水化物分（澱料換算）は 36.7 ％である。固体醗酵法の最重要条件である保水性は、甘藷澱粉粕（商業生産原料）に比し４４％と著しく低い。更に工業的に使用されている菌体ではクエン酸生成の醗酵阻害作用が観察され、クエン酸収率は著しく低い。

(2)　Corn Starch　：Starch Value は 79.1 ％である。工業生産に適用されている甘藷澱粉粕と同じ性状を示す、高性能の固体醗酵支持担体の入手が可能なら一定範囲の限度内で、クエン酸生産原料となり得ると判断される。

2)　原料評価醗酵試験条件

(1)　支持担体：Masese（ジンバブエ産）〔対象試験区は甘藷澱粉粕（日本九州産）〕

(2)　炭水化物源：Corn Starch（ジンバブエ産）

(3)　栄養源：米糠（日本産）

(4)　醗酵法：クエン酸固体醗酵法〔昭和化工㈱標準〕

(5)　試験規模：Corn Starch ； 6.0／7.5 gr/Batch

(6)　試験期間：７日間

(7)　試験場所：昭和化工㈱

3)　試験結果

クエン酸生成は殆ど認められず、菌糸の異状繁殖が観察された。試験結果は Table IV－１に纒めた。

4) 結　論

Masese は現状商業技術では、クエン酸固体醗酵法の支持担体として不適格である。

Corn Starch は特定条件下で、固体醗酵法クエン酸製造の炭水化物源として一定範囲の限度内で使用可能と推論される。

Table Ⅳ-1 EXPERIMENTAL RESULTS SUMMARY FOR CITRIC ACID PRODUCTION BY SOLID CULTURE FERMENTATION USING MASESE AS SOLID CULTURE SUPPORT CARRIER

Test No.	Masese gr	Corn Starch gr	Rice Bran gr	Added Water ml	Water Ratio %	Culture Seed ml	Total Water %	$CaCO_3$ gr	Total Citric Acid, gr 2 Days	Total Citric Acid, gr 7 Days	CAM Yield/ Starch, % 2 days	CAM Yield/ Starch, % 7 Days
1	9.0	6.0	0.3	10.0	44.8	5	56.0	0		0.32		6.1
2	9.0	6.0	0.3	12.0	48.9	5	56.9	0		0.35		6.6
3	9.0	6.0	0.3	14.0	52.4	5	59.4	0		0.49		9.3
4	9.0	6.0	0.5	10.0	44.8	5	56.0	0		0.27		5.1
5	9.0	6.0	0.5	12.0	48.9	5	56.9	0		0.33		6.3
6	9.0	6.0	0.5	14.0	52.4	5	59.4	0		0.40		7.6
7	9.0	6.0	0.8	10.0	44.8	5	56.0	0	1.17	0.29	22.2	5.5
8	9.0	6.0	0.8	12.0	48.9	5	56.9	0	0.95	0.34	18.0	6.5
9	9.0	6.0	0.8	14.0	52.4	5	59.4	0	1.05	0.47	19.9	8.9
10	9.0	6.0	1.0	10.0	44.8	5	56.0	0		0.27		5.1
11	9.0	6.0	1.0	12.0	48.9	5	56.9	0		0.29		5.5
12	9.0	6.0	1.0	14.0	52.4	5	59.4	0		0.31		5.9
13	7.5	7.5	0.3	10.0	44.5	5	54.7	0		0.30		4.6
14	7.5	7.5	0.3	12.0	48.6	5	56.6	0		0.34		5.2
15	7.5	7.5	0.3	14.0	52.2	5	59.2	0		0.41		6.2
16	7.5	7.5	0.5	10.0	44.5	5	54.7	0		0.29		4.4
17	7.5	7.5	0.5	12.0	48.6	5	56.6	0		0.36		5.5
18	7.5	7.5	0.5	14.0	52.2	5	59.2	0		0.39		5.9
19	7.5	7.5	0.8	10.0	44.5	5	54.7	0	0.96	0.29	18.2	4.4
20	7.5	7.5	0.8	12.0	48.6	5	56.6	0	0.76	0.34	14.4	5.2
21	7.5	7.5	0.8	14.0	52.2	5	59.2	0	1.12	0.36	21.2	5.5
22	7.5	7.5	1.0	10.0	44.5	5	54.7	0		0.24		3.6
23	7.5	7.5	1.0	12.0	48.6	5	56.6	0		0.30		4.6
24	7.5	7.5	1.0	14.0	52.2	5	59.2	0		0.34		5.2
25	7.5	7.5	0.3	10.0	44.5	5	54.7	0.3		0.27		4.1
26	7.5	7.5	0.3	12.0	48.6	5	56.6	0.3		0.31		4.7
27	7.5	7.5	0.3	14.0	52.2	5	59.2	0.3		0.39		5.9
28	7.5	7.5	0.5	10.0	44.5	5	54.7	0.3		0.27		4.1
29	7.5	7.5	0.5	12.0	48.6	5	56.6	0.3		0.30		4.6
30	7.5	7.5	0.5	14.0	52.2	5	59.2	0.3		0.38		5.8
31	7.5	7.5	0.8	10.0	44.5	5	54.7	0.3	1.42	0.27	21.6	4.1
32	7.5	7.5	0.8	12.0	48.6	5	56.6	0.3	1.16	0.31	17.6	4.7
33	7.5	7.5	0.8	14.0	52.2	5	59.2	0.3	0.55	0.36	8.4	5.5
34	7.5	7.5	1.0	10.0	44.5	5	54.7	0.3		0.26		4.0
35	7.5	7.5	1.0	12.0	48.6	5	56.6	0.3		0.28		4.3
36	7.5	7.5	1.0	14.0	52.2	5	59.2	0.3		0.30		4.6
37	9.0	6.0	1.0	15.0	54.0	5	60.6	0.3		0.19		2.9
38	9.0	6.0	1.0	16.0	55.5	5	61.7	0.3		0.20		3.0
39	9.0	6.0	1.0	17.0	56.9	5	62.7	0.3		0.54		10.2
40	7.5	7.5	1.0	15.0	53.7	5	60.4	0.3	0.99	0.18	15.0	2.7
41	7.5	7.5	1.0	16.0	55.2	5	61.5	0.3	1.30	0.20	19.6	3.0
42	7.5	7.5	1.0	17.0	56.4	5	62.5	0.3	1.29	0.20	23.2	3.0
Standard	9.0	6.0	0.3	10.0	69.4	5	74.5	0	1.39	5.03	28.6	80.2

Experimental Notes

1. Start Date : Dec 20, 1990
2. Completion Date: Dec 27, 1990
3. Place : Showa Cheml Co. Ltd, Japan
4. Raw Material Specification, %

Raw Material	Moisture	pH	Total Sugar	Starch Content	Water Retaining Capability	Origin
- Corn Starch	4.8	-	92.3	79.1	-	ZW
- Masese	10.2	4.3	45.4	36.7	2.9/1.0	ZW
- Sweet Potato Starch Extraction Lees (Standard)	78.4	5.6	57.0	-	6.5/1.0	Japan

5. Water retaining capacity of Mesese is low and enough water could not be added.
6. Citric acid production is lower in 7th days than 2nd days due to abnormal growth of white colored hyphae on surface

3. Corn Starch原料の液体法クエン酸醗酵製造評価試験

1) 試験目的

ジンバブエ産 Corn Starch を炭水化物原料とし、現在商業規模で実証されている醗酵菌株による液体（深部培養）法技術による、クエン酸製造可能性を評価する。

2) 原料試料と特性

項　目	原料分析値	磐田化学工業㈱ 原料基準	備　考
原料と（産地）	Corn Starch(ZW)	−	未経験
外観検査	白色粉末	白色粉末	合　格
水懸濁	淡黄色	白色／淡黄色	やや不適
上濁液	白濁	透明	不　適
異物	微小粒子浮遊	異物なし	やや不適
水分，%	11.6	13.0以下	やや不適
糖分，%	96.0	95.0以下	やや不適
澱粉価，%	86.4	85.5以下	やや不適
粗蛋白	0.84	0.4以下	不　適（過多）
電気伝導度，S/m	1,400	100以下	不　適（過剰）
粗灰分，%	0.4	0.1以下	不　適（過多）
pH	5.4	4.3～5.0	やや不適（高い）

ジンバブエ産 Corn Starch の分析値より、クエン酸原料として醗酵の際に菌体増殖の過剰現象が発生すると推定される。

3) 試験方針と試験計画

(1) 培養条件：磐田化学工業㈱標準

(2) 結果の判定：磐田化学工業㈱基準

(3) 試験計画：

試験規模	シード培養	種培養	副原料	原料濃度	通気量	温度	pH	その他
フラスコ	○	○						
ジャー	○	○						
培養条件の調整			○	○	○	○	○	○

(4) 試験方針：フラスコ試験結果を解析し、ジャー試験に進み、培養条件の最適化条件を把握し、更にその試験結果を総合的に検討し、パイロット・プラント

試験を実施し、商業工場規模の連続操業を繰り返し、最終的な操業条件の確定、クエン酸製造装置の概念設計および工場建設費の積算を実施する。

4) 試験条件

(1) フラスコ試験

A．シード培養：試料50grに液化酵素（10,000単位のアミラーゼ0.05gr）を添加液化（糖化工程は不要）、無機栄養素（N、P_2O_5、K_2Oなど）および有機醗酵促進剤と水1.0mlを添加し種培地とする。この種培地200mlを500mlエルレンマイヤーフラスコに分注、培養用栓を施し、オートクレーブにて121℃、20分間の殺菌を行なった後冷却する。更に斜面培養保存中の変異株胞子(Aspengillus Niger C−32)の1白金耳を無菌的に移植し、ロータリーシェイカーにて35℃、220rpm、45時間の培養を行なう。

B．主培養：試験（151gr＝150／0.96−5.0）に液化酵素0.15grを添加液化し、これに基準配合無機栄養素と有機醗酵促進剤と水900mlを添加し培地とする。この培地90mlを500mlエルレンマイヤーフラスコに分注し、培養用栓を施し、オートクレーブにて、121℃、20分間の殺菌を行なった後冷却する。更に45時間培養した種菌（シード）を10ml無菌的に移植し、ロータリーシェイカーにて35℃、250rpm条件下で培養し、24時間毎にフラスコ3本分の培養液を抜取り、醗酵培養状況を観察するとともに、分析試験を行う。試験期間は192時間までとした。

C．分析方法

－pH　：ガラス電極

－クエン酸：培養液濾液1.0mlを0.15NのNaOH標準液で滴定（指示薬はフェノールフタレン）する。

盲検差し引き、クエン酸（MW＝192.12）に換算し、クエン酸の確認は急速液体クロマトグラフィーによる。

－残　糖：培養液濾液を澱粉分析（ソモギー変法）にて全糖分測定を行なう。

－菌　体：フラスコ全体の培養液を濾紙濾過し、濾紙上固形物を水洗、105℃にて乾燥し、全菌体量を算出する。

5) 試験結果と考察

フラスコ試験結果は、TableⅣ－2に示す。試験結果は3点分析値の平均値である。

総合結果は、対添加糖収率が64.67％と低い値に止った（9.70／15.00＝0.6467）。供試原料の特徴は、菌が成育過剰現象を呈することであり、生産クエン酸量に比較し菌体量が過多となる。即ち、炭化水素の無駄喰いが起り、糖からクエン酸への転化率が低く、

クエン酸製造所要培養時間も長期間を要することを意味する。

この現象は、液体深部醗酵法による商業生産に際して、通気・撹拌用電力消費量増大をも意味し、クエン酸製造事業の採算性を極めて悪化させる。

フラスコ試験の結果より、現在商業規模で実証されている技術（醗酵菌体および醗酵条件）を適用した場合、ジンバブエより送付されたCorn Starchはクエン酸収率は理論収率の62％以下であり、原料価格にもよるが、工業化には不適当と推論される。

したがって、これ以上の研究・試験の続行は意義なしと判断した。もし、ジンバブエより送付されたCorn Starchをクエン酸製造原料として使用することが不可避であるなら、次の4点を解明することが先決である。

－原料価格およびジンバブエ産代替銘柄品Corn Starchの供給可能性

－電力価格

－ジンバブエ送付Corn Starchに適した新菌の発見

－最適培養条件（培地組成、通気・撹拌条件など）確立

後者二項の問題解決は長期間、広範に亘る組織的研究と試験を要し、なおかつ幸運に恵まれることが条件である。したがって、この二点について研究開発責任者として見解を開示することは、無責任となるので慎みたい。更に、現時点で上記諸問題を完全に解明するための所要期間と予算について予測することも慎みたい。

（桑原　誠・安川俊武）

Table IV-2 CITRIC ACID PRODUCTION BY SOLUTION PROCESS FROM CORN STARCH IN FLASK SCALE TEST

Time, Hour	pH	Citric Acid g/dl	Residual Sugar g/dl	Fungi g/dl
0	5.50	-	-	-
24	2.72	0.45	13.62	1.25
48	2.27	1.80	11.20	1.44
72	2.00	3.38	9.00	1.65
96	1.85	4.95	6.91	1.88
120	1.76	6.87	4.82	2.00
144	1.71	8.45	2.90	2.05
168	1.68	9.50	1.35	2.00
192	1.65	9.70	0.72	2.00

Ⅴ　本格調査における留意点

V　本格調査における留意点

1. 調査全般に係わる留意点

1) 本件調査は、国産資源を利用して、技術的に、経済的に、また財務的に実行可能性のあるクエン酸製造工場設立計画を作成することを目的としているが、このことを第一義的に留意しておくことが望ましい。

2) 今回の調査において、本件プロジェクトに必要な原料事情を把握するため、ＩＤＣに対して、適切な官庁、試験・研究所、専門家などの紹介を依頼したが、何等の対応も得られなかった。しかしながら、工場視察等を通じて、キャッサバ、さつまいも、メイズ、マセセ等各種の原料がそれぞれ特有の可能性をもって提案されているので、今後は可能な範囲で広汎に各種原料についての実行可能性を調査することが望ましい。

3) クエン酸製造方式についても、雇用創出、低投資コストに配慮することが必要であるが、原料選択とも関連して、多角的に検討されることが望ましい。

4) 本件調査は、多くの想定される条件を前提として、限られた範囲で実施されることになるので、本格調査の着手に際しては、日本側調査団として調査基本方針を十分に確立してから、ジンバブエ側へ調査計画を説明するよう、留意することが望ましい。

（冨田堅二）

2. 技術的観点からの留意点

本格調査における留意点を、Ｓ／ＷおよびＭ／Ｍに従い項目順に説明する。

項　　目	本格調査における留意点
S/W—I.	特記事項はない。
S/W—II.	現状の可給原料とともに、近い将来に供給可能となる原料についても調査することになるが、甘藷あるいはじゃが芋、キャッサバなど固体醗酵法原料については、ジンバブエの農業施策、契約栽培などで増産可能と判断出来るか詳細な調査が必要である。また、日本あるいはインドネシアで商業的規模で実施されている澱粉抽出工業の粕利用によるクエン酸製造を行なった場合、副産澱粉はジンバブエで現在大規模に生産されているメイズ澱料と価格および品質競争力があるか解析すること。ジンバブエ農家は伝統的に、Large Scale Farmers, Small Scale Farmers及び Communal Farmers に三大別され、農業経営理念に大きな差異があることに留意し、将来の農産物供給の可能性を解明すること。

項　　目	本格調査における留意点
	更に、甘藷あるいはキャッサバなどを澱粉抽出を行なわず直接固体醗酵法に適用する場合、繊維質の補強添加が必要と推測されるが、バガスなどジンバブエで安価に入手可能なものを使用し、日本国内で充分なる試験および研究を行ない、新規プロセスによる工場の概念設計が可能であることを実証すること。澱粉不抽出の場合は甘藷あるいはキャッサバの長期間（年間）保存法が確立されることが前提となる。固体醗酵に添加される米糠についても、現状ではジンバブエでの入手可能性は低い、近隣諸国からの輸入あるいは国産代替品の探索調査および実証試験が必要となる。Masese およびメイズ澱粉粕については事前調査団の小規模試験の結果では、撥水性を示し繊維補強剤としての特性は期待できないと推定された。 液体醗酵法に関しては、平成２年２月の予備調査では廃糖密についてMogas添加用のEtOH醗酵原料に活用され、クエン酸製造法原料について供給余力がない旨確認されているが、原糖および廃糖密のジンバブエの生産量は各々442,000TPY－1988および62,000TPY－1980である。仮に、クエン酸を3,000TPY生産する場合、原糖あるいは廃糖密の所要量は各々3,900TPY（0.88%）あるいは8,100TPY（12.9%）である。クエン酸生産の方が原料付加価値が高い場合は、この種原料の使用が許容される可能性があるか調査すること。 液体醗酵法原料として、ジンバブエに豊富に生産されているメイズ（白色あるいは黄色）澱粉あをいは脱脂メイズ澱粉が考えられる。現状では黄色メイズ澱粉が低価格で、脱脂メイズ澱粉が高価格と言われているが、供給安定性とクエン酸原料としての特性との比較で、原料評価を行なうこと。ジンバブエのメイズ事情については、まず、Food and Industrialなどから調査を着手するのが効率的であろう。
S/W-III-1.	ジンバブエ政府が1989/90年度予算案に示した構造調整計画（ＳＡＰ）が財政赤字、外貨不足、国内総生産、貿易赤字、対外債務問題を中心に展開される機運にあることに留意し、クエン酸生産計画との関連を解明することが重要である。 更に、ジンバブエ政府は貿易自由化、輸出促進および外資誘致政策を1990年10月に公布する計画であるので、新政策とクエン酸生産計画との関連も解明すること。

項　　目	本格調査における留意点
S/W-III-2.1	各国別のクエン酸およびＬＯＣの生産、輸出、輸入および消費に関する歴史的統計の入手には限度がある。各国の協会あるいは調査機関の資料を充分活用し、実態の解明に努力すること。貿易統計はCommodity Codeの内容につき細心の注意を払うこと。 ＩＤＣはすくなくとも、1988年に欧米のエンジニアリング会社の協力を得て、液体醗酵法による3,500ＴＰＹのクエン酸生産計画を調査したと推察される。
S/W-III 2.4/2.5	予備調査報告書によればジンバブエのクエン酸の輸入・消費は500 TPYと推定されている。ジンバブエではFood and IndustrialがLactic Acidを醗酵法で約500ＴＰＹ製造しており、Lactic Acidの流通・販売を追跡することでクエン酸の市場状況解析がある程度可能となろう。Lactic Acidとクエン酸の市場競合可能性についても調査すること。
S/W-III-2.6	輸出可能性についてのＩＤＣ要望はＰＴＡ、ＳＡＤＣＣおよびＳＡＣＵの本格調査の一環として現地調査を実施することであるが、ＪＩＣＡの方針として調査団員による第三国調査は不可能である。次善の方策で最大限の調査実績をあげ、ＩＤＣの要望に応える必要がある。 ＳＡＣＵはクエン酸を3,500ＴＰＹ主にベルギー、アイルランドなどより輸入している巨大市場であるが、品質と価格競争力の比較と同時に政治的に市場開放の可能性について考察することが重要である。 ＰＴＡの一部であっても、モロッコおよびエチオピアなどを潜在市場と考えるのは地理的に無理があろう。 ジンバブエの市場については詳細なる調査が要求される。次に、大きな市場はZambia, Malawi, Zaire, AngolaおよびMozambiqueであろうが、合計して消費は300ＴＰＹ以下と推定される。これ以外の諸国については充分な資料はなく、調査も困難であろう。むしろ供給業者側の情報入手が実際的であろう。 なお、南アではTurner and Newall（旧 Butachem）が2,500ＴＰＹのMalic Acidを製造しており、クエン酸の特定市場で競合していることも留意すべきである。更にMalic Acid輸入量は320ＴＰＹま

項　　目	本格調査における留意点
	たLactic Acid輸入量は1,150ＴＰＹである。
S/W-III3.1	甘藷およびキャッサバを原料とする固体醗酵法の適用について澱粉工場設立の可否を含めて農業生産・農産加工業の統合計画としての調査・考察も行なうこと。米糠あるいはその代替品についても調査する。
S/W-III-3.4.	硫酸についてはＺIMPHOSがChemical Gradeを製造販売している。品質、供給量、輸送法、価格などを調査すること。現状はパイライト原料の硫酸よりChemical Gradeを製造しているが、小額の改造工事で硫黄原料の硫酸プラントよりChemical Gradeを増産製造することが可能であると言われている。 石灰についてはＺIMPHOSが炭酸カルシウムおよび消石灰を原料として購入使用しており、ＺIMPHOSより供給体制の調査を着手するのが得策であろう。
S/W-III-4.	特記事項なし。
S/W-III-5.6	ジンバブエは機器製作・据付技術はかなり高い。工場保全能力も充分ある。
S/W-III-6.	特記事項なし。
S/W-V-3	Step2開始後10ケ月以内にDraft Final Report提出となっているが、一方Annexでは7.5ケ月となっている。 調査はAnnex通りの最短スケジュールで実施されるのが望ましい。 ＩＤＣの一部担当者は調査期間の短縮を希望していた。しかし、原料評価試験、プロセス選定と最適条件確立などのため試料送付、分析、試験、解析に長期間を必要とされる場合も、10ケ月以内に性能確認と概念設計が完了し、Draft Final Reportをジンバブエ側へ提出することが要求される。
S/W-VI-5.	必要最小限度の代表サンプルを迅速に発送することが望ましい。 植物検疫の規制を予め研究し、充分なる対策を講ずること。 農産物は収穫時期の関係で入手不可能な時期があることに留意すること。
M/M-5-2)	Carbondydratesは Carbohydratesの誤植。
M/M-6.	" S/W-IIの本格調査における留意点"参照。 ＩＤＣ側は輸出市場に大きな期待を持っている。ジンバブエにおける

項　　目	本格調査における留意点
	クエン酸製造工場設計にあたっては、次の三要因が調和のとれた型で解決されることが重要である。 －原料の選定と確保 －プロセスの選定と最適条件の解明 －市場規模の設定と価格策定 なお、本格調査実施にあたっては、予備調査の際ＩＤＣ側に提出した" Discussion Paper and Questionnaire for Mutual Understanding and Preparation of Feasibility Study "にも参考資料が纏められているので活用されたい。（参考資料－４） （桑原　誠・安川俊武）

Ⅵ　参　考　資　料

1. 事前調査団が未署名のまま残してきたＳ／Ｗ及びＭ／Ｍ
（１９９０年８月３１日）

SCOPE OF WORK

FOR

THE FEASIBILITY STUDY

ON

THE ESTABLISHMENT OF A CITRIC ACID PLANT

IN

THE REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN

MINISTRY OF INDUSTRY AND COMMERCE

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Harare, August 28, 1990

Mr S. Geza
Permanent Secretary
Ministry of Industry & Commerce

Dr Kenji Tomita
Leader of the
Preliminary Survey
Team, Japan
International
Cooperation Agency

Mr C M D Sanyanga
Director & General Manager
Industrial Development Corporation
of Zimbabwe Limited

I. INTRODUCTION

In response to the request of the Government of the Republic of Zimbabwe (hereinafter referred to as "GOZ"), the Government of Japan decided to conduct a feasibility study on the establishment of a citric acid plant in the Republic of Zimbabwe (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly Japan International Cooperation Agency (hereinafter referred to as "JICA"),the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will undertake the study in close cooperation with authorities of the GOZ.

The present document sets forth the scope of work with regard to the Study.

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   1.3 Present industrial situation in Zimbabwe

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6.1 Financial analysis with sensitivity analysis

6.2 Economic analysis and social evaluation

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Step 1: Preparatory work in Japan

Step 2: Work in Zimbabwe

Step 3: Work in Japan

Step 4: Presentation and discussion of the Draft

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As shown in Annex

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JICA shall prepare and submit the following reports in English to the GOZ:

		Copies
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3.	Draft Final Report and its Summary within 10 (ten) months after commencement of step 2	15
4.	Final Report and its Summary within 3 (three) months after the receipt of comments on the Draft Final Report	30

VI. UNDERTAKING OF THE GOZ

1. To facilitate smooth conduct of the study, the GOZ shall take necessary measures:

1.1 To secure the safety of the Japanese study team (hereinafter referred to as "the Team")

1.2 To permit the members of the Team to enter, leave and sojourn in Zimbabwe for the duration of their assignment therein, and exempt them from alien registration requirements and consular fees

1.3 To exempt the members of the Team from taxes, duties and other charges on equipment, machinery and other materials brought into Zimbabwe for the conduct of the Study.

1.4 To exempt the members of the Team from income tax and other charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with the implementation of the Study

1.5 To provide necessary facilities to the Team for remittance as well as utilisation of the funds introduced into Zimbabwe from Japan in connection with the implementation of the Study

1.6 To secure permission for entry into private properties or restricted areas for the conduct of the Study

1.7 To secure permission for the Team to take all data and documents (including photographs) related to the Study out of Zimbabwe to Japan

1.8 To provide medical services as needed. Its expenses will be chargeable to the members of the Team

2. The GOZ shall bear claims, if any arises against members of the Team resulting from, occuring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Team.

3. Industrial Development Corporation of Zimbabwe Limited (hereinafter referred to as "IDC") shall act as counterpart agency to the Team and also as coordinating body in relation with other governmental and non-governmental organisation concerned for smooth conduct of the Study.

4. IDC shall, at its own expense, provide the Team with the following, in cooperation with other organisation concerned:

4.1 Available data, information and samples related to the Study

4.2 Counterpart personnel

4.3 Suitable office space with necessary equipment in Harare

4.4 Credentials for identification cards

5. IDC shall, in cooperation with other relevant organisation, provide assistances for sampling, packaging and dispatching representative samples of raw materials for the proposed project which are required for laboratory examinations in Japan.

VII UNDERTAKING OF JICA

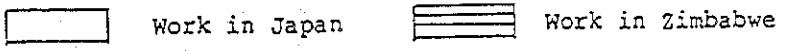
For the implementation of the Study, JICA shall take the following measures:

1. To dispatch, at its own expense, the Team to Zimbabwe
2. To pursue technology transfer to Zimbabwe counterpart personnel in the course of the study

VIII OTHERS

JICA and IDC shall consult with each other in respect of any matter that may arise from or in connection with the Study.

Annex TENTATIVE SCHEDULE OF THE SUDY



Year	1991											
Project Month	1	2	3	4	5	6	7	8	9	10	11	12
Calendar Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Preparatory Work in Japan (Step 1)												
Work in Zimbabwe (Step 2) Presentation of Inception Report Presentation of Progress Report												
Work in Japan (Step 3)												
Presentation of Draft Final Report (Step 4)												
Work in Japan Submission of Final Report in Zimbabwe												

MINUTES OF MEETING

FOR

THE FEASIBILITY STUDY

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AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Harare, August 28, 1990

1. The Preliminary Survey Team made a visit to Zimbabwe from August 20th to August 28th, 1990 to discuss with relevant Zimbabwe authorities on the Scope of Work for the Study.

2. In connection with the above, a series of meetings were held on August 21st, 22nd, 24th and 27th, 1990 between Zimbabwe officials headed by Mr L A Munyawarara, Research and Development Manager , IDC on the Zimbabwe side and the Preliminary Survey Team headed by Dr Kenji Tomita on the Japanese side (Attendance as shown in the Appendix) to discuss the Scope of Work drafted by the Japanese side.

3. Both sides confirmed that the Study would be conducted under the following Zimbabwe government's policy on the industrial sector development which is shown in the five year national development plan (1986 - 1990)

   1) Utilization of domestic resources

   2) Creation of employment

   3) Savings and earnings of foreign currencies

   4) Minimized investment cost

   5) Establishment of the economic and financial viability of the project

4. The Japanese side explained the basic conception, present worldwide situation and future trend of citric acid production including applicable raw materials and processes for the smooth conduct of the Study. The Zimbabwe side appreciated it.

5. In accordance with the request from the Japanese side, the Zimbabwe side confirmed that the following information, data and samples would be available to the Japanese side in Tokyo, Japan by the end of September, 1990.

   1) Answer to the questionnaire

APPENDIX

LIST OF ATTENDANCE

The Japanese Side

The Preliminary Survey Team

Dr Kenji Tomita (Leader)	-	Special Technical Advisor JICA
Mr Yasujiro Suzuki (Project Planning)	-	Industry Division, JICA
Mr Makoto Kuwabara (Chemical Engineering)	-	UNICO International Corporation
Mr Toshitake Yasukawa (Biotechnology)	-	Citric Acid Producers Association

Embassy of Japan

Mr Yukio Kawajiri	-	First Secretary

The Zimbabwe Side

Mr L.A. Munyawarara	-	Manager for Research and Development
Mr P. Sibanda	-	Projects Appraisal Manager
Dr C. Chitsora	-	Senior Engineer
Mrs L. Dhliwayo	-	Research Economist
Mrs E Ndlovu	-	Research Economist
Mr T Sain	-	Legal Advisor.

2) Analytical data of representative samples of potatoes, sweet potatoes and cassava on moisture, carbondydrates, starch, sugars, protein, ash, fiber and fat.

3) Analytical data of representative samples of calcium carbonate, calcium oxide and calcium hydroxide on heavy metals and magnesium

4) Analytical data of chemical grade sulfuric acid on heavy metals and other elements such as Cd, Se, As.

5) Representative sample of cooking oil extracted starch and masese.

6. The Japanese side explained that the regional study of citric acid in the third countries including SADCC, PTA and others should not be undertaken by field survey, and should be analyzed by utilizing internationally available primary statistics and analytical studies in accordance with the Japanese Development Study scheme by JICA.

The Zimbabwean side pointed out that the Study would not be complete without the field work being undertaken as this will leave a large percentage of the plant's output without a confirmed market.

7. Visits and discussions at the University of Zimbabwe, a starch factory and a fertilizer factory in Harare were made by both sides.

SIGNED THIS DAY OF AUGUST 1990

Mr P Sibanda
Projects Appraisal Manager
Industrial Development
Corporation of Zimbabwe Limited

Dr Kenji Tomita
Leader of the Preliminary Survey Team,
Japan International Cooperation Agency.

2. 署名済Ｓ／Ｗ及びＭ／Ｍ（１９９０年１１月２７日）

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Mr M. Nziramasanga
Permanent Secretary
Ministry of Industry & Commerce

富田堅二

Dr Kenji Tomita
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1. To facilitate smooth conduct of the study, the GOZ shall take necessary measures:

1.1 To secure the safety of the Japanese study team (hereinafter referred to as "the Team")

1.2 To permit the members of the Team to enter, leave and sojourn in Zimbabwe for the duration of their assignment therein, and exempt them from alien registration requirements and consular fees

1.3 To exempt the members of the Team from taxes, duties and other charges on equipment, machinery and other materials brought into Zimbabwe for the conduct of the Study.

1.4 To exempt the members of the Team from income tax and other charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with the implementation of the Study

1.5 To provide necessary facilities to the Team for remittance as well as utilisation of the funds introduced into Zimbabwe from Japan in connection with the implementation of the Study

1.6 To secure permission for entry into private properties or restricted areas for the conduct of the Study

1.7 To secure permission for the Team to take all data and documents (including photographs) related to the Study out of Zimbabwe to Japan

1.8 To provide medical services as needed. Its expenses will be chargeable to the members of the Team

2. The GOZ shall bear claims, if any arises against members of the Team resulting from, occuring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Team.

3. Industrial Development Corporation of Zimbabwe Limited (hereinafter referred to as "IDC") shall act as counterpart agency to the Team and also as coordinating body in relation with other governmental and non-governmental organisation concerned for smooth conduct of the Study.

4. IDC shall, at its own expense, provide the Team with the following, in cooperation with other organisation concerned:

4.1 Available data, information and samples related to the Study

4.2 Counterpart personnel

4.3 Suitable office space with necessary equipment in Harare

4.4 Credentials for identification cards

5. IDC shall, in cooperation with other relevant organisation, provide assistances for sampling, packaging and dispatching representative samples of raw materials for the proposed project which are required for laboratory examinations in Japan.

VII UNDERTAKING OF JICA

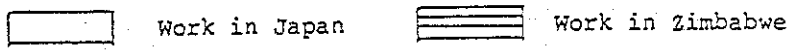
For the implementation of the Study, JICA shall take the following measures:

1. To dispatch, at its own expense, the Team to Zimbabwe
2. To pursue technology transfer to Zimbabwe counterpart personnel in the course of the study

VIII OTHERS

JICA and IDC shall consult with each other in respect of any matter that may arise from or in connection with the Study.

Annex TENTATIVE SCHEDULE OF THE SUDY



Year	1991											
Project Month	1	2	3	4	5	6	7	8	9	10	11	12
Calendar Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Preparatory Work in Japan (Step 1)												
Work in Zimbabwe (Step 2) Presentation of Inception Report Presentation of Progress Report												
Work in Japan (Step 3)												
Presentation of Draft Final Report (Step 4)												
Work in Japan Submission of Final Report in Zimbabwe												

MINUTES OF MEETING

FOR

THE FEASIBILITY STUDY

ON

THE ESTABLISHMENT OF A CITRIC ACID PLANT

IN

THE REPUBLIC OF ZIMBABWE

Harare, August 27, 1990

Mr P. Sibanda
Projects Appraisal Manager
Industrial Development
Corporation of Zimbabwe Limited

富田堅二

Dr Kenji Tomita
Leader of the Preliminary
Survey Team, Japan
International Cooperation
Agency

1. The Preliminary Survey Team made a visit to Zimbabwe from August 20th to August 28th, 1990 to discuss with relevant Zimbabwe authorities on the Scope of Work for the Study.

2. In connection with the above, a series of meetings were held on August 21st, 22nd, 24th and 27th, 1990 between Zimbabwe officials headed by Mr L A Munyawarara, Research and Development Manager , IDC on the Zimbabwe side and the Preliminary Survey Team headed by Dr Kenji Tomita on the Japanese side (Attendance as shown in the Appendix) to discuss the Scope of Work drafted by the Japanese side.

3. Both sides confirmed that the Study would be conducted under the following Zimbabwe government's policy on the industrial sector development which is shown in the five year national development plan (1986 - 1990)

   1) Utilization of domestic resources

   2) Creation of employment

   3) Savings and earnings of foreign currencies

   4) Minimized investment cost

   5) Establishment of the economic and financial viability of the project

4. The Japanese side explained the basic conception, present worldwide situation and future trend of citric acid production including applicable raw materials and processes for the smooth conduct of the Study. The Zimbabwe side appreciated it.

5. In accordance with the request from the Japanese side, the Zimbabwe side confirmed that the following information, data and samples would be available to the Japanese side in Tokyo, Japan by the end of September, 1990.

   1) Answer to the questionnaire

2) Analytical data of representative samples of potatoes, sweet potatoes and cassava on moisture, carbondydrates, starch, sugars, protein, ash, fiber and fat.

3) Analytical data of representative samples of calcium carbonate, calcium oxide and calcium hydroxide on heavy metals and magnesium

4) Analytical data of chemical grade sulfuric acid on heavy metals and other elements such as Cd, Se, As.

5) Representative sample of cooking oil extracted starch and masese.

6. The Japanese side explained that the regional study of citric acid in the third countries including SADCC, PTA and others should not be undertaken by field survey, and should be analyzed by utilizing internationally available primary statistics and analytical studies in accordance with the Japanese Development Study scheme by JICA.

The Zimbabwean side pointed out that the Study would not be complete without the field work being undertaken as this will leave a large percentage of the plant's output without a confirmed market.

7. Visits and discussions at the University of Zimbabwe, a starch factory and a fertilizer factory in Harare were made by both sides.

SIGNED THIS DAY OF AUGUST 1990

Mr P Sibanda
Projects Appraisal Manager
Industrial Development
Corporation of Zimbabwe Limited

Dr Kenji Tomita
Leader of the Preliminary Survey Team,
Japan International Cooperation Agency.

APPENDIX

LIST OF ATTENDANCE

The Japanese Side

The Preliminary Survey Team

Dr Kenji Tomita (Leader)	–	Special Technical Advisor JICA
Mr Yasujiro Suzuki (Project Planning)	–	Industry Division, JICA
Mr Makoto Kuwabara (Chemical Engineering)	–	UNICO International Corporation
Mr Toshitake Yasukawa (Biotechnology)	–	Citric Acid Producers Association

Embassy of Japan

Mr Yukio Kawajiri	–	First Secretary

The Zimbabwe Side

Mr L.A. Munyawarara	–	Manager for Research and Development
Mr P. Sibanda	–	Projects Appraisal Manager
Dr C. Chitsora	–	Senior Engineer
Mrs L. Dhliwayo	–	Research Economist
Mrs E Ndlovu	–	Research Economist
Mr T Sain	–	Legal Advisor

3. 質問書に対する回答書

（回答書原文は事業団が保管している。原文は判読困難であり、参考のためEditingを行ったが、正文は事業団保管の原文である。）

INDUSTRIAL DEVELOPMENT CORPORATION

OF ZIMBABWE LIMITED

Telephone: 706971
Telegraphic Address: INDUSTRIES
Telex: 4-409 IDC ZW

93 Park Lane
HARARE
P.O. Box 8531
Causeway
Zimbabwe

KENJI '90.11.29 TOMITA

EN/LAM/if/IDC

26th November, 1990.

Japan International Cooperation Agency (JICA)
PO Box No. 216
Shinjuku Mitsui Building
2-1 Nishi - Shinjuku
Shinjuku, Tokyo
JAPAN.

ATTENTION : DR KENJI TOMITA
SPECIAL TECHNICAL ADVISOR

Dear Sir,

RE: CITRIC ACID PROJECT FEASIBILITY STUDY

Attached please find the data we have agreed to provide for the study. We also wish to take this opportunity to reiterate that the time you normally allow for such studies would be too long for our purposes.

Our timetable for the development of this project unvaryingly requires that you complete the study and present your report within six (6) months from effective date of agreements. Later than this we would have no use for the findings and recommendations due to competing developments in the region and owing to changes in the international market scene.

Yours faithfully

L.A. MUNYAWARARA
DEPUTY GENERAL MANAGER
BUSINESS DEVELOPMENT DIVISION

[Retyped and partly edited by JICA, M. Kuwabara on December 3, 1990.
Notes by M. Kuwabara are also added in parenthesis]

3. Water at Potential Site

Adequate water supplies exist in the country with major dams rising in their levels during the rainy season.

With the opening of the water tunnel linking Drawindale with the Morton Jaffray water purification works, Harare now has three times as much water as it did in the past when it relied solely on Lake Mcllwaine.

Water rates vary from about 29,8 cents to 32,7 cents a cubic meter and some authorities give reduced rates to large consumers.
Industrial water rate is Z$0,42/$m^3$ in Harare.

4. Electricity at Potential Sites

a) Availability and future supply development programs

Zimbabwe has one of the largest power systems in Sub-Sahara Africa mainly due to the demands of the Mining and Industrial sectors. Generation is by coal and hydroelectric sources.

Maximum demand on the power system was 1,342 MW and the system's annual load factor was 73% in last year. The total energy supplied to the system was 8,891 GWH of which imports from Zambia amount to 2,214 GWH or 25% of the total supply. The consumption of electricity is dominated by the industrial sectors in Harare and Bulawayo at 51% of total supply.

Annual growth rate has fluctuated from zero to 9% over the last decade and it is anticipated that a sustained growth of about 3.3% will be met by the installation of new hydroelectric plant on the Zambezi river; Refurbishment and up-rating of old thermal and hydroelectric units and the transmission and distribution networks; installation of new local fire plant and economic importation of power and energy.

b) Black out frequency and voltage fluctuations

Black outs were experienced only in January/February, 1990 due to breakdowns at Kafue Power Station in Zambia. Otherwise maximum demand is usually met, especially in such sensitive industries as those of Citric Acid.

c) Tariff

Attached is a excerpt of the Tariff Table of Zimbabwe Electricity Supply Authority (ZESA). It would be wise, however to include generators in the feasibility study.

Zimbabwe Electricity Supply Authority
Announced October 26, 1990
Effective November 1, 1990

Tariffs	Metered Domestic Consumers	Low Capacity Commercial, Industrial and Mining Consumers up to 300 kVA	Low Capacity Agricultural Consumers up to 300 kVA	Street Lighting		Hith Capacity Commercial, Industrial and Mining Consumers exceeding 300 kVA	High Capacity Agricultural Consumers exceeding 300 kVA	Load Limited Domestic Consumers	
				Metered Circuits	Unmetered Circuits			Load Limiter	Monthly Charge, Z$
Fixed Monthly Charges, Z$	10	15	15	15	-	22.50	22.50	1	9.15
								2.5	9.25
Monthly Maximum Power Demand, Z$/unit	-	-	-	-	-	22.50	16.97	5	14.40
								7.5	19.55
								10	31.93
Energy Consumption, Z¢/kWh	8.57	8.40	8.52	8.40	-	-	-	15	45.22
- Peak period (0600-2100)	-	-	-	-	-	2.15	2.15	22.5	65.22
- Others	-	-	-	-	-	1.88	1.88	30	85.15
Fixed Monthly Charge, Z¢/watt	-	-	-	-	2.66	-	-		

5. Availability, Quality and Pricing of Major Raw Materials for Citric Acid Production in Zimbabwe
(JICA Preliminary Study Team would appreciate if IDC will fill the followings and supply relevant additional information)

Agricultural Products and By-Products	Annual Production TPY - 1989	Selable Product Quality for Citric Acid Production TPY - 1989	Sugar and/or Starch Content %	Fiber Content %	Supply Location	Seasonal Suppliability DPY	Note and Additional Relevant Information Price, Z$/Ton
(1) Raw Sugar	450,000	293,000	Sugar : 99.9 Ash : 6.70 Water : 1.30	na	Chiredzi	365	900
(2) Refined White Sugar	110,245	113,000	Sugar : 98.5 Starch: 60-80ppm	Less than 10ppm	Harare and Bulawayo	365	925 (Production Price of 650 will be applicable if ZRS in partner.)
Brown Sugar	na	na	Sugar : 98.5 Starch: 150ppm	200ppm	Harare and Bulawayo	365	565
(3) Starch	4,587	600	98.5	1.8	Chitungviza and Harare	365	1,042.5
(4) $CaCO_3$	20,000	Any amount as	-	-	Harare	365	na
CaO	1,500	per request	-	-			na
$Ca(OH)_2$	na	by customer	-	-			na
(5) Sulphuric Acid	144,000	Any quantity	Grade 98%	2% water	Harare	365	650
(6) Maize. TPY							

	1988/9	1989/90
Delivered Sales	1,196,870	1,165,657
- Local	766,600	758,829
- Export	313,727	174,244
- Balance	206,543	232,584

na | na | na | na | na

[$Ca(OH)_2$ must be available, production $CaCO_3$ is questionable and no data was given by IDC on potatoes, sweet potatoes, cassava and rice bran and others which were requested in M/M between IDC and JICA, August 1990.]

6. Specification of Limes

	Agricultural Lime ($CaCO_3$)	Stock Feed Lime	Supper Fine	Slaked Lime
Source	Early Worm Mining	Early Worm Mining	Early Worm Mining	Early Worm Mining
General	Finely ground raw calcitic of 81 to 90% $CaCO_3$ with a neutralizing value of 95%.	Selectively mined and ground raw calcitic of approximately 90% $CaCO_3$ for stock feed.	Ultrafine ground raw lime stone for industrial uses, especially for carpet manufacturing with a calcium carbonate of approximately 90% $CaCO_3$.	-
Packaging	-	Plypaper bag, 25 kg	-	-
Screen Test Mesh through, %				
100	71.5	71.5	-	-
200	54.2	54.2	-	-
270	45.6	45.6	-	-
Color	Off white to white	White	White	Grey
Neutralizing Value, %	95	-	-	-
Analysis, %		-	-	
$CaCO_3$	81.0			68.08 as $Ca(OH)_2$
Al_2O_3	3.12			1.83
MgO	2.17			0.39
Na_2O	Nil			Nil
Fe_2O_3	1.60			1.03
TiO_2	0.05			0.11
MnO	0.35			0.07
K_2O	0.38			0.34
P_2O_5	Nil			Nil
SiO_2	3.02			4.40
Sub-Total	91.69			76.25
LOI	8.31			23.75
Total	100.00			100.00
Use	Soil conditioning for acid soil, used with fertilizer and other neutrients.			Water and sugar purification. Gold, copper and steel mining and manufacturing. Refractory, candle, grease and glue. Sewage purification, soil conditioning and stock feed.

4. DISCUSSION PAPER AND QUESTIONNAIRE（桑原　誠）

1st edition submitted on Aug. 20 to 27, 1990 at IDC, Harare, ZW ($1.0=Z$2.451)
2nd revised edition prepared on Sept. 5, 1990

DISCUSSION PAPER AND QUESTIONNAIRE

FOR

MUTUAL UNDERSTANDING AND PREPARATION

OF

FEASIBILITY STUDY ON CITRIC ACID PROJECT

IN

THE REPUBLIC OF ZIMBABWE

2ND EDITION

AUGUST 20 TO 27, 1990
HARARE, ZIMBABWE

PRELIMINARY SURVEY TEAM
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

Content

1. Production Processes and Raw Materials for Citric Acid Manufacturing

(1) Citric acid (2-hydroxy-1,2,3-propanetricarboxylic acid, $C_6H_8O_7$) is one of the few fine chemicals still produced in commercial scale by fermentation of carbohydrates using aspergillus niger strain.

Production of citric acid from normal-paraffins by candida gailler or candida lipolytica strain is established bio-technology, however it is not yet commercially proven.

Citric acid was also chemically synthesized from 1, 3-dichloroacetone and cyanic acid, which was invented by Dr. E. Grimoux in 1880. Several alternative chemical processes were invented, but no chemical synthesis method was developed up to commercially competitive technology.

Most of commercial production is by aspergillus niger aerobic fermentation of starch, crude sugar or corn dextrose, however still approximately 5% of citric acid is extracted from natural citrus-fruit wastes.

The overall reactions of fermentations are expressed as below:

Sucrose ; $C_{12}H_{22}O_{11} + H_2O + 3O_2 = 2C_6H_8O_7 + 4H_2O$

Dextrose; $C_6H_{12}O_6 + 1.5O_2 = C_6H_8O_7 + 2H_2O$

(2) Citric acid is mostly used acidulant in food, baverage, cosmetics and pharmaceuticals because of its extremely low toxicity, high solubility in water, pleasant sour flavor, ready assimilability, and relatively low price.

Citric acid is also used industrially as chelating, sequestering agent in application such as cleaning, detergent, electroplating, tanning and printing. Recent consumption increase sector is the detergent builder as substitute of sodium tripolyphosphate or zeolites.

(3) Generally chemical industries have been developed to realize the optimum process configuration to seek the maximum yield and maximum selectivity of objective chemicals from the financially lowest cost raw materials and utilities.

Main features of citric acid production are the relatively low priced product and heavily dependent on carbon utilization of carbohydrates. The combination of process and raw materials should be optimized for each locality of citric acid industialization project.

It is considered generally that submerged culture process has positive economy of scale and capital intensive automated technology while solid culture process has advantage for high concentration of citric acid in the substrate, relatively low capital intensive and high labour intensive nature but has low economy of scale. It is also considered generally that financial break even capacity is some where around 9,000 TPY of annual citric acid production scale. (Product is mostly citric acid mono-hydrate and called as CAM in industries)

Brief summary of citric acid process comparison is summarized as below:

Table CITRIC ACID PRODUCTION PROCESSES AND RAW MATERIALS

Fermentation Process and Substrate	Fermentation Features		
	Concentration of Sustrate, %	Fermentation Period, days	Yield on Substrate, %
Shallow Tray Surface Culture			
- Molasses	12.5	6.0	62.5
Submerged Culture			
- Molasses or Raw Sugar	12.5	8.0	57.5
- Starch	14.0	4.5	55.0
- Glucose	13.5	4.5	65.0
- Sweet Potatoes Powder Suspension (China)	-	6.0	-
- Normal-Paraffins	8.5	3.0	135.0
Semi-Solid Culture			
- Fruit Juice on Bagasse	22.5	3.5	68.0
Solid Culture			
- Sweet Potatoes Starch Extracted Lees	37.5	3.5	55.0
- Cassave Starch Extracted Lees	37.5	3.5	55.0

Source: S. Usami and K. Kirimura, Fermentation and Industry in Japan, 43 (11), 1985

(4) Key issues of citric acid production in Zimbabwe will be itemized as follows:

- Raw Materials Availability and Cost Factors
- Process Configuration
- Rated Production Scale and Identified Market Size (Including Export Market)
- Price and Quality Competitiveness of Product(s)
- Financial and Economic Returns on Investment

Availability of raw materials, selection of process configuration and potentical market size are the three key foundations of project structure which should be investigated in due consideration on economy of scale.

Here product(s) means citric acid mono-hydrate (CAM) plus/or calcium citrate (CC).

(5) Processes Outline

Recent process licensor available for citric acid production is summarized in Table 1.

In Table 2, recent citric acid production projects are presented which will be beneficial for future supply and demand projection.

Figure 1 and 2 show the typical flow sheet for submerged culture process and solid culture process.

Table 3 illustrates a preliminary process-wise consumption comparison for citric acid production.

Table 4 is summarizing world-wide citric acid plant list with rather high accuracy and Table 5 is showing world wide citric acid international trade which is rather low accuracy because of limited trade data availability.

Table 5 is summarizing the recent movements of world-wide citric acid industries.

Table 1 PROCESS LICENSORS FOR CITRIC ACID PRODUCTION

September 5, 1990
UNICO, Tokyo

Licensor	Type of License	Approved Contractor	Process Outlines
- American Maize Products	Exclusive, World-wide except USA	Abay Engg	Citric Acid from Starch
- Vogelbusch	-	-	Citric Acid from Molasses (Cane and/or Beet) by Submerged Fermentation
- Chepos (Bratislava)	Case by Case	Siry Chamon	Citric Acid from Molasses
- Licensintorg	-	Uhde	Citric Acid from Molasses, Continuous Fermentation
- Lurgi	-	Lurgi	Citric Acid from Molasses by Aerobic Surface and Submerged Fermentation
- Salzgitter	-	Various	Citric Acid from Molasses by Submerged Fermentation and Airlift Fermenters
- Showa Cheml Co Ltd	Case by Case	-	Citric Acid from Sweet Potatoes Starch Extracted Lees and/or Cassava Starch Extracted Lees by Solid Fermentation

Table 2 RECENT CITRIC ACID PRODUCTION PROJECT

September 5, 1990
UNICO, Tokyo

Country/Company/Location	Project Capacity TPY	Process	Contractor	Contract Cost $,MM	Start-up Schedule
France					
Bayer, Marie	-	-	-	-	P
Jungbunzlauer AG, Marckholsheim	-	-	-	110	S
Miles Inc., North France (?)	-	-	-	-	S
China					
Zhanjiang, Guangdong	5,010	Vogelbusch	-	-	1990
Ningxia, Fuizu	3,000	Vogelbusch	-	-	1991
Wanguan, Hebei	3,000	Vogelbusch	-	-	1991
Tang, Shan	3,000	Vogelbusch	-	-	1992
UK					
Sturge, Selby	25,000	Sturge	Courtaulds Engg, John Brown	50	1989
Ireland					
Pfizer, Ringaskiddy	33% Citric Acid (Exp)	Pfizer	Pfizer	10	1988
Belgium					
Citrique-Belge, Tienen	70,000 (Exp)	Citrique-Belge	-	-	1991
West Germany					
Biochemie Landenburge, Ludwigshafen	25,000 (Exp)	-	-	-	1988
Austria					
Jungbunzlauer, Pernhofen	60,000 (Exp)	Jungbunzlauer	Jungbunzlauer	-	1988
Australia					
Sirius Biotechnology Ltd, Melbourne	3,000	Vogelbusch	-	-	-
Saudi Arabia					
Saudi Industrial Resine,	-	-	-	-	P
Total/Average	197,000 (+Exp)	-	-	170(+)	-

Figure 1 SIMPLIFIED FLOW DIAGRAM FOR CITRIC ACID PRODUCTION (1/2)

- SUBMERGED CULTURE PROCECSS -

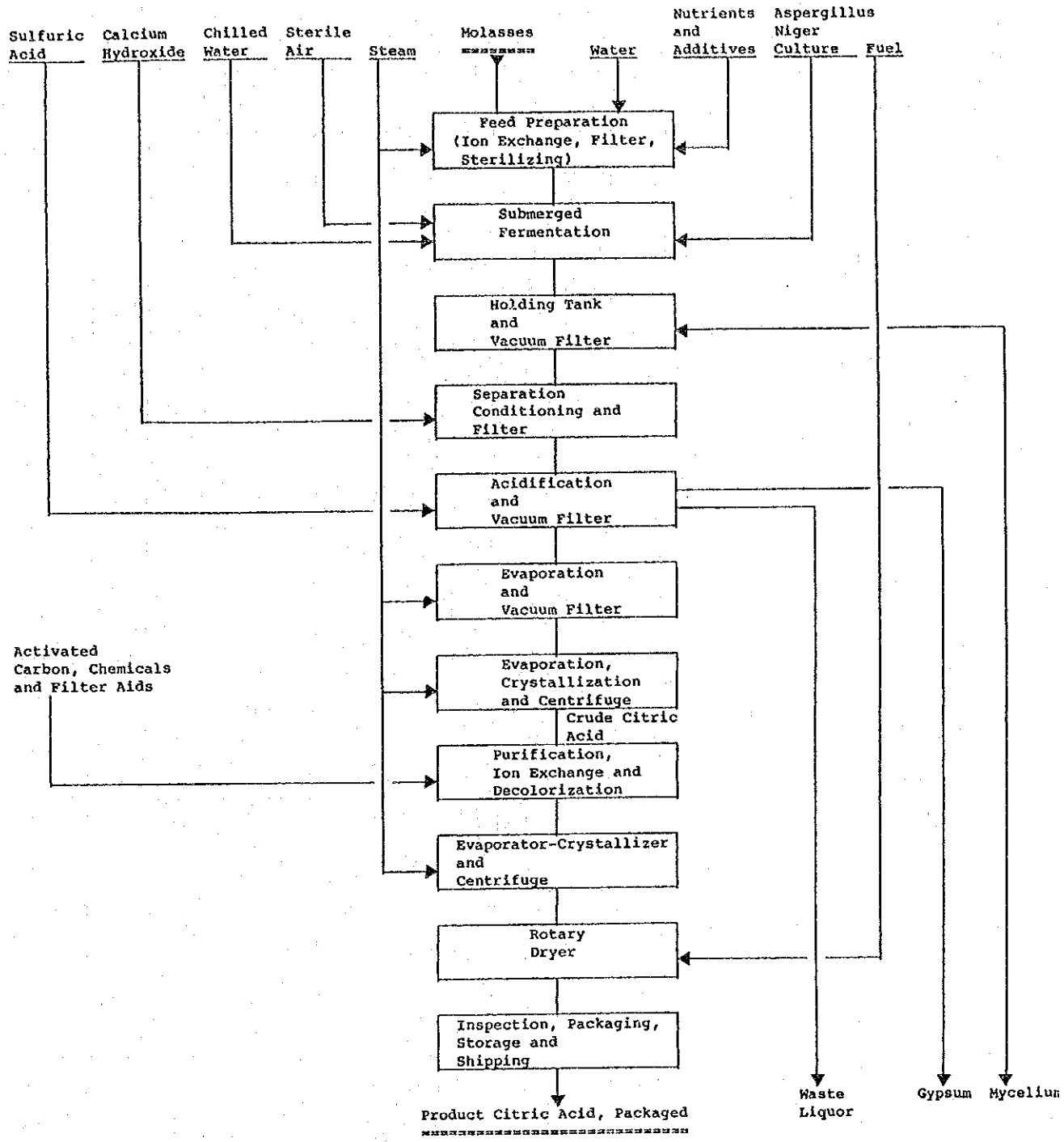
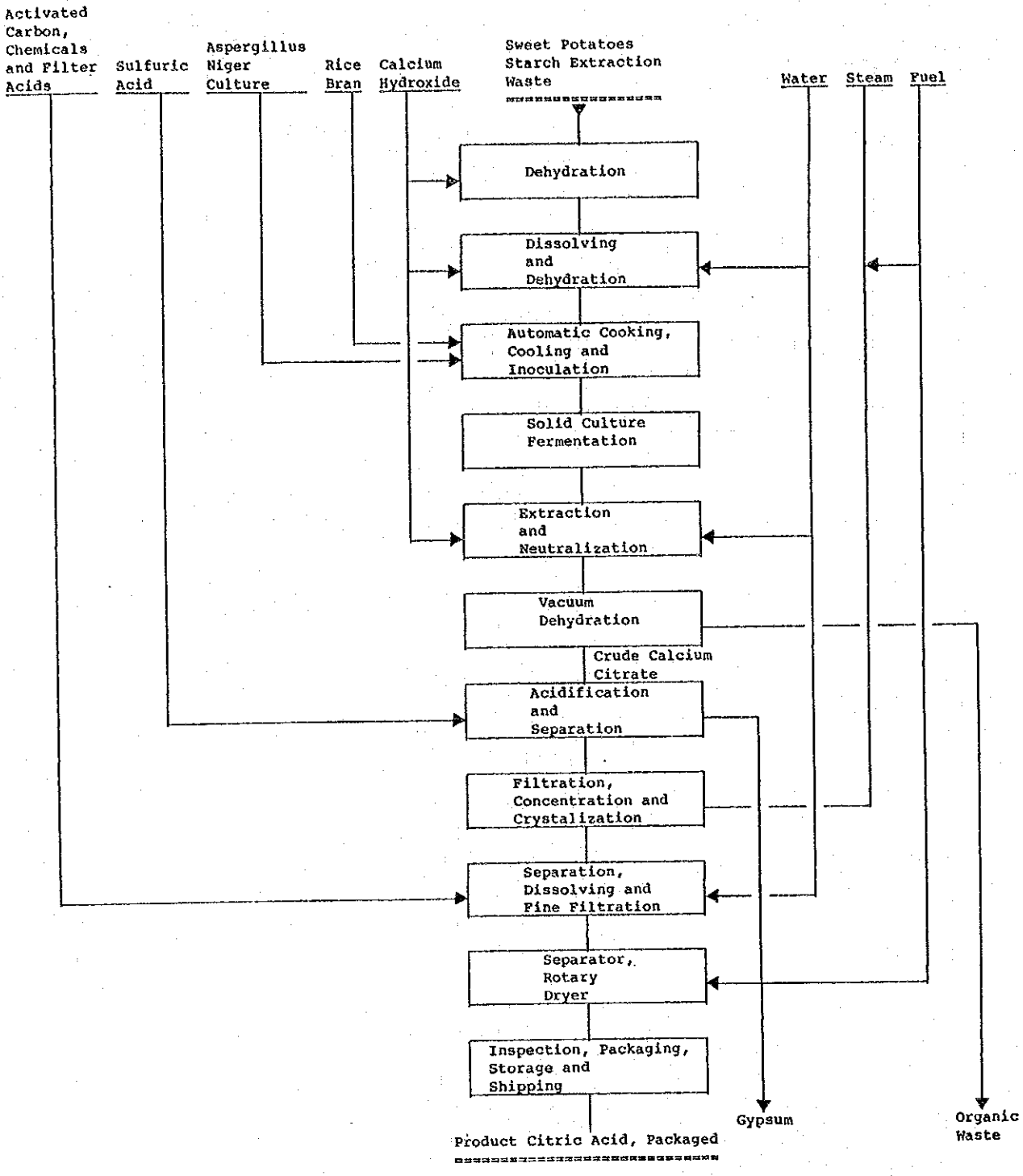


Figure 2 SIMPLIFIED FLOW DIAGRAM FOR CITRIC ACID PRODUCTION (2/2)

- SOLID CULTURE PROCECSS -



(Preliminary)

Table 3 FINANCIAL COMPARISON OF PROCESS-WISE CITRIC ACID PRODUCTION PROCESS

September 5, 1990: UNICO
(Annual Operable day: 300 DPY)

Financial Cost Items	Unit	Unit Cost	Citric Acid Process Comparison: Submerged Culture Process	Citric Acid Process Comparison: Solid Culture Process
Rated Capacity (Assumed)	TPY	-	3,000 ($C_6H_5O_7 \cdot H_2O$)	3,000 ($C_6H_5O_7 \cdot H_2O$)
Estimated Erect Plant Cost in Zimbabwe-1990	$, MM	-	na	na
Total Site Area Required	m^2	-	na	50,000 (with pond)
Total Personnel	Man-Year	-	215	400
Overhead	Man-Year	100%		
Variable Cost Components				
- Molasses	TPT		2.7 (Sugar:1.3)	-
- Sweet Potatoes Starch Extraction Lees	TPT		-	3.0 (Starch: 1.4)
- Aspergillus Niger Culture	$PT		-	-
- Rice Bran/Minerals	$PT		na	0.3
- Calcium Hydroxide with Low Magnesium	TPT		0.73	0.8
- Sulfuric Acid	TPT	$250/Ton	0.89	0.8
- Nutrient, Additives, Activated Carbon, Chemicals and Filter Aides	$PT			
- Electricity	kWh	Z$0.05/kWh	1,975	50
- Fuel	TPT		na	0.002
- Raw Water	TPT		525 (Once through)	75 (Once through)
- Steam	TPT		8.75	
- Packaging Material	$PT	2.7	2.7	2.7
Credits				
- Gypsum, Dry	TPT	$2.0/Ton	(-) 1.55	(-) 1.3
- Mycelium	$PT		(-)	(-)
- Waste Liquor	TPT		(-) 45	(-)
- Organic Waste	TPT	$2.0/Ton	(-) 0.2	(-) 40.0
Indirect Fixed Cost Components				
- Personel	Man-Year	Z$20,500		
- Administration and Commercial	$PT			
- Income Tax	% of Annual Sales			
- Spare Parts and Maintenance Cost	% of Taxable Income			
- Insurance and Local Tax	% of Erected Plant Cost			
- Sales Expense	% of Book Value			
	% of Annual Sales			

Notes: 1) Tax Holiday Years =
2) Depreciation Method = , Salvage Value =
3) Amortization Method = , Salvage Value =
4) Escalation/Deflator Rate =
5) Overall process yield of citric acid monohydrate (CAM) production is assumed 0.77 TPT of sugar in molasses.
6) Overall process yield of citric acid monohydrate (CAM) production is assumed 0.70 TPT of starch in sweet potatoes starch extraction lees

Table 4 LIST OF CITRIC ACID PLANTS (1/2)

September 5, 1990: UNICO

Region, Country	Company	Location	Rated Capacity of Citric Acid, TPY	Raw Material	Process and Licensor	Eng'g	Completion Year	Present Status and Expansion Plan
North America								
USA	Archer Daniels Midland	Decatur, Ill	na (liq, dry)	-	-	-	(1991)	$150MM
	Cargill	Eddyville, Iowa	25,000 (grn, liq)	Glucose	Frmnt	-	(1990)	Near corn wet milling plant
	Miles Lab (Haarmann and Reimer)	Dayton, Ohio	27,000	Dextrose	Frmnt, Miles Lab	-	1977	Corn starch/Dextrose
		Elkhart, Ind	39,000	Dextrose	Frmnt, Miles Lab	Badger, Lummus	1981	Purification by Lummus
	Pfizer	Groton, Conn	45,500	Molasses	Frmnt	-	-	-
		Southport, NC	45,500	Molasses	Frmnt	-	-	Food grade acid
		North America Total	(182,000+)					
Central/South America								
Argentina	Pfizer	Moreno, Bs As	750	Molasses	Frmnt	-	-	-
Brazil	Fermenta-Produtos Quimicos Amalia	Sao Paulo, SP	12,000	Molasses	Frmnt, Miles Lab	-	-	Haarmann and Reimer
Colombia	Sucromiles	Vendemos	6,000	Sugar	Frmnt, Miles Lab	-	1974	Haarmann and Reimer
Cuba	State	na	na	Sugar/Citrus	Frmnt, USSR	-	-	Export to USSR
Mexico	Productos de Ferm y Ind Citricos	na	na	na	na	-	-	-
	Quimica Mexana	Cuernavaca	19,000	Molasses	Frmnt	-	-	Haarmann and Reimer
		Central/South America Total	(37,750+)					
East Europe								
Austria	Jungbunzlauer	Pernhofen	40,000	Molasses (Beet)	Frmnt	-	-	Expansion Plan (+20,000)
Bulgaria	State	Ruse	300	Molasses	Frmnt, USSR	USSR	1964	-
Czechoslovakia	Lachema Managea	Kaznejov	6,000	Molasses	Frmnt	Chepos	1968	Expanded in 1986
Poland	State	Raciborz	1,000	Molasses	Frmnt	-	1963	-
		Zgierz	120	Molasses	Frmnt	-	1965	-
Romania	State	Giurgiu	1,500	Molasses	Frmnt, Czech	Chepos/Lachema	1974	-
USSR	State	Alma-Ata, Kaz	na	Molasses	Frmnt	-	-	-
	State	Latvia	na	-	Frmnt	-	-	-
	State	Moldavia	na	Sugar	Frmnt	-	1986	-
	State	Smela, Ukr	2,640	-	Frmnt	-	-	-
	State	na	na	-	Frmnt	-	-	-
	State	na	na	-	Frmnt	-	-	-
Yugoslavia	Pomoravlje	Cuprija	7,500	Molasses (Beet)	Frmnt	-	-	-
	Tovarna Organskih Kislin	Ilirska Bistrica	na	Molasses	Frmnt	-	-	Acid and sodium salt
		East Europe Total	(59,060+)					
West Europe								
Belgium	Citrique Belge	Tienen	42,000	Molasses (Beet/Cane)	Frmnt	-	-	-
German FR	Biochemie Ladenburg	Ladenburg	30,000	Molasses (Beet/Cane)	Frmnt	-	1972	-
Ireland	Pfizer Chemls	Ringaskiddy	36,000	Carbohydrate	Frmnt, Pfizer	-	-	-
Italy	Biacor	Casei Gerola	25,000	Molasses	Frmnt, Sturge	-	1960	-
	Chimica Arenella	Palermo, Sicily	6,600	Molasses (Beet)	Frmnt	Standard Messo	1976	-
Spain	Ebro	Cortes, Navarra	5,000	Molasses	Frmnt	-	-	-
UK	John and E Sturge	Selby, Yorkshire	14,000	Molasses	Frmnt, Submerge	Courtaulds	-	Expansion Works to 25,000 TPY
	Rhone-Poulenc	Selby, Yorkshire	23,000	-	-	-	1990	$101 MM (Expandable to 36,000 TPY)
		West Europe Total	(181,600+)					

Table 4 LIST OF CITRIC ACID PLANTS (2/2) September 5, 1990: UNICO

Region, Country	Company	Location	Rated Capacity of Citric Acid, TPY	Raw Material	Process and Licensor	Eng'g	Completion Year	Present Status and Expansion Plan
Africa and Middle East								
Israel	Gadot Petrochemi Ind	Haifa	14,000	Molasses	Frmnt, Miles Lab	-	1964	Bought from Miles Lab
Nigeria	Pfizer	Aba	4,500	Molasses	Frmnt	-	-	-
		Ikeja		Molasses	Frmnt	-	-	-
South Africa	Bush Boake Allen	Kempton Park	na	-	-	-	-	Now closed down
Turkey	Fursan Fermentasyon	Istanbul	3,000	Molasses (Beet)	Frmnt, Surface	Standard Messo	-	-
		Africa and Middle East Total	(21,500+)					
Asia and Oceania								
Australia	Pfizer Chemls	Parramatta, NSW	na	Molasses	Frmnt, Miles Lab	-	-	-
China	State	Yichang, Hebei	3,000	Sweet Potatoes Starch	Frmnt, Submerge	Vogelbusch	1993	
		Hefei, Anhui	na	Sweet Potato	Frmnt	-	-	Acid is exported
		Lianyungang, Jiangsu	na	Molasses	Frmnt	-	-	-
		Shijiazhuang	na	-	-	-	-	-
		Zhanjian	5,010	Molasses (Cane)	Frmnt, Submerge	Vogelbusch	1990	-
		Ningxia	3,000	Sweet Potatoes Starch	Frmnt, Submerge	Vogelbusch	1991	
		Wanquan Hebei	3,000	Cassava Starch	Frmnt, Submerge	Vogelbusch	1991	
		Tang Shan	3,000	Glucose	Frmnt, Submerge	Vogelbusch	1992	
		Others	na	-	-	-	-	-
		China Total	(40,000?)					
India	Andhra Citrates	Hyderabad, AP	600	Sugar	Frmnt,Submerge,Indian	Indian	-	-
	Citric India	Bombay, Mah	1,500	Ca Salt	Acdfct	-	-	-
	Citurgia Biochemls	Surat, Guj	4,650	Molasses (Cane)	Frmnt, Deep, Sturge	-	-	-
Indonesia	Budi Acid Yaya	Bandar Lampung	1,080 (Ca Salt 2,160?)	Tapioca Waste/Rice Bran	Frmnt, Solid	-	1981	Rp1.3B($2.0MM), 125 Manpower
		Semarang					1979	Formerly Inti Rasa Jaya
	Budi Alam Kencana	Bandar Lampung	6,000 (Ca Salt 3,000)	Tapioca Waste/Rice Bran	Frmnt, Solid	-	1984	Rp1.5B($1.5MM), 94 Manpower
	Semarang Diamond Chemls	Semarang	5,100	Tapioca Waste/Rice Bran	Frmnt, solid	-	1978	Rp1.3B($0.8MM), 215 Manpower
Japan	Fuso Chem1	Osaka	4,000	Ca Salt	Acdfct	-	-	-
	Iguchi Shokuhin	Hidaka	600	Ca Salt	Acdfct	-	-	-
	Iwata Kagaku Kogyo	Iwata	4,000	Molasses	Frmnt, Submerge	-	-	-
	Kyushu Kako	Kanoya	4,000	Sweet Potatoe Waste/ Rice Bran	Frmnt, Solid	-	-	-
	Satsuma Kako	Kagoshima	1,400	Sweet Potatoe Waste/ Rice Bran	Frmnt, Solid	-	-	-
	Sanei Chem1 Inds	Okayama	3,000	Ca Salt	Acdfct	-	-	-
	Towa Chem1	-	900	Ca Salt	Acdfct	-	-	-
	Tamai Chem1	-	600	Ca Salt	Acdfct	-	-	-
		Japan Total	(18,500)					
Pakistan	Markir Alkaloids	Quetta	na	-	-	-	-	-
Taiwan	Pfizer	Tanshui	na	Molasses	Frmnt	-	-	-
	San Fu Chem1	Tainan	1,500	Molasses	Frmnt	-	-	-
Thailand	Citric Acid Ind Co Ltd	Samutprakan, Bangkok	1,600(Ca Salt 3,000)	Tapioca Waste/Rice Bran	Frmnt, Solid	-	1989	Baht 96MM ($4MM)
		Asia and Oceania Total	(74,710+)					
		World Total	[556,620+]					

Notes: 1) Miles Lab is now Haarmann and Reimer of a subsidiary of Bayer AG.
2) Pfizer is now a subsidiary of Archer Daniels Middland Co.
3) Biochemie Landenburg is wholly owned subsidiary of Jungbunzlaur.
4) Rhone-Poulanc's Yorkshire plant is solid to Haarmann and Reimer of Bayer AG.

Abbreviation: Acdfct = Acidification, Frmnt = Fermentation, Tapioca Waste = Starch Extracted Tapioca Lees (cassava, manjoca), Sweet Potatoe Waste = Starch Extracted Sweet Potatoe Lees

Sources : Chemical Plant Data, Citric Acid, Chemical Intelligence Service, London, Uk and other publications

Table 5 CITRIC ACID PRODUCTION AND TRADE STATISTICS (1/2)

September 5, 1990: UNICO

Region	Country	Production, TPY	Export			Import		
			Quantity, TPY	Unit Price, $/T	Major Destination	Quantity, TPY	Unit Cost, $/T	Major Origin
North America								
	Canada	-	61	1,426	Undisclosed	7,873	911	USA, Belgium
	USA	-	3,274	2,325	Japan, Canada	28,810	1,465	Belgium, German FR
		(-)	(3,335)	(Av 2,325)		(36,683)	(Av 1,188)	
Central/South America								
	Brazil	10,316	2,153	1,372	Argentina, South Africa	2,153	1,300	Mexico, USA, Colombia
	Canary Islands	-	5	1,400	Sierra Leone	79	1,861	Ireland, Netherlands
	Chile	-	51	397	Bolivia	1,697	1,502	Colombia, Austria
	Colombia	6,391	3,741	1,487	Venezuela, Peru	1	6,000	Undisclosed
	Ecqador	-	-	-	-	403	1,725	Colombia, German FR
	Guinea-Bissau	-	-	-	-	1	3,000	-
	Guyana	-	-	-	-	20	3,400	USA, UK
	Jamaica	-	0	-	-	204	1,637	USA, German FR
	Mexico	-	8,262	1,243	USA, Brazil	1	4,000	USA, Canada
	Puerto Rico	-	150	2,027	Guatemala, Dominican	80	1,170	German FR
	Paraguay	-	-	-	-	na	-	Venezuela
	Trinidad & Tobago	-	-	-	-	75	2,160	USA, Netherlands
	Uruguay	-	-	-	-	126	1,563	-
	Venezuela	-	-	-	-	2,960	1,597	Colombia, Mexico
		(6,391+)	(13,821)	(Av 1,533)		(8,427)	(Av 1,554)	
East Europe								
	Austria	-	-	-	-	1,392	1,236	China, Belgium
	Poland	-	-	-	-	1,264	1,337	Czecho, Austria
	USSR	-	661	1,484	Cuba	-	-	-
	Yugoslavia	4,259	270	1,226	France, Germany FR	1,772	1,621	Italy, Austria
		(4,259+)	(931)	(Av 1,355)		(4,428)	(Av 1,398)	
West Europe								
	Belgium	-	-	-	-	3,308	1,347	Austria, German FR
	Cyprus	-	-	-	-	133	1,662	Italy Ireland
	Denmark	3	26	2,692	Kuwait	2,516	1,244	Belgium, German FR, Italy
	Finland	-	1	1,000	Undisclosed	1,491	1,297	China, Austria
	France	-				22,792	1,119	Italy, German FR
	German FR	-	-	-	-	27,574	1,206	Austria, Belgium
	Greece	-	-	-	-	3,273	1,631	-
	Iceland	-	-	-	-	24	1,875	Denmark
	Ireland	-	24,522	1,532	-	1,325	1,650	Austria, UK
	Italy	-	11,299	1,481	Undisclosed	6,226	1,481	Ireland, Austria
	Malta	-	-	-	-	9	1,444	Netherlands
	Netherlands	-	2,369	1,221	German FR, Belgium	8,104	1,220	Belgium, Austria
	Norway	-	13	2,846	Undisclosed	852	1,414	China, German FR
	Portugal	-	28	2,857	Angola, Cape Verde	1,285	1,471	Ireland, Belgium
	Spain	-	30	2,033	German FR, Italy, Portugal	30	2,033	Belgium, Austria
	Sweden	-	84	1,274	Denmark	2,890	1,282	Austria, China
	Switzerland	-	312	1,337	Italy, Hungary	4,287	1,421	Austria, China
	UK	-	na	-	Undisclosed	16,369	1,277	Ireland, Austria
		(-)	(40,110)	(Av 1,362)		(108,648)	(Av 1,387)	

Table 5 CITRIC ACID PRODUCTION AND TRADE STATISTICS (2/2)

September 5, 1990: UNICO

Region	Country	Production, TPY	Export: Quantity, TPY	Export: Unit Price, $/T	Export: Major Destination	Import: Quantity, TPY	Import: Unit Cost, $/T	Import: Major Origin
Middle East and Africa								
	Algeria	-	-	-	-	2,203	1,694	Belgium, Austria
	Bahrain	-	-	-	-	44	1,205	Belgium, UK
	Dubai	-	-	-	-	443	1,363	Austria, China
	Iraq	-	-	-	-	1,687	1,686	Turkey, Austria
	Israel	-	-	-	-	2,054	7737	UK, Netherlands
	Jordan	-	-	-	-	545	1,433	China, Italy
	Kuwait	-	8	875	UAE, Saudi Arabia	176	1,420	China, Ireland
	Morocco	-	-	-	-	643	1,597	Germany FR, Italy
	South Africa	-	-	-	-	3,509	1,329	Belgium, Ireland
	South Arabia	-	6	3337	-	996	1,668	Belgium, German FR
	Sudan	-	-	-	-	61	1,656	Belgium, Netherlands
	Syria	-	-	-	-	1,701	1,073	China, Belgium
	Tunisia	-	-	-	-	104	1,798	-
	Turkey	-	2,500?	1,351	USA, German FR	847	1,397	Austria, Belgium
	Zaire	-	-	-	-	39	3,564	-
	Zambia	-	-	-	-	45	2,244	German FR, Brazil
		(-)	(2,514)	(1,351)		(14,101)	(Av 1,436)	Belgium, USSR, Denmark
Asia and Oceania								
	Australia	-	-	-	-	6,824	1,226	Ireland, USA, China
	Bangladesh	-	-	-	-	270	1,237	China, Australia
	Myanmar	-	-	-	-	66	1,727	German FR, Netherlands
	China	71,333-1988	35,283-1988	1,095	-	-	-	-
	Hong Kong	-	4,969	1,052	South Korea, India	5,175	1,013	China, Ireland
	India	4,209	29	1,621	UAE, Sri Lanka	1,458	1,000	China, Taiwan
	Indonesia	-	3,163	1,204	German FR, Taiwan	126	1,587	Belgium, Ireland
	Japan	-	45	6,067?	South Korea, Taiwan	14,544	1,357	China, Ireland, Austria, Belgium
	South Korea	-	-	-	-	4,878	1,259	Belgium, Austria, Taiwan
	Macao	-	-	-	-	2	2,000	USA, China
	Malaysia	-	-	-	-	976	1,555	USA, China, Belgium
	New Zealand	-	1	3,000?	Australia	1,021	1,407	USA, Ireland
	Pakistan	-	-	-	-	1,667	1,343	China, Belgium
	Philippines	-	-	-	-	1,632	1,645	Ireland, Belgium
	Taiwan	-	44	959	Japan, Singapore	2,119	1,441	Indonesia, Austria
	Thailand	-	122	1,451	Japan, Pakistan	711	1,332	China, Ireland
		(33,440)	(41,995)	(Av 1,149)		(40,388)	(Av 1,634)	
World Total/ Average:		44,090+	102,706	Av 1,513		212,675	Av 1,433	

Notes : 1) The statistic cited here is the latest available throughout 1987 to 1989
2) Price and cost is simple average for more than 100 TPY annual trade quantity

Sources: Chemical Intelligence Services, Chemical Trade and Production Statistics, July 1990, London, UK and Others

Table 6 NEW MOVEMENTS OF CITRIC ACID INDUSTRY

September 5, 1990
UNICO, Tokyo

(1) Pfizer Inc. is to sell Citric Acid Business to Archer Daniels Midland.

Pfizer citric acid plants capacity is 81,648 TPY in Southport, N.C., Groton Conn. the USA and Ringskiddy, Ireland, and sales in 1989 is estimated $180MM (Unit sales price is $2,205/Ton of Citric Acid).

(ECN, July 9, 1990)

(2) Phone-Poulenc is to sell Citric Acid Business to Bayer A.G.

Phone-Poulenc's Sturge Plant in Selby, Yorkshire, UK with 23,000 TPY capacity (expandable to 36,000 TPY) will be sold at $100MM.

Bayer's world wide capacity will be increased upto 150,000 TPY and will be integrated into Bayer's Haarmann and Reimer unit which has citric acid plants in USA and joint-ventures in Mexico, Colombia, and Brazil.

World market of citric acid is estimated 500,000 TPY in 1990.

(CMR, July 23, 1990)

(3) Cargill's entry into Citric Acid Business.

Cargill will complete 25,000 TPY capacity plant of citric acid in Eddyville, Iowa, the USA.

(4) France, President Francois Mitterand ruled new citric acid plant is not environmentally harmfull.

Jungbunzlauer AG, Austrian company will construct a citric acid unit in the Rhine forest at Marckolsheim.

The total area was reduced from 152 Ha which previously set aside to 80 Ha according to the protest by Green's campaign against the land use authorization granted Strasbourg.

(ECN, July 30, 1990)

(5) Citric Acid Market Softens

New Entry	:	Cargill; 25,000 TPY plant (1990) in Eddyville, Iowa, the USA
		Archer Daniel Midland Company; $150MM plant in Decatur, Ill, the USA
		Miles Inc; Debottlenecking to 22,680 TPY (+7,938 TPY) and also will construct new citric acid plant in Northern France.
Domestic Price in the USA	:	List price of domestic producers; Miles Inc. and Pfizer Inc. is still $1,841/Ton but importers say $1,653/Ton.
Market Annual Growth:		Approximately 3 to 5% (Past few years)
Importers	:	Hoffmann-La Roche Inc., Belgium; Prices on par with domestic producers
		Jungbunzlauer AG, Austria plus its subsidiary Biochemie Landenburg GmbH; Third largest world producer
Importers (Second Tier)	:	Turkey, Israel, Indonesia and China; Miles Inc. Imports from Brazil
USA Consumption	:	140,162 TPY - 1988
USA Production	:	112,493 TPY - 1988
USA Import	:	29,030 TPY - 1988
Big Threes of Citric Acid Producers	:	Pfizer Inc (Archer Daniel Midland), Miles Inc (Bayer AG) and Jungbunzlauer/Biochemie Ladenburg

(6) Citric Acid Plants in Indonesia using Solid Culture Process

[1] Name of Company : P.T. Semarang Diamond Chemicals

Status : Private Company under Foreign Investment Law

Plant Location : Randugarut, Kecamatan Tugu, Semarang

Management : Mr. Harun Widjaja
Mr. Julius Mitra

Start of Production : March, 1979

Product : Calcium Citrate

Capacity : 5,100 TPY

Raw Materials : Local; Tapioca Waste, Tapioca Chip and Rice Bran

Import; Spora (Sead, Hohshi), Enzyme

Manpower : 251

Investment : $2.2 MM

[2] Name of Company : P.T. Inti Rasa Yaya

Status : Private Company under Foreign Investment Law

Plant Location : Semarang

Management : Mr. Harun Widjaja
Mr. Julius Mitra

Start of Production : May, 1979

Product : Calcium Citrate, Citric Acid

Capacity : 3,600 TPY, 1,200 TPY

Raw Materials : Local ; Tapioca Waste, Rice Bran and Sulfuric Acid

Import; Sodium Ferrocyanide

Manpower : 525

Investment : $2.0 MM

Expansion Plan : 1982

2. Specific Conditions for Citric Acid Production in Zimbabwe

(1) Availability of raw materials and other requirements for citric acid should be summarized in Table 7 Questionnaire.

(2) Table 8 is showing reference data of export market potentials in Zimbabwe's near-by regions, especially PTA, SADDC region and South Africa.

(3) Table 9 is crop production data for 1988 in Zimbabwe.

A simple comparison between the World, Africa and Zimbabwe is illustrated.

(4) Table 10 is similar comparison of beverage. Information on Zimbabwe is not published in international batabase.

(5) Table 11 is showing citric acids, salts and esters price trend in the USA.

Table 7 QUESTIONNAIRE

1. Availability, Quality and Pricing of Major Raw Materials for Citric Acid Production in Zimbabwe

JICA Preliminary Study Team would appreciate if IDC will fill the followings and supply relevant additional information.

Agricultural Products and By-Product	Annual Production TPY - 1989	Salable Product Quantity for Citric Acid Production TPY - 1989	Sugar and/ or Starch Content % in Wet Basis	Fiber Content % in Wet Basis	Supply Location	Seasonal Suppliability	Note and Additional Relevant Information
(1) Potatoes							
Potatoes Starch							
Potatoes Starch Lees							
(2) Sweet Potatoes							
Sweet Potatoes Starch							
Sweet Potatoes Starch Lees							
(3) Cassava							
Cassava Starch							
Cassava Starch Lees							
(4) Cane Sugar, Raw							
Molasses							
Bagasse							
(5) Beet Sugar, Raw							
Molasses							
(6) Other Sugar, Raw							
Molasses							
Lees							
(7) White Maize							
White Maize Starch							
(8) Yellow Maize							
Yellow Maize Starch							
(9) Cooking Oil ExtractedMaize							
(10) Rice							
Rice Bran							
(11) Calcium Carbonate							
Calcium Oxide							
Calcium Hydroxied							
(12) Sulfuric Acid							
(13) Chibuku/Rufaro Mhamba Lees (As texture structure of solid culture fermentation)							
(14) Bagasse							

Notes:

(1) JICA Preliminary Study Team will bring back to Japan several representative samples for preliminary analysis and evaluation tests for the technical viability assessment for citric acid production from Zimbabwe's domestically available resources.

IDC's assistance for sampling, pretreatment, packaging and dispatching through uncompanied flight baggage or any other efficient way is appreciated. IDC's is also requested to obtain custom clearance certificate documents prior the departure of JICA Preliminary Study Team at Harare.

The above mentioned preliminary analysis and evaluation tests will require 90 days for testing and reporting in Japan after the arrival of the representative samples at the specified research and testing labs in Japan.

(2) Present status and future expansion potentials of agricultural production specified in Item 1.

(3) Water at Potential Site
- Availability of industrial water
- Seasonable fluctuation of quality and quantity
- Quality of water
- Tariff table
- Control standard of waste water

(4) Electricity at Potential Site
- Availability
- Voltage fluctuation
- Black out frequency and time required for recovery
- Tariff table
- Future supply development program

(5) Present Fermentation Industries and Technical/Scientic Research Activities in Zimbabwe

(6) Labor Efficiency, Wages, Bonus and Overhead

(7) Other Important Information

Table 8 INTERNATIONAL AND GEOGRAFICAL COOPERATION SCHEME OF ZIMBABWE

September 5, 1990
UNICO, Tokyo

Southern Africa Country	Population, MM-1988	GDP/Capita US$-1988	PTA, Preferential Trade Area	SADCC, Southern African Development Coordination Conference
Angora	9.5	na	-	X
Botswana	1.2	1,050	X	X
Brundi	5.2	230	X	-
Morocco	23.9	750	X	-
Djibouti			X	-
Ethiopia	47.9	120	X	-
Kenya	23.9	360	X	-
Lesotho	1.7	410	X	X
Malawi	7.8	160	X	X
Mauritius	1.1	1,810	X	-
Mozambique	14.9	100	X	X
Rwanda	6.8	310	X	X
Somalia	7.1	170	X	-
Swaziland	0.7	790	X	X
Uganda	17.2	280	X	-
Tanzania	24.0	160	-	X
Zambia	7.5	290	X	X
Zimbabwe	8.9	660	X	X
South Africa	(33.8)	(2,290)	(-)	(-)
Total Population, MM-1988	209.3 (243.1)	-	175.8 (209.6)	83.0 (116.8)
Average GDP/Capita, US$-1988	-	290.2 (568.2)	342.1 (640.7)	288.9 (844.5)
GDP, $, MM	-	60,732 (138,134)	56,892 (134,294)	21,236 (98,638)
GDP Ratio = Region/Zimbabwe;	- (-)	10.3 (23.5)	9.7 (22.9)	3.6 (16.8)
GDP/Capita Ratio = Region/Zimbabwe;	- (-)	0.44 (0.86)	0.52 (0.97)	0.34 (1.28)
Population Ratio = Region/Zimbabwe;	23.5 (27.3)	- (-)	19.8 (23.6)	9.3 (13.1)

Note: ( ) = Including South Africa

Table 9 CROPES PRODUCTION IN 1988

Unit: 1,000 Ha
Ton/Ha
1,000 Ton

Crops	World			Africa			Zimbabwe		
	Area Harvest	Yield	Production	Area Harvest	Yield	Production	Area Harvest	Yield	Production
Cereal, Total	702,083	2.48	1,742,985	76,185	1.17	89,224	1,945	1.54	2,989
Wheat	202,406	2.31	509,952	8,103	1.68	13,630	45	5.56	250
Rice, Paddy	145,602	3.32	483,466	5,447	1.73	9,467	10	3.33	1
♦Rice Bran	-	-	na	-	-	na	-	-	na
Coarse Grain Primary	336,074	2.23	749,567	62,635	1.06	66,127	1,900	1.44	2,738
Barley	75,961	2.22	168,423	4,851	1.15	5,575	5	5.77	30
♦Maize	126,613	3.20	405,460	19,940	1.52	30,313	1,300	1.73	2,253
Rye	14,903	1.99	29,617	28	0.18	5	-	-	-
Oats	23,549	1.65	38,848	788	0.24	187	1	1.50	1
♦Millet	40,641	0.78	31,536	17,680	0.76	13,377	374	0.74	278
♦Sorghum	45,590	1.36	61,787	17,556	0.87	15,280	220	0.80	176
Roots and Tubers, Total	46,552	12.27	571,182	13,920	7.04	97,986	24	4.83	118
♦Potatoes	18,135	14.87	269,702	806	8.75	7,053	2	15.95	30
♦Sweet Potatoes	9,258	14.08	130,355	1,184	5.02	5,949	1	2.36	1
♦Cassava	14,718	9.39	138,237	8,093	7.05	57,020	22	3.96	87
♦Yams	2,450	9.64	23,629	2,318	9.70	22,470	-	-	-
Pulses, Total	68,536	0.80	54,652	11,289	0.61	6,865	71	0.69	49
Beans, Dry	27,332	0.57	15,533	2,469	0.68	1,678	66	0.70	46
Soybeans	54,651	1.69	92,333	434	1.09	472	51	2.00	102
Groundnuts in Shell	19,535	1.17	22,752	5,725	0.81	4,616	190	0.71	135
Sunflower Seed	15,458	1.36	20,947	830	0.84	699	70	0.93	65
Seed Cotton	34,058	1.56	53,115	3,853	0.98	3,792	265	1.05	279
♦Sugar Cane	16,349	60.45	988,209	1,197	61.12	73,185	32	97.75	3,128*
Sugar Beets	8,535	34.53	294,690	87	44.83	3,902	-	-	-
Sugar, Centrifuge	-	-	102,779	-	-	7,984	-	-	442
Sugar, Noncentrifuge	-	-	12,275	-	-	90	-	-	na
♦Bagasse - 1985	-	-	223,002	-	-	23,862	-	-	1,485
♦Molasses - 1980	-	-	31,752	-	-	2,177	-	-	62.6

Notes : (1) Price in $/Ton - 1988 : Maize, US Gulf, FOB = 107
Sorghum, US Gulf, FOB = 99
Potatoes, USA = 121
Cassava, Bangkok, Pellet, FOB = 86
Rotterdam, CIF = 167
New York, CIF = 293

(2) *Bagasse production is estimated approximately 1,485,000 TPY and molasses is approximately 62,560 TPY

Sources: FAO Yearbook, FAO - 1988
Energy Statistic, United Nations - 1985 for Bagasse
Access to Japan's Import Market - Molasses, 2nd Edition, JETRO - 1983 for Molasses

Table 10 BEVERAGE STATISTIC OF ZIMBABWE IN 1987

Unit: Thousand Hectoliters/Year

Beverage	World	Africa	Zimbabwe	Japan
Distilled Alcoholic Beverage	67,936	797	na	8,725
Ethyl Alcohol for All Purpose	217,122	342	na	2,463
Wine	318,076	14,321	na	391
Beer	1,006,733	59,394	1,235* (1983)	54,922
Soft Drinks	552,593	40,952	na	27,710
Mineral Water	159,428	3,748	na	860

* Data is available up to 1985, figure in 1983 is historical highest

Source: Industrial Statistics Yearbook - 1987, Vol. 2, United Nations

Table 11 PRICE TREND OF CITRIC ACID AND CITRATES IN THE USA

Citric Acid and Citrate	Chemical Marketing Reporter*, $/Ton in the USA					
	July 26, 1985	July 25, 1986	July 24, 1987	July 22, 1988	Aug. 21, 1989	July 16, 1990
- Ammonium Citrate, Dibasic, 250-lb, Dms, fob Works	6,151	6,151	6,151	6,151	6,217	6,217
- Calcium Citrate, Purif, 200-lb, Dms, 10,000 lbs or more, fob Works	8,422	8,422	8,422	8,422	8,818	8,818
- Citric Acid, USP, Hydrous, Gran, 250-lb, Dms, TL	2,623	2,623	2,623	2,623	2,756	2,756
- Citric Acid, USP Anhyd, Gran, 100-lb, Bgs, TL, Dlvd. East	1,852	1,896	1,830	1,841	1,841	1,620
- Citric Acid, Anhyd, Powd, TL, 200-lb, Bgs	1,786	1,931	1,973	1,973	1,973	1,808
- Potassium Citrate, USP, Gran, 100-lb, Bgs TL, Dlvd. East	2,061	2,061	1,995	1,995	2,105	2,105
- Sodium Citrate, USP, Gran, Dihydrate, 100-lb, Bgs, TL, Dlvd. East	1,642	1,642	1,687	1,687	1,797	1,797

* Schnell Publishing Company, Inc. New York, the USA

(6) Table 12 shows industrial standards on citric acids and Table 13 shows food additives standards in Japan.

(7) Table 14 shows citric acid derivatives generally produced in Japan.

(8) Table 15 and 16 are climatic conditions which are influential for process design for citric acid production and site selection. IDC is requested to review the data at potential sites in Zimbabwe. Kagoshima, Japan, Surabaya, Indonesia and Bangkok, Thailand are selected where solid culture fermentation production for citric acid production is practised commercially.

Table 12 JAPANESE INDUSTRIAL STANDARD FOR CITRIC ACID

Item	JIS K1355 - 1954 (Reaffirmed: 1979)	JIS 8283 - 1986
1. Scope	Citric Acid (Monohydrate) as Industrial Chemicals	Citric Acid Monohydrate as Reagent (FW: 210.14)
2. Property Characteristics	-	Crystalline grain or powder, soluble in water and ethanol and insoluble in ethyl ether
Qualitative Reaction	-	Calcium salt in alkaline solution
Reference	-	Infrared absorption spectrum: Main absorptions are 3450, 1750, 1720, 1180, 1140, 940 and 980 cm^{-1}
3. Quality and Grade	Appearance and Odour: Colourless, odourless and transparent crystal or colourless and odourless crystalline powder State when Dissolved in Water: Turbidity Ash : 0.2% max Oxalic Acid: Turbidity in Alkaline Calcium Solution Sulfate : 0.15% max as SO_4 Sulfuric Acid-Coloured: Heated Colour Heavy Metal: 0.001% max as Pb by Colourimetric Contente as $C_6H_8O_7 \cdot H_2O$: 99.0% min by Titration	Solubility in Water : Transparency of 2g/20ml water Solubility in Ethanol: Transparency of 2g/20ml ethanol Chloride : 0.005% max Phosphate : 0.001% max Sulfur : 0.005% max as SO_4 Oxalic Acid : 0.01% max as $C_2H_2O_4$ Tartaric Acid : 0.01% max as $C_4H_6O_6$ Calcium : 0.002% max as Ca Copperm : 0.0001% max as Cu Zinc : 0.0001% max as Zn Lead : 0.0001% max as Pb Iron : 0.0003% max as Fe Content : 99.5 to 100.5% as $C_6H_8O_7 \cdot H_2O$
4. Container	-	Airtight
5. Marking	-	Name of Product, Quntity of Contents, Manufactured Year and Month, Manufacturer's Name or its Mark

Note: 1) JIS has separate standard for Potassium Citrate (JIS K8285-1961, revised in Jan. 1986), Ammonium Citrate (JIS K8284 - 1961, revised in Feb. 1989), Sodium Citrate (JIS K8288 - 1961, revised feb. 1980), Ferric Ammonium Citrate (JIS K8287 - 1961) and Ferric Citrate (JIS K8286 - 81).

Table 13 JAPANESE STANDARDS FOR FOOD ADDITIVES - 1987 EDITION

Items	Citric Acid - Citric Acid (Crystal) ..... Monohydrate - Citric Acid (Anhydrate) ... Anhydrate	Calcium Citrate	Calcium Hydroxide	Activated Carbo
Contents	($C_6H_8O_7$ = 192.13) 99.5% min	($C_{12}H_{10}Ca_3O_{14}$ = 498.44) 97% min	[$Ca(OH)_2$] 95% min	-
Characteristics	Transparent and colourless crystal or white crystalline powder, and acidic	White power, orderless	White powder	-
Confirmation Test	Acidic, Deniges Reagent ($C_5H_4O_3Hg \cdot Hg(OHg)_2SO_4$	Hydrochloric acid insoluble, pH of solution	Alkaline Calcium solution	-
Purity	Residual H_2SO_4 Heavy Metals as Pb Calcium as Oxalate Arsenic, 4mg/1,000g max Oxalate as Calcium Salt Isocitric Acid by Chromatgrahy Multi nuclear aromatic hydrocarbon by UV absorption Sulfuric acid colouring	Chloride Sulfate Heavy Metals as Pb Arsenic	Hydrochloric Acid Insoluble Carbonate Heavy Metal as Pb Magnesium (Solubility of Oxalate?) Barium as $BaCrO_4$ Arsenic	-
Quantitative Analysis	Alkalline Titration	EDTA Titration	EDTA Titration	-
Additional Note	-	-	Magnesium content must be minimum	For Purificatio

Table 14 WEIGHT CONVERSION FOR CITRIC ACID, SALTS AND ESTERS

Chemicals	Formular	Formular Weight	Weight Ratio against CAM ($C_6H_8O_7 \cdot H_2O$=100.00)
Citric Acid (Monohydrate)	$C_6H_8O_7 \cdot H_2O$	210.14	100.00 (CAM is Major Industrical Chemicals)
(Anhydrate)	$C_6H_8O_7$	192.13	91.43
Potassium Citrate	$C_6H_5K_3O_7 \cdot H_2O$	324.42	154.38
Diammonium Hydrogencitrate	$C_6H_6(NH_4)_2O_7$	226.19	107.64
Isopropyl Citrate	$C_{15}H_{26}O_6$	313.37	149.12
Calcium Citrate	$C_{12}H_{10}O_{14}Ca_3 \cdot 4H_2O$	570.50	271.49 (135.75) (CC is Major Intermediate of CAM Production)
Ferric Ammonium Citrate	-	-	-
Ferric Citrate	$C_6H_5FeO_7 \cdot 3H_2O$	298.99	142.28
Ferrous Sodium (Succinate) Citrate	C_6H_5FeNa	-	-
Trisodium Citrate	$C_6H_5Na_3O_7 \cdot nH_2O$ (n = 0 or 2)	258.07 (n=0)	122.81
Sodium Ferrous Citrate	$C_{12}H_{10}FeNa_4O_{14}$	526.01	250.31 (125.16)
Limes	CaO	56.08	26.69
	$Ca(OH)_2$	74.10	35.74 (Major Consumption Chemicals)
	$CaCO_3$	100.09	47.63
Sulfuric Acid	H_2SO_4	98.07	46.67

Table 15 CLIMATIC CONDITIONS OF MAJOR CITIES OF ZIMBABWE

August 20, 1990
JICA, Tokyo

Month	Monthly Average Temperature, °C		Monthly Average Humidity, %		Monthly Average Rain Fall, mm	
	Harare	Bulawayo	Harare	Bulawayo	Harare	Bulawayo
January	20.0	21.7	77	61	216	142
February	19.8	21.4	79	63	172	109
March	19.4	20.6	72	60	99	84
April	18.7	19.7	67	51	36	18
May	15.9	16.4	61	45	11	10
June	13.6	13.9	59	45	4	3
July	13.6	14.2	41	62	1	0
August	15.6	16.1	36	62	3	0
September	19.0	19.7	33	62	5	5
October	21.3	22.2	34	62	30	20
November	20.8	22.5	47	65	100	81
December	20.4	22.0	56	69	186	122
Average/Total	21.8	18.2	48	67	863	594

Notes

	Longitude	Latitude	Height, mH	Atmospheric Pressure, mb
Harare, Zimbabwe :	E31°06'	S17°55'	1,478	842
Bulawayo, Zimbabwe:	E28°37'	S20°01'	1,326	868

Table 16 CLIMATIC CONDITIONS OF CITRIC ACID PLANT LOCATION USING SOLID MASS FERMENTATION PROCESS INITIATED BY JAPANESES

September 5, 1990
UNICO, Tokyo

Month	Monthly Average Temperature, °C			Monthly Average Humidity, %			Monthly Average Rain Fall, mm		
	Kagoshima	Surabaya	Bangkok	Kagoshima	Surabaya	Bangkok	Kagoshima	Surabaya	Bangkok
January	7.0	27.2	26.1	73	78	74	95	226	9
February	8.2	27.2	27.6	71	78	77	106	279	29
March	11.2	27.2	29.2	70	79	77	147	213	34
April	16.1	27.2	30.3	74	78	77	256	137	89
May	19.8	27.0	29.8	76	75	80	275	94	166
June	23.0	26.1	28.9	81	72	81	475	56	171
July	27.2	25.9	28.4	80	68	85	323	25	178
August	27.7	25.9	28.2	78	66	84	209	5	191
September	24.9	26.7	27.9	77	65	85	211	5	306
October	19.6	27.5	27.6	72	64	87	108	18	255
November	14.3	28.1	26.7	73	68	86	92	61	57
December	9.2	27.2	25.5	74	74	82	80	165	7
Average/Total	17.3	27.0	28.0	75	72	84	2,375	1,285	1,492

Notes

	Longitude	Latitude	Height, mH	Atmospheric Pressure, mb
Bangkok, Thailand :	E100°30'	N13°44'	16	1,012
Surabaya (For Semaranga), Indonesia :	E112°43'	S07°13'	3	1,013
Kagoshima, Japan :	E130°33'	N31°34'	6	1,013

Source: Rikanenpyo, Maruzen, 1984

(9) Sweet Potatoes, Cassava and Rice Bran

For the production of citric acid by traditional solid culture fermentation process plant with annual capacity scale of 3,000 TPY, approximately 100,000 TPY of sweet potatoes starch extracted lees and/or cassava starch extracted lees, and 1,000 TPY of rice bran is generally consumed in Japan, Indonesia, Thailand, India and other countries. It is understood, according to the FAO estimates, that latest production in Zimbabwe is:

Agricultural Product	TPY
Rice:	1,000
Sweet Potatoes:	1,000
Cassava:	87,000

1) IDC is requested to reconfirm or revise the above FAO estimates and provide with commercially available quantity for citric acid production in Zimbabwe as well as each price level in Z$/Ton, CIF and FOB, and each transportaion distance in km.

2) Rice bran is low cost fermentation nutrient and UGF (unknown growth factor) for citric acid production by aspergillus niger. The yield of bran (25% of germ and 75% bran) is approximately 10% of rice. IDC is requested to provide information on the commercial availability of rice bran and its price level in Z$/Ton, CIF and FOB, and each transportation distance in km.

3) If rice bran is not obtainable considering even import from surrounding countries, it may be possible to use corn steep liquor, molasses or beer fermentation lees as substitute. IDC is requested to provide with relevant information and representative samples for evaluation in Zimbabwe and/or in Japan.

4) If sweet potatoes or cassava lees is not available for citric acid production in adequate quantity, sweet potatoes or cassava itself will be applicable by addition of appropriate texture structure for solid culture fermentation. Process performance optimization experiments at demonstration plant scale will be required before commercialization.

5) At the discussion with ZIMPHOS, fertilizer companies such as ZIMPHOS, Sable, ZFC and Windmill have many extension services personnel who will be able to supply agroeconomic information on citric acid raw materials farming at communal farmings as well as estate farmings in Zimbabwe.

(10) Sugar, Molasses and Bagasse

It is understood, according to the FAO and UN publications, that sugar cane, sugar bagasse and molasses production in Zimbabwe is summarized as follow:

Sugar Related Materials	Production, TPY	Price Level, Z$/Ton
Sugar Cane	3,128,000	-
Sugar Beets	-	-
Sugar Centrifuge	442,000	880 (Raw Sugar)
Bagasse	1,485,000	
Molasses	62,600	130

Major sugar growing regions are Hippo Valley, Triangle and Mkwasine in Zimbabwe. Sugar cane is transported from Mkwasine to Hippo Valley and/or Triangle, where molasses are converted into ethanol for mogas additives. Molasses are one of the ideal raw material for the production of citric acid by submerged culture process.

Approximately 2.7 ton of molasses are required for citric acid production. For the production of one ton of ethanol, approximately 4.2 ton of molases is required, hence 15,000 TPY of ethanol will be available, if all domestic molasses are consumed for ethanol production. In Zimbabwe, mogas consumption is estimated 170,000 TPY, therefore it is equivalent approximately 8.8% of mogas in weight-wise, and in terms of BTU-LHV-wise, the ratio is reduced to 5.3%. At present a portion of molasses is utilized as cattle feed at price of Z$130/Ton and no molasses is assumed for citric acid production. However, if a small portion of molasses is available, it will be beneficial and economical to apply for the production of citric acid as fermentation nutrients as substitution of rice bran as well as source of carbohydrate.

Bagasse production is estimated 1,485,000 TPY, however the majority is consumed as fuel in sugar refineries. Bagasse will be an excellent fermentation fibrous matter for solid culture fermentation process of

citric acid production, which will enable the elimination of starch extraction process steps for sweet potatoes and/or cassava and production quantity increase of citric acid by the whole sweet potatoes and/or cassava utilization. It is understood that maize starch is produced at a large scale plant and lower cost in Zimbabwe.

1) IDC is requested to confirm or revise the basic production and price figures of sugar related materials.

2) Availability and pricing in Z$/Ton, FOB and CIF as well as transportation mode and distance for bagasse and molasses

3) Complete analysis of bagasse and molasses, commercially available in Zimbabwe.

4) If analysis data is not available, representative samples should be taken for observation and investigation, if required.

(11) Sweet Potatoes

It is considered that the sweet potatoes is one of the available raw materials in Zimbabwe for the production of citric acid solid culture process. FAO estimate of sweet potatoes production is 1,000 TPY. For the production of 3,000 TPY citric acid, approximately 10,000 TPY starch extracted lees of sweet potatoes is required.

1) IDC is requested to provide with typical analysis of Zimbabwe's sweet potatoes as follows:

Table TYPICAL ANALYSIS OF SWEET POTETOES IN JAPAN AND ZIMBABWE

Country	Species	Moisture %	Carbohydrate %	Starch %	Sugars %	Protein %	Ash %	Fiber %	Fat %
Japan	(1) Norin No.1	63.7	30.6	25.3	2.5	1.6	0.8	1.0	0.4
	(2) Norin No.2	67.1	30.9	25.2	3.0	1.2	0.8	0.7	-
	(3) Okinawa No.100	72.1	23.1	20.9	2.9	1.3	0.7	0.6	-
	Simple Average	67.7	28.2	23.8	2.8	1.4	0.8	0.8	0.4
Zimbabwe	(1)								
	(2)								
	(3)								
	Simple Average								

Sources: (1) Foods processing Technologies Handbook, Food Technology Engineers Center, Japan, 1971

(2) IDC, Zimbabwe - 1990

2) IDC is requested to providing with information on sweet potatoes farming region and harvesting season.

3) It is understood that sweet potatoes is not marketed as main food. Commercial supply is limited and city market retailer price is sometimes zero and temporary priced up to Z$400/Ton in 1990.

4) IDC is requested to verify the above statements and supply with more reliable availability information of sweet potatoes in quantity, price and seasonal suppliability.

If sweet potatoes lees of starch extraction is identified as the best citric acid raw materials in Zimbabwe, approximate requirement of sweet potatoes is 33,000 TPY. IDC is requested to provide with sweet potatoes farming promotion program and which organization is responsible for the program development.

(12) Lime and Gypsum

It is understood that Zimbabwe has three Cement Plants as follows:

Table CEMENT PLANTS IN ZIMBABWE

Company	Location	Capacity	Completion Year
SPCLTD	Manresa, Harare	330,000	1957/72
UPCCL (Private)	Bulawayo	110,000	1954/73
	Colleen Bawn	230,000	na
Total	-	670,000	-

For the production 3,000 TPY citric acid, approximately 2,500 TPY of calcium hydroxide is required.

IDC is requested to confirm above data and obtain samples and following information:

1) Annual consumption of lime in TPY for each plant above and location of lime quarry.

2) Complete chemical analysis of lime for each plant. Magnesium content and heavy metals content should be carefully analyzed. Price information in Z$/Ton, CIF and FOB, and transportation distance in km.

3) Annual consumption of gypsum in TPY for each plant.

4) Representative samples of calcium hydroxide with best quality available for citric acid production. Sample should be attached certificate showing sampling location, date, method of pre-treatment, and the name of IDC officer attended for the sampling.

   If calcium hydroxide is not available, availability of calcium oxide and then calcium carbonate should be investigated, to cover above items from (1) to (4).

(13) Availability of Maize Starch in Zimbabwe for Citric Acid Production

It is understood, according to the First Five-Year National Development Plan, 1986-1990, Volume II, April, 1988 by Republic of Zimbabwe, that the Department of Energy in the Ministry of Energy, Water Resources and Development, in collaboration with National Foods Limited, is carrying out experiments to produce butanol as diesel extender (B/D = 10/900 to B/D = 40/60) from major starch which is available during the production of cooking oil from maize and most of which is thrown away at present in Zimbabwe.

IDC is requested to supply with following information:

1) Progress status of butanol production program in Zimbabwe.

2) Total availability of maize starch in TPY which is available as by-products from cooking oil production. Consumption of maize starch in TPY for butanol production program.

3) Complete analysis of maize starch recovered from cooking oil production.

4) Price level in Z$/Ton of maize starch which is available for citric acid production.

5) It was felt that the progress of diesel extender program and thrown away practice of cooking oil extracted maize in Zimbabwe are questionable according to the discussions at Food and Industrial, Delta Consolidation in Harare.

6) Food and Industrial is producing, from maize, starch, multose, and glucose at 500 TPY scale, and has expansion program to expand 1,000 TPY with Z$3.0 MM investment. Food and Industrial is also producing lactic acid by fermentation process by using enzyme supplied by Novo with 100 m^3/month (25 - 50%) capacity scale. It is explained that government control price for white maize is Z$1,050/Ton, price of yellow maize is approximately 70% of white maize. The price of cooking oil extracted maize lees is much higher that those of white maize.

(14) Sulfuric Acid Supplability and Pricing

1) It is understood that in Zimbabwe, there are five fertilizer production facilities as follows:

Table FERTILIZER PLANTS

Company	Location	Main Products	Rated Capacity, TPY
Sable Cheml Ind Ltd	Kwe Kwe	Ammonium Nitrate (Water Electrolysis and Import of Ammonia)	210,000
Zimbabwe Phos Ind Ltd, Kemplex	Dorowa and Harare	SSP, TSP, MCP, Alum (H_2SO_4: 75,000 TPY from imported sulfur and local pyrite from Iron Duke Phos Acid: 21,000 TPY as P_2O_5 Phos Rock from Dorowa, Mutare)	40,000 as P_2O_5
ZFC		NPKS, BB	— 410,000
Windmill		NPKS, BB	

2) For the production of 3,000 TPY of citric acid, approximately 2,500 TPY of sulfuric acid is required. IDC is requested to supply with the commercial availability and pricing of sulfuric acid for the proposed project. IDC is also requested to obtain detailed analysis of sulfuric acid, impurity of heavy metals, arsenics, selenium and cadmium should be carefully investigated. Price quotation should be given in ZS/Ton, FOB and CIF with transportation mode and charges for delivery distance in km.

3) It is confirmed at the discussion with ZIMPHOS that ZIMPHOS is buying both lime stone at Z$75/Ton and slated lime at Z$125/Ton. ZIMPHOS is producing chemical grade sulfuric acid from pyrite roaster gas. Present selling price of chemical grade sulfuric acid is Z$550/Ton. Production capacity is limited but felt plant capacity increase is possible for even using sulfur burning gas.

Table 17 ENERGY SITUATION IN ZIMBABWE

(1) Commercial Energy Balance - 1985 in Oil Equipment (TOE = 10.0 x 10^6 Kcal)

Item	Supply	Demand
Production		
- Solid	1.65 MMTPYY	1.56 MMTPY
- Liquid	0.00	0.59
- Gas	0.00	0.00
- Electricity	0.29	0.55
- Sub-total	1.94	2.70
Import	0.97	-
Export	0.14	Per Capita 0.31 Ton
Bunkers	0.06	
Supply Total	2.71	

(2) Renewal Energy - 1985 in Oil Equivalent

- Firewood	5.73 MMTPY
- Charcoal	0.00
- Bagasse	1.49
Total	7.22

(3) Petroleum Products Import - 1985 in Oil Equivalent

Domestic Consumption	
- LPG	0.004 MMTPY
- Aviation Gasoline	0.002
- Mogas	0.170
- Kerosene	0.012
- Jet Fuel	0.070
- Diesel Oil	0.380
- Fuel Oil	0.000
- Sub-Total	0.639
Bunker	(-)0.065
Consumption Total	0.574

(4) Petroleum Refinery Distillation Capacity: 1.0 MMTPY ?
Refinery : At Umtali, 2,000 BPSD - 1966 Closed
Crude Pipeline: Beira - Umtali

(5) Electricity Generation - 1985

- Thermal	906 MW
- Hydro	633
Total	1,539
- Self	51
- Public	1,488
Total	1,539

(6) Coal Reserve - 1977

- In-Place	1,533 MMTon
- Recoverable	735

(7) Bituminous Coal - 1979

- In-Place	965 MMTon
- Recoverable	na

Source: Energy Statistics Yearbook - 1985, United Nations

(15) Organic Fertilizer

As one of by-products from solid culture process for citric acid production, organic wastes is obtainable, it is utilized in Japan as organic fertilizers. Approximate production of citric acid fermentation lees is 12,000 TPY (Including 80% of moisture) at 3,000 TPY citric acid production plant. In Japan such lees are utilized as organic fertilizers, and contributing to increase revenue to some extent.

IDC is requested to tabulate the information on organic fertilizers produced and/or imported into Zimbabwe.

Table ZIMBANIAN ORGANIC FERTILIZERS

Trade Name/ Manufacturer	Fertilizer Analysis, %						Price, Z$/Ton	Annual Sales, Type
	T-N	AV-P_2O	W-P_2O_5	S-K_2O	Organics	Miosture		
(1)								
(2)								
(3)								
(4)								
(5)								

Annex

MEMBERS FOR PRELIMINARY STUDY TEAM OF JAPAN INTERNATIONAL COOPERATION AGENCY FOR FEASIBILITY STUDY ON THE ESTABLISHMENT OF CITRIC ACID PLANT IN THE REPUBLIC OF ZIMBABWE

Name	Title	Function
Dr. Kenji TOMITA	Special Technical Advisor, JICA, Tokyo	Leader, Preliminary Study Team
Mr. Yasujiro SUZUKI	Industry Division, JICA, Tokyo	Study Project Coordinator
Mr. Toshitake YASUKAWA	General Manager, Citric Acid Producers Association, Osaka	Citric Acid Production Technology
Mr. Makoto KUWABARA	Senior Consultant, UNICO International Corp., Tokyo	Chemical Engineer, Techno-Economist

Future correspondence, please address to: Mr. Yasujiro Suzuki,
Industry Division,
Mining and Industrial Planning and Survey Department,
Japan International Cooperation Agency (JICA)

Mail : PO Box No.216,
48th Flr, Shinjuku Mitsui Bldg.,
1-1, Nishi-Shunjuku 2-chome,
Shinjuku-ku, Tokyo, 163 JAPAN

Tel : 813-346-5289

Fax : 813-346-5439

Telex : J22271 (JICAHDQA)

Cable : JICAHDQ

LIST OF VISITING ORGANIZATION AND PERSONNEL BY JICA CONTACT MISSION

(1) Ministry of Finance, Economic Planning and Development

- Mr. O.M. Malshalaga,	Undersecretary (Aid Sector)
- Ms. E. Ruparanganda,	Administrative Officer

(2) Ministry of Foreign Affairs

- Mr. B. Marowa,	Administrative Officer

(3) Ministry of Industry and Technology

- Ms. F.Z. Chideya,	Acting Undersecretary
- Mr. C.E. Nyatanga,	Senior Administrative Officer
- Mr. A. Mushaninga,	Administrative Officer

(4) Industrial Development Corporation of Zimbabwe Limited*(IDC)

- Mr. C.M.D. Snayanga,	Director and General Manager
- Mr. L.A. Munyawarara,	Manager for Research & Development
- Mr. P. Sibanda,	Projects Apraisal Manager
- Ms. Evelyn Ndlovu,	Research Economist

(5) University of Zimbabwe

- Dr. M.A. Benhura,	Professor, Department of Biochemistry

(6) Confederation of Zimbabwe Industries (CZI)

- Mr. Mike Humphrey,	Chief Economist

(7) Food Manufacturers Association

- Mr. J.W. Slupinski,	Technical Director of Lions Africa Management Resources

(8) Schweppes (Central Africa) Limited

- Mr. P. Hind,	General Manger

(9) National Breweries Limited

- Dr. Mushiri,	Production Manager
- Mr. S. Makwanya,	Brewing Manager

(10) Triangle Limited

- Mr. W. Lenman,	Technical Director
- Mr. Clive M. Wenman,	Technical Director
- Mr. H.B. Morar,	Sugar Mill Manager
- Mr. Peter T. Mukuna,	Public Relations Manager
- Mr. W.S. Grham,	Process Consultant
- Mr. M.J. Pazuakavanmbca,	Ethanol Plant Manager

(11) EOJ

- Mr. Yukio Rokujo,	Councillor
- Mr. Yukio Kawajiri,	First Secretary

(12) JETRO

- Mr. Kohmei Nakajima,	Representative

* Counterpart, Executing Agency and Coordinating Body for the Study

LIST OF REFERENCE MATERIALS
(Not Essential, Not Completed, Just for Suggested)

ZW :
- Statistical Yearbook - 1987, Central Statistical Office
- Industrial Development Corporation of Zimbabwe Limited, Annual Report and Accounts, the 30th June, 1989
- Regional Investment Promotion Meeting for SADCC Countries, November 3 - 7, 1986, Harare
- Investment Register (Summary), 1988
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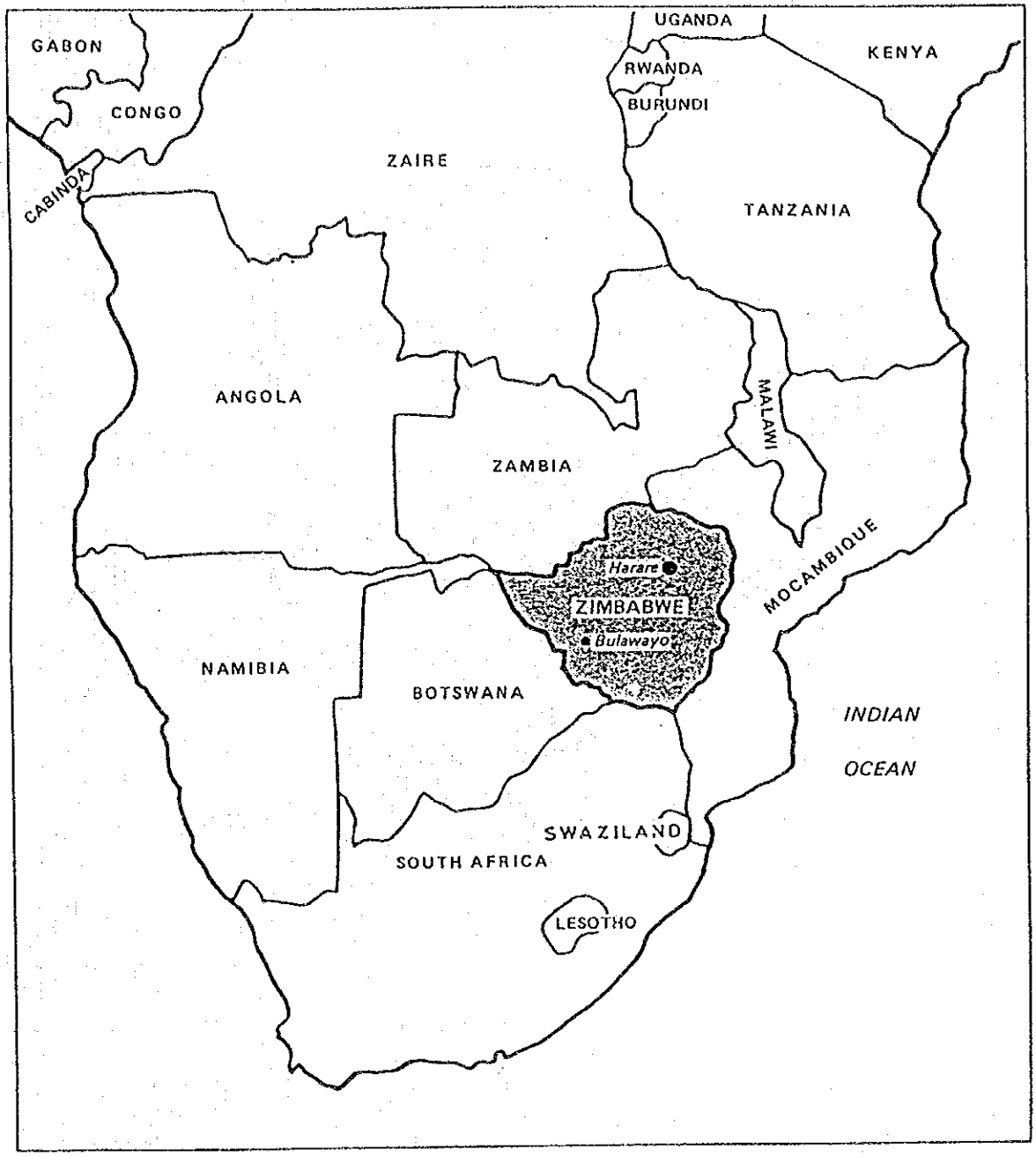
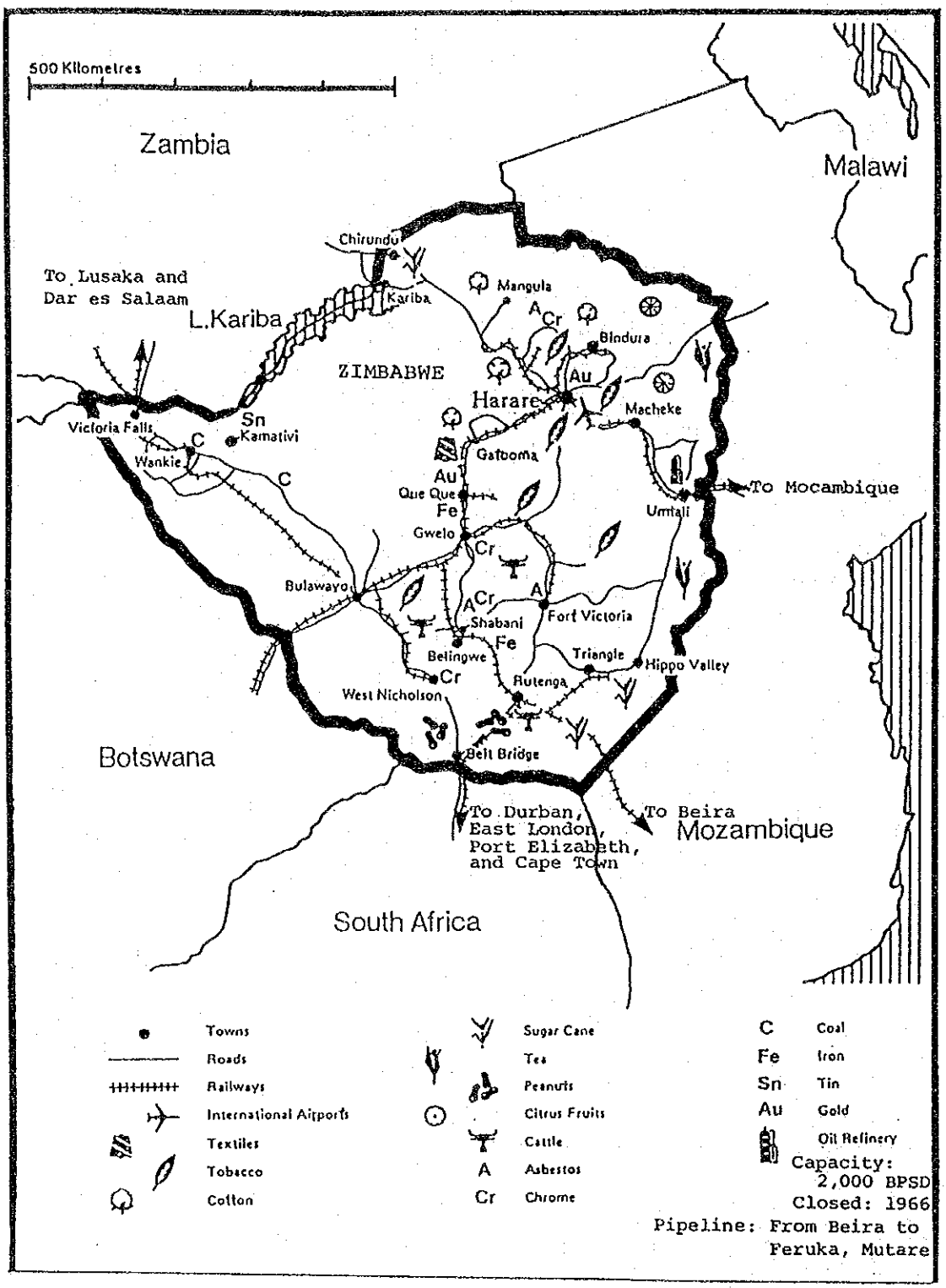
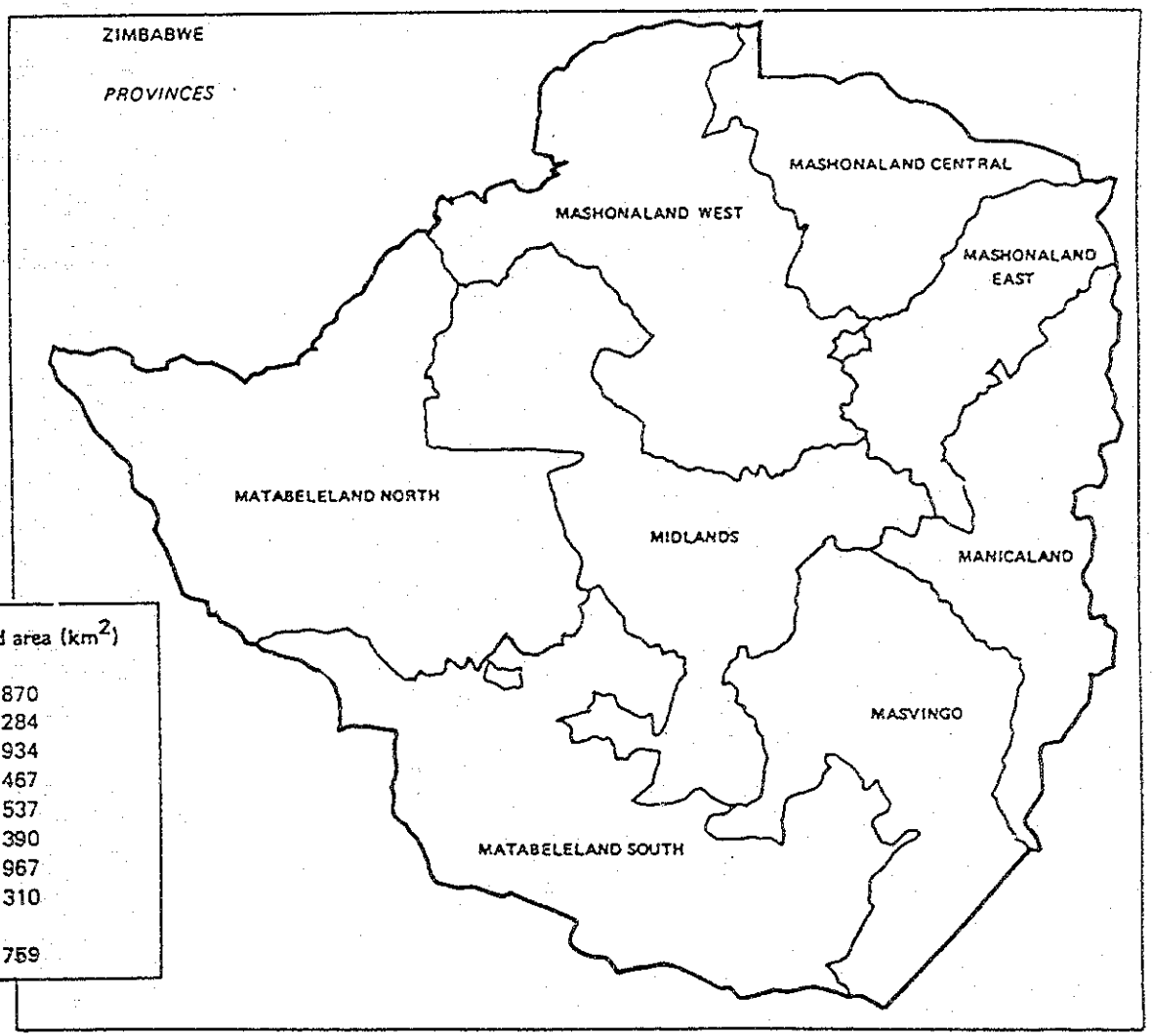
アフリカ全図


セウタ(ス)
メリラ(ス)
ラバト
アルジェ
チュニス
チュニジア
モロッコ
トリポリ
カイロ
西サハラ
アルジェリア
リビア
エジプト
モーリタニア
ヌアクショット
マリ
ニジェール
チャド
ハルツーム
ダカール
セネガル
ガンビア(バンジュル)
バマコ
ワガドゥグ
ニアメ
スーダン
ジブチ
ギニア
コナクリ
ブルキナファソ
ナイジェリア
ヤムスクロ
ガーナ
ラジャメナ
アジスアベバ
エチオピア
ソマリア
ギニアビサウ(ビサウ)
カーボベルデ(プライア)
シェラレオネ(フリータウン)
モンロビア
リベリア
コートジボアール
アクラ
トーゴ(ロメ)
ベナン(ポルトノボ)
ラゴス
中央アフリカ
バンギ
カメルーン
ヤウンデ
モガディシュ
ウガンダ
カンパラ
ケニア
ナイロビ
赤道ギニア(マラボ)
サントメ・プリンシペ(サントメ)
リーフルビル
ガボン
コンゴ
ブラザビル
キンシャサ
ザイール
ルワンダ(キガリ)
ブルンジ(ブジュンブラ)
タンザニア
セーシェル(ビクトリア)
ダルエスサラーム
マラウイ(リロングェ)
コモロ(モロニ)
ルアンダ
アンゴラ
ザンビア
ルサカ
マダガスカル
アンタナナリボ
ハラレ
ジンバブエ
モザンビーク
モーリシャス(ポート・ルイス)
ナミビア
ボツワナ
ウィントフーク
ガボローン
プレトリア
マプト
スワジランド(ムババーン)
南アフリカ
レソト(マセル)

Countries of southern Africa




500 Kilometres
Zambia
Malawi
Chirundu
To Lusaka and
Dar es Salaam
L.Kariba
Kariba
Mangula
Cr
Bindura
ZIMBABWE
Au
Harare
Macheke
Victoria Falls
Sn
Kamativi
C
Wankie
C
Gatooma
Au
Que Que
Fe
To Mocambique
Umtali
Gwelo
Cr
Bulawayo
A
Cr
A
Fort Victoria
Shabani
Fe
Triangle
Hippo Valley
Belingwe
Cr
Rutenga
West Nicholson
Botswana
Bell Bridge
To Durban,
East London,
Port Elizabeth,
and Cape Town
To Beira
Mozambique
South Africa
Towns
Roads
Railways
International Airports
Textiles
Tobacco
Cotton
Sugar Cane
Tea
Peanuts
Citrus Fruits
Cattle
A Asbestos
Cr Chrome
C Coal
Fe Iron
Sn Tin
Au Gold
Oil Refinery
Capacity:
2,000 BPSD
Closed: 1966
Pipeline: From Beira to
Feruka, Mutare



Land area by provinces	Land area (km^2)
Manicaland	34 870
Mashonaland Central	27 284
Mashonaland East	24 934
Mashonaland West	60 467
Matebeleland North	73 537
Matebeleland South	66 390
Midlands	58 967
Masvingo	44 310
Total	390 759

Table SUGARCANE, production in tonnes, area in hectares and yield in tonnes/ha, 1970-1984

	Productive area			Non productive area
	Production	Area	Yield	
1970	1 760 000	19 501	90.2	580
1971	1 625 000	16 315	99.6	3 192
1972	1 795 000	19 486	92.1	458
1973	1 806 000	21 883	82.5	526
1974	2 314 000	21 190	109.2	4 140
1975	2 628 000	22 769	115.4	4 041
1976	2 112 000	25 328	83.4	417
1977	3 087 000	26 419	116.8	898
1978	2 635 000	24 677	106.7	343
1979	2 555 000	24 518	104.2	316
1980	2 528 000	24 515	103.1	6 038
1981	3 551 000	34 146	103.9	466
1982	3 587 000	31 547	113.7	533
1983	3 438 000	33 033	104.1	1 400
1984[1]	3 459 000	33 048	104.7	109

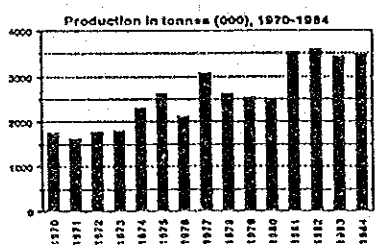
1) Provisional data

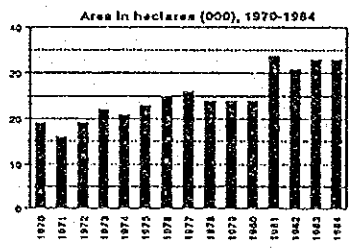
Source: Central Statistical Office.

Area planted: Sugarcane is grown almost entirely on large scale commercial farms. Area put to the crop has increased substantially since 1970, mainly due to a steady increase in price.

Yield: Since 1974, yield has on average been over 100 ton/ha

Production: Production has increased steadily over the years, reaching a top level of 3 600 000 tonnes in 1982





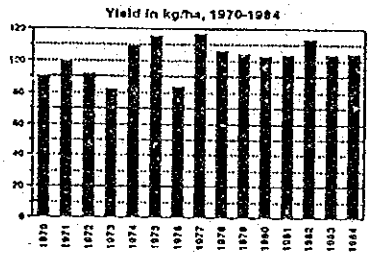


Table MAIZE, production in tonnes, area in hectares and yield in kg/ha, 1970–1985

	Commercial			Communal[1]			Total		
	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield
1970	839 627	292 010	2 875	245 700	610 800	402	1 085 327	902 810	1 202
1971	1 400 499	304 017	4 607	455 000	672 000	677	1 855 499	976 017	1 901
1972	1 762 067	338 016	5 213	555 100	664 661	835	2 317 167	1 002 677	2 311
1973	810 358	315 335	2 570	145 000	475 000	305	955 358	790 335	1 209
1974	1 634 356	311 058	5 254	470 000	725 000	648	2 104 356	1 036 058	2 031
1975	1 328 075	278 170	4 774	435 000	725 000	600	1 763 075	1 003 170	1 758
1976	1 287 752	257 301	5 005	550 000	760 000	724	1 837 752	1 017 301	1 807
1977	1 213 285	264 354	4 590	400 000	600 000	667	1 613 285	864 354	1 867
1978	1 178 234	273 144	4 314	450 000	700 000	643	1 628 234	973 144	1 673
1979	721 916[2]	199 430[2]	3 620	420 000	600 000	700	1 141 916	799 430	1 428
1980	910 739[2]	227 733[2]	3 999[2]	600 000	900 000	667	1 510 739	1 127 733	1 340
1981	1 833 395	363 448	5 044	1 000 000	1 000 000	1 000	2 833 395	1 363 448	2 078
1982	1 213 376	316 440	3 835	595 000	1 100 000	595	1 808 376	1 416 440	1 277
1983	624 786	283 880	2 201	285 000	1 050 000	271	909 786	1 333 880	682
1984[3]	678 403	224 586	3 021	454 400	1 136 000	400	1 132 803	1 360 586	833
1985[3]	1 153 000	238 000	4 844	1 558 000	1 018 000	1 394	2 711 000	1 256 000	2 158

1) Estimates
2) Refers to large scale commercial farms only
3) Provisional data

Source: Central Statistical Office

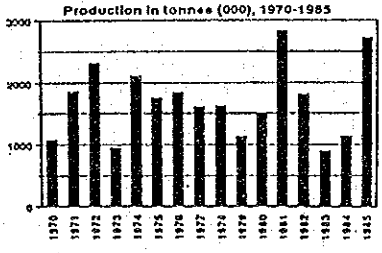
Area planted: Communal lands accounted for 81 % of the total area planted with maize in 1985. In the communal lands the area planted more than doubled between 1979 and 1985

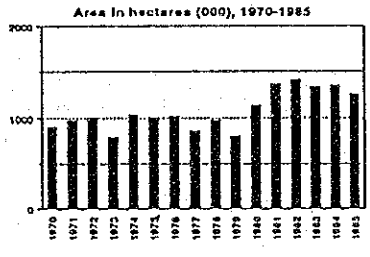
The area planted to maize on commercial farm land has declined every year after 1972. A slight recovery was made in 1981 but area planted never exceeded the 1972 hectarage

Yields: On average the yield on commercial farm land has been 7–8 times higher than in communal lands. The 1983 yield from both commercial and communal areas was the lowest recorded between 1970 and 1985 because of the drought

Production: Between 1970 and 1985 commercial farms accounted for about two thirds of total production. However their output declined between 1972 and 1978, reflecting the effects of the war situation, and a shift to other crops which had relatively higher prices. The upturn in 1981 was negated by subsequent droughts in 1982 and 1983

In communal land there was a record crop in 1981 and 1984. The low output in 1982 and 1983 was due to severe drought





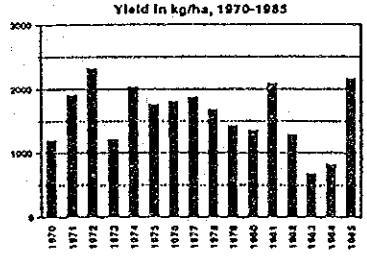


Table ZIMBABWE DOLLAR EXCHANGE RATE, 1982-1985

Period[1]	U.S. Dollar	Sterling	French Franc	Deutsch Mark	S.A. Rand	Swiss Franc
1982						
Jan	1.3804	0.736901	8.1754	3.2153	1.3448	2.5662
Dec[2]	1.0876	0.671047	7.3195	2.5896	1.1670	2.1790
1983						
Jan	1.0637	0.673158	7.1886	2.5362	1.1340	2.0920
Dec	0.9046	0.622574	7.5082	2.4564	1.1017	1.9693
1984						
Jan	0.8740	0.621843	7.5265	2.4616	1.1048	1.9632
Feb	0.9112	0.612263	7.3147	2.3785	1.0932	1.9773
Mar	0.9000	0.621762	7.1843	2.3319	1.1146	1.9314
Apr	0.8689	0.619979	7.2206	2.3534	1.0852	1.9446
May	0.8559	0.617978	7.1874	2.3394	1.0989	1.9320
June	0.8325	0.614845	7.0950	2.3125	1.1337	1.9339
July	0.7598	0.580887	6.7413	2.1958	1.2446	1.8651
Aug	0.7691	0.587323	6.8123	2.2192	1.2027	1.8470
Sept	0.7235	0.580541	6.7286	2.1915	1.2089	1.8098
Oct	0.6869	0.564652	6.3899	2.0822	1.3084	1.7131
Nov	0.6841	0.569608	6.4562	2.1075	1.2633	1.7328
Dec	0.6656	0.571085	6.3848	2.0872	1.3163	1.7211
1985						
Jan	0.6466	0.571201	6.2581	2.0488	1.2842	1.7292
Feb	0.6141	0.563911	6.2393	2.0434	1.2251	1.7379
Mar	0.6505	0.529723	6.1976	2.0305	1.2414	1.7189
Apr	0.6447	0.517208	6.0618	1.9873	1.2597	1.6669

1) Last trading day of the relevant period
2) Zimbabwe Dollar devalued by 20 % on the 9th of December 1982

Source: Reserve Bank

5. 主要入手資料リスト

5. 主要入手資料リスト

1) Industrial development Corporation of Zimbabwe Limited パンフレット